

## STM32CubeMX for STM32 configuration and initialization C code generation

### Introduction

STM32CubeMX is a graphical tool for STM32 microcontrollers. It is part of the STM32Cube initiative (see [Section 1](#)) and is available as a standalone application as well as in the STM32CubeIDE toolchain.

STM32CubeMX has the following key features:

- **Easy microcontroller selection** covering the whole STM32 portfolio
- **Board selection** from a list of STMicroelectronics boards
- **Easy microcontroller configuration** (pins, clock tree, peripherals, middleware) and generation of the corresponding initialization C code
- **Easy switching to another microcontroller** by importing a previously-saved configuration to a new MCU project
- **Easy exporting of current configuration to a compatible MCU**
- **Generation of configuration reports**
- **Generation of embedded C projects** for a selection of integrated development environment tool chains. STM32CubeMX projects include the generated initialization C code, MISRA 2004 compliant STM32 HAL drivers, the middleware stacks required for the user configuration, and all the relevant files for opening and building the project in the selected IDE.
- **Power consumption calculation** for a user-defined application sequence
- **Self-updates** allowing the user to keep STM32CubeMX up-to-date
- Download and update of STM32Cube embedded software required for user application development (see [Appendix E](#) for details on the STM32Cube embedded software offer)

Although STM32CubeMX offers a user interface and generates C code compliant with STM32 MCU design and firmware solutions, users need to refer to the product technical documentation for details on actual implementation of peripherals and firmware.

The following documents are available on [www.st.com](http://www.st.com):

- STM32 microcontroller reference manuals and datasheets
- STM32Cube HAL/LL driver user manuals for STM32F0 (UM1785), STM32F1 (UM1850), STM32F2 (UM1940), STM32F3 (UM1786), STM32F4 (UM1725), STM32F7 (UM1905), STM32G0 (UM2303), STM32G4 (UM2570), STM32H7 (UM2217), STM32L0 (UM1749), STM32L1 (UM1816), STM32L4/L4+ (UM1884), STM32L5 (UM2659), STM32MP1 (<https://wiki.st.com/stm32mpu>), STM32WL (UM2642) and STM32WB (UM2442).



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## 1 STM32Cube overview

STM32Cube is an STMicroelectronics original initiative to make developers' lives easier by reducing development effort, time and cost. STM32Cube covers the whole portfolio of STM32 devices, based on 32-bit Arm®<sup>(a)</sup> Cortex® cores.

STM32Cube includes:

- STM32CubeMX, a graphical software configuration tool that allows the generation of C initialization code using graphical wizards.
- A comprehensive embedded software platform, delivered per Series (such as STM32CubeF2 for STM32F2 Series and STM32CubeF4 for STM32F4 Series)
  - The STM32Cube HAL, STM32 abstraction layer embedded software ensuring maximized portability across the STM32 portfolio.
  - Low-layer APIs (LL) offering a fast light-weight expert-oriented layer, which is closer to the hardware than the HAL. LL APIs are available only for a set of peripherals.
  - A consistent set of middleware components such as RTOS, USB, TCP/IP.
  - All embedded software utilities, delivered with a full set of examples.

arm

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

## 2 Getting started with STM32CubeMX

### 2.1 Principles

Customers need to quickly identify the MCU that best meets their requirements (core architecture, features, memory size, performance...). While board designers main concerns are to optimize the microcontroller pin configuration for their board layout and to fulfill the application requirements (choice of peripherals operating modes), embedded system developers are more interested in developing new applications for a specific target device, and migrating existing designs to different microcontrollers.

The time taken to migrate to new platforms and update the C code to new firmware drivers adds unnecessary delays to the project. STM32CubeMX was developed within STM32Cube initiative which purpose is to meet customer key requirements to maximize software reuse and minimize the time to create the target system:

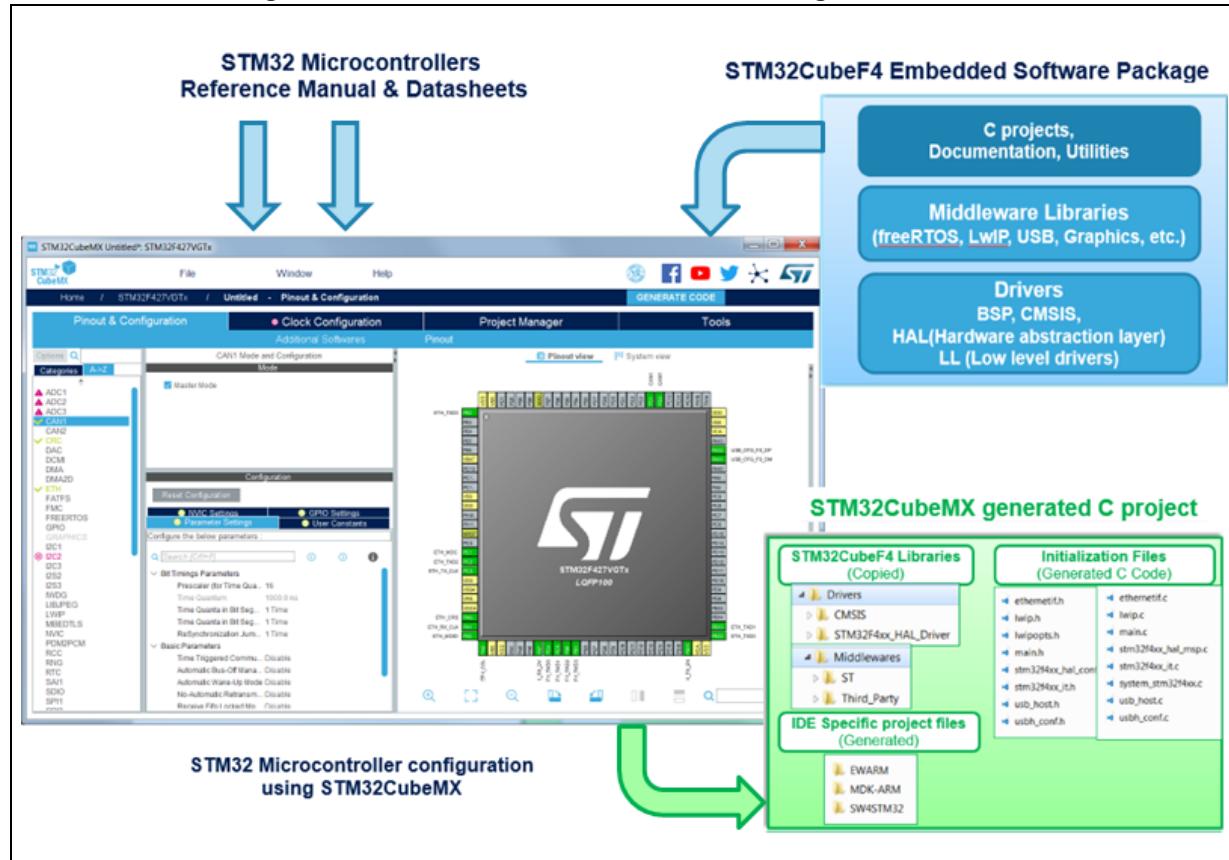
- Software reuse and application design portability are achieved through STM32Cube firmware solution proposing a common Hardware Abstraction Layer API across STM32 portfolio.
- Optimized migration time is achieved thanks to STM32CubeMX built-in knowledge of STM32 microcontrollers, peripherals and middleware (LwIP and USB communication protocol stacks, FatFs file system for small embedded systems, FreeRTOS).

STM32CubeMX graphical interface performs the following functions:

- Fast and easy configuration of the MCU pins, clock tree and operating modes for the selected peripherals and middleware
- Generation of pin configuration report for board designers
- Generation of a complete project with all the necessary libraries and initialization C code to set up the device in the user defined operating mode. The project can be directly open in the selected application development environment (for a selection of supported IDEs) to proceed with application development (see [Figure 1](#)).

During the configuration process, STM32CubeMX detects conflicts and invalid settings and highlights them through meaningful icons and useful tool tips.

Figure 1. Overview of STM32CubeMX C code generation flow



## 2.2 Key features

STM32CubeMX comes with the following features:

- **Project management**

STM32CubeMX allows the user to create, save and load previously saved projects:

- When STM32CubeMX is launched, the user can choose to create a new project or to load a previously saved project.
- Saving the project saves user settings and configuration performed within the project in an .ioc file to be used when the project will be loaded in STM32CubeMX again.

STM32CubeMX also allows the user to import previously saved projects in new ones.

STM32CubeMX projects come in two flavors:

- MCU configuration only: .ioc file is saved in a dedicated project folder.
- MCU configuration with C code generation: in this case .ioc files are saved in a dedicated project folder along with the generated source C code. There can be only one .ioc file per project.

- **Easy project creation starting from an MCU, a board or an example**

The new project window allows the user to create a project by selecting a microcontroller, a board, or an example project from STMicroelectronics STM32 portfolio. Different filtering options are available to ease the MCU and board selection. There is also the possibility to select an MCU through the Cross selector tab by comparing characteristics to those of competitors. Comparison criteria can be adjusted.

- **Easy pinout configuration**

- From the **Pinout** view, the user can select the peripherals from a list and configure the peripheral modes required for the application. STM32CubeMX assigns and configures the pins accordingly.
- For more advanced users, it is also possible to directly map a peripheral function to a physical pin using the **Pinout** view. The signals can be locked on pins to prevent STM32CubeMX conflict solver from moving the signal to another pin.
- Pinout configuration can be exported as a .csv file.

- **Complete project generation**

The project generation includes pinout, firmware and middleware initialization C code for a set of IDEs. It is based on STM32Cube embedded software libraries. The following actions can be performed:

- Starting from the previously defined pinout, the user can proceed with the configuration of middleware, clock tree, services (RNG, CRC, etc...) and peripheral parameters. STM32CubeMX generates the corresponding initialization C code. The result is a project directory including generated main.c file and C header files for configuration and initialization, plus a copy of the necessary HAL and middleware libraries as well as specific files for the selected IDE.
- The user can modify the generated source files by adding user-defined C code in user dedicated sections. STM32CubeMX ensures that the user C code is

preserved upon next C code generation (the user C code is commented if it is no longer relevant for the current configuration).

- STM32CubeMX can generate user files by using user-defined freemarker .ftl template files.
- From the **Project settings** menu, the user can select the development toolchain (IDE) for which the C code has to be generated. STM32CubeMX ensures that the IDE relevant project files are added to the project folder so that the project can be directly imported as a new project within third party IDE (IAR™ EWARM, Keil™ MDK-ARM, Atollic® TrueSTUDIO® and AC6 System Workbench for STM32).

- **Power consumption calculation**

Starting with the selection of a microcontroller part number and a battery type, the user can define a sequence of steps representing the application life cycle and parameters (choice of frequencies, enabled peripherals, step duration). STM32CubeMX Power Consumption Calculator returns the corresponding power consumption and battery life estimates.

- **Clock tree configuration**

STM32CubeMX offers a graphic representation of the clock tree as it can be found in the device reference manual. The user can change the default settings (clock sources, prescaler and frequency values). The clock tree is then updated accordingly. Invalid settings and limitations are highlighted and documented with tool tips. Clock tree configuration conflicts can be solved by using the solver feature. When no exact match is found for a given user configuration, STM32CubeMX proposes the closest solution.

- **Automatic updates of STM32CubeMX and STM32Cube MCU packages**

STM32CubeMX comes with an updater mechanism that can be configured for automatic or on-demand check for updates. It supports STM32CubeMX self-updates as well as STM32Cube firmware library package updates. The updater mechanism also allows deleting previously installed packages.

- **Report generation**

.pdf and .csv reports can be generated to document user configuration work.

- **Support of embedded software packages in CMSIS-Pack format (Software Packs)**

STM32CubeMX allows getting and downloading updates of embedded software packages delivered in CMSIS-Pack format. Selected software components belonging to these new releases can then be added to the current project.

- **Generating Software Packs with STM32PackCreator**

STM32PackCreator is a graphical tool installed with STM32CubeMX in the Utilities folder. It allows the user to create Software Packs and STM32Cube Expansion

packages enhanced for STM32CubeMX. It can be launched from the ST Tools tab found in STM32CubeMX Tools view.

- **Contextual help**

Contextual help windows can be displayed by hovering the mouse over Cores, Series, Peripherals and Middleware. They provide a short description and links to the relevant documentation corresponding to the selected item.

- **Access to ST tools**

From STM32CubeMX project, the Tools tab allows the user to launch Tools directly or to access tools download pages on [www.st.com](http://www.st.com).

- **Video tutorials**

STM32CubeMX allows the user to browse and play video tutorials. The video tutorial browser is accessible from the Help menu.

## 2.3 Rules and limitations

- C code generation covers only peripheral and middleware initialization. It is based on STM32Cube HAL firmware libraries.
- STM32CubeMX C code generation covers only initialization code for peripherals and middleware components that use the drivers included in STM32Cube embedded software packages. The code generation of some peripherals and middleware components is not yet supported.
- Refer to [Appendix A](#) for a description of pin assignment rules.
- Refer to [Appendix B](#) for a description of STM32CubeMX C code generation design choices and limitations.

## 3 Installing and running STM32CubeMX

### 3.1 System requirements

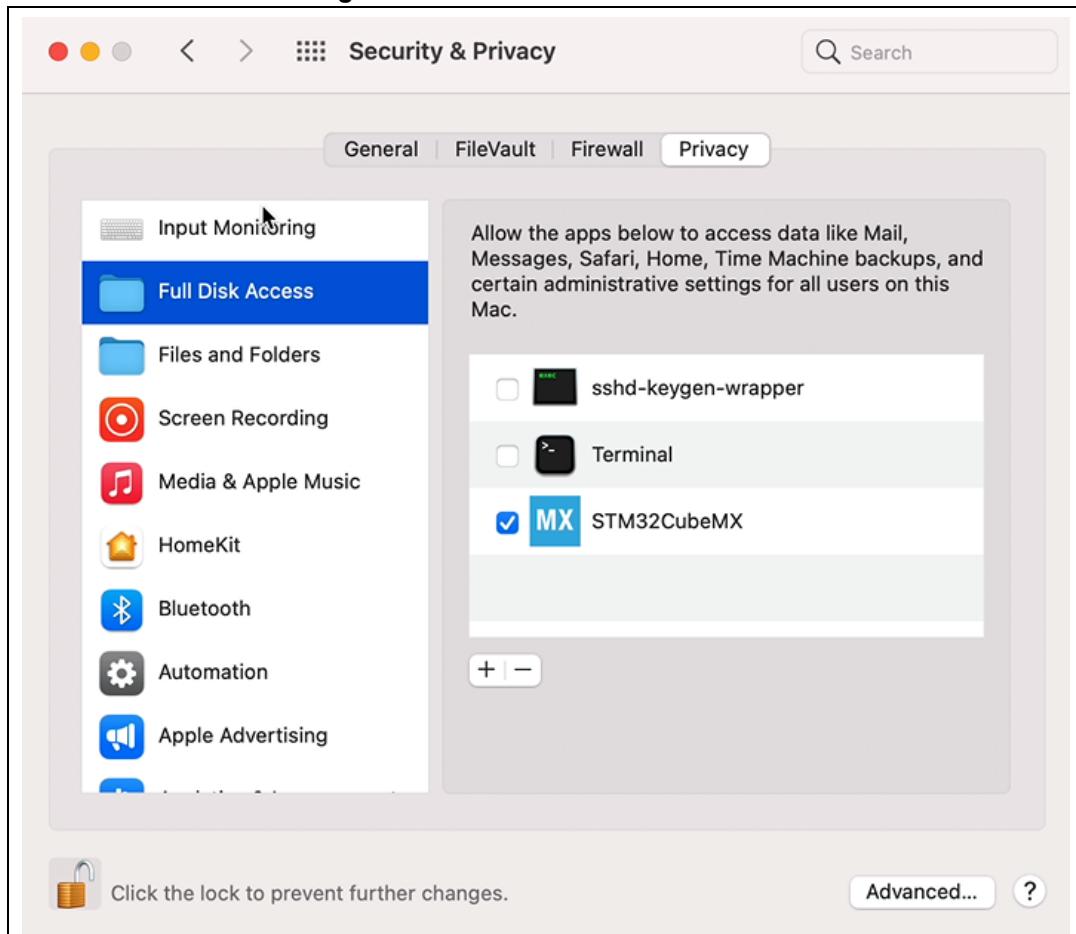
#### 3.1.1 Supported operating systems and architectures

- Windows® 8: 64-bit (x64)
- Windows® 10: 64-bit (x64)
- Linux®: 64-bit (x64) (tested on RedHat, Ubuntu and Fedora)
- macOS®: 64-bit (x64) (tested on OS X El Capitan and later)

For macOS the full disk access is required to load project files or install other packages from the file system. To enable full disk access for STM32CubeMX:

1. Go to "System preferences" and click to open "Security & Privacy" window ([Figure 2](#))
2. Select "Privacy" tab
3. Select "Full Disk Access" from the left panel
4. Click the checkbox to enable full disk access to STM32CubeMX

Figure 2. Full disk access for macOS



### 3.1.2 Memory prerequisites

- Recommended minimum RAM: 2 Gbytes.

### 3.1.3 Software requirements

Administrator rights are required to download STM32CubeMX self-update packages, and at next STM32CubeMX launch, to complete the update process.

#### Java™ Runtime Environment

Starting with the version 6.2.0, STM32CubeMX embeds the Java Runtime Environment (JRE™) required for its execution and no longer uses the one installed on the user machine.

*Note:* The bundled JRE is Liberica 1.8.0\_265 of BellSoft.

STM32CubeMX previous versions require a JRE to execute.

The JRE version constraints are:

- 64-bit version mandatory; 32-bit version not supported
- The STM32PackCreator companion tool requires JRE supporting JavaFX™
- Minimum JRE version is 1.8\_45 (known limitation with 1.8\_251)
- Version 11 is supported
- Versions 7, 9, 10, 12 and upper are not supported

STMicroelectronics promotes the use of the following JREs:

- Oracle® (a) JRE, subject to license fee
- Amazon Corretto™ (b) (c) JRE, no-cost solution based on OpenJDK; JDK installer recommended.

STM32CubeMX operation is not guaranteed with other JREs.

#### macOS software requirements

- Xcode must be installed on macOS computers
- Both Xcode and Rosetta must be installed on macOS computers embedding Apple® M1 processor.

## 3.2 Installing/uninstalling STM32CubeMX standalone version

### 3.2.1 Installing STM32CubeMX standalone version

To install STM32CubeMX, make sure you have administrator rights and then:

1. From an Internet browser, open the page [www.st.com/stm32cubemx](http://www.st.com/stm32cubemx)
2. Click “Get Software” to go to the software download section

#### On Windows

- a) On STM32CubeMX-Win line, click “Get software” to download the package
- b) Extract (unzip) the downloaded package
- c) Make sure you have administrator rights
- d) Double-click on SetupSTM32CubeMX-VERSION-Win.exe to launch the installation wizard

**Note:** Upon successful installation on Windows, STM32CubeMX icon is displayed on your desktop and STM32CubeMX application is available from the Program menu. STM32CubeMX .ioc files are displayed with a cube icon, double-clicking on it opens the project in STM32CubeMX. When working on Windows, only the latest installation of STM32CubeMX is enabled in the Program menu. Previous versions can be kept on your PC (not recommended) when different installation folders have been specified. Otherwise, the new installation overwrites the previous one(s).

**On Linux:**

- a) On **STM32CubeMX-Lin** line, Click “Get software” to download the package
- b) Extract (unzip) the downloaded package.
- c) Make sure you have administrator rights to access the target installation directory. You can run the installation as root (or sudo) to install STM32CubeMX in shared directories.
- d) Do **chmod 777 SetupSTM32CubeMX-VERSION** to change the properties, so that the file is executable.
- e) Double-click on the **SetupSTM32CubeMX-VERSION** file, or launch it from the console window.

**On macOS:**

- a) On **STM32CubeMX-Mac** line, Click “Get software” to download the package
- b) Extract (unzip) the downloaded package.
- c) Make sure you have administrator rights.
- d) Double-click **SetupSTM32CubeMX-VERSION.app** application file to launch the installation wizard.

In case of error, try to fix it: - \$sudo xattr -cr ~/SetupSTM32CubeMX-VERSION.app.

### 3.2.2 Installing STM32CubeMX from command line

There are two ways to launch an installation from a console window: either in console interactive mode or via a script.

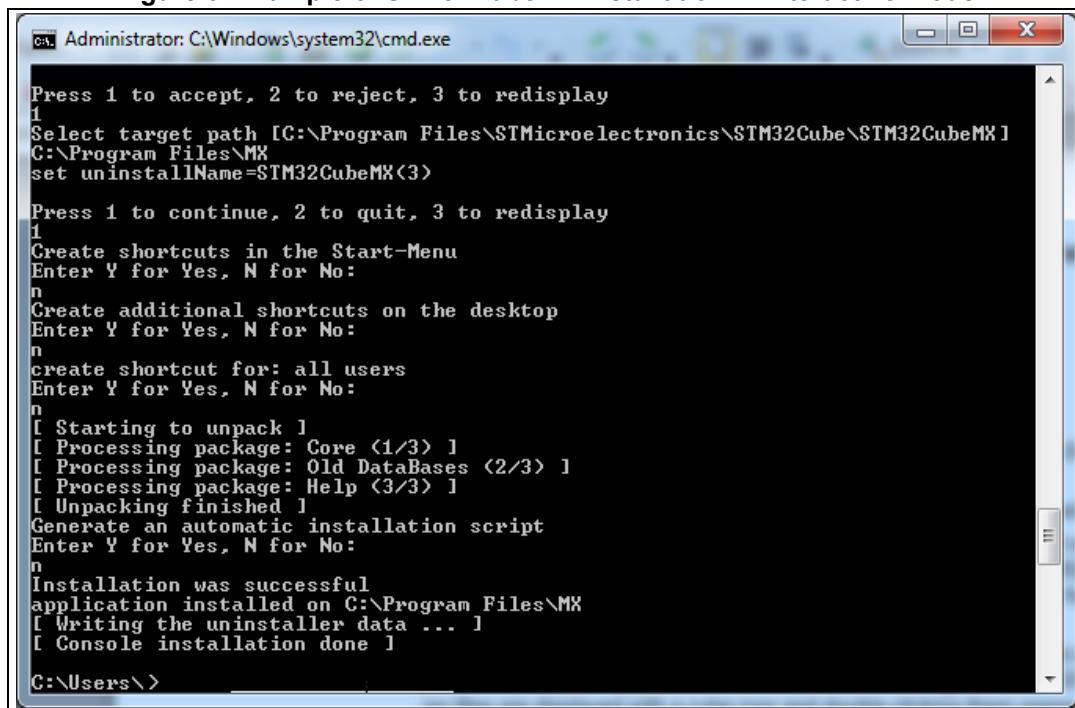
#### Interactive mode

To perform interactive installation, proceed as follows:

1. extract (unzip) to folder the auto-extract installation file (SetupSTM32CubeMX-VERSION-Win.exe)
2. open a console window with administrator rights
3. go to the extracted folder (cd <folder path>)
4. run the command `jre\bin\java -jar SetupSTM32CubeMX-<VERSION>.exe -console`

At each installation step, an answer is requested (see [Figure 3](#)).

**Figure 3. Example of STM32CubeMX installation in interactive mode**



The screenshot shows a Windows Command Prompt window titled "Administrator: C:\Windows\system32\cmd.exe". The window contains the following text output from the installation script:

```
Press 1 to accept, 2 to reject, 3 to redisplay
1
Select target path [C:\Program Files\STMicroelectronics\STM32Cube\STM32CubeMX]
C:\Program Files\MX
set uninstallName=STM32CubeMX<3>

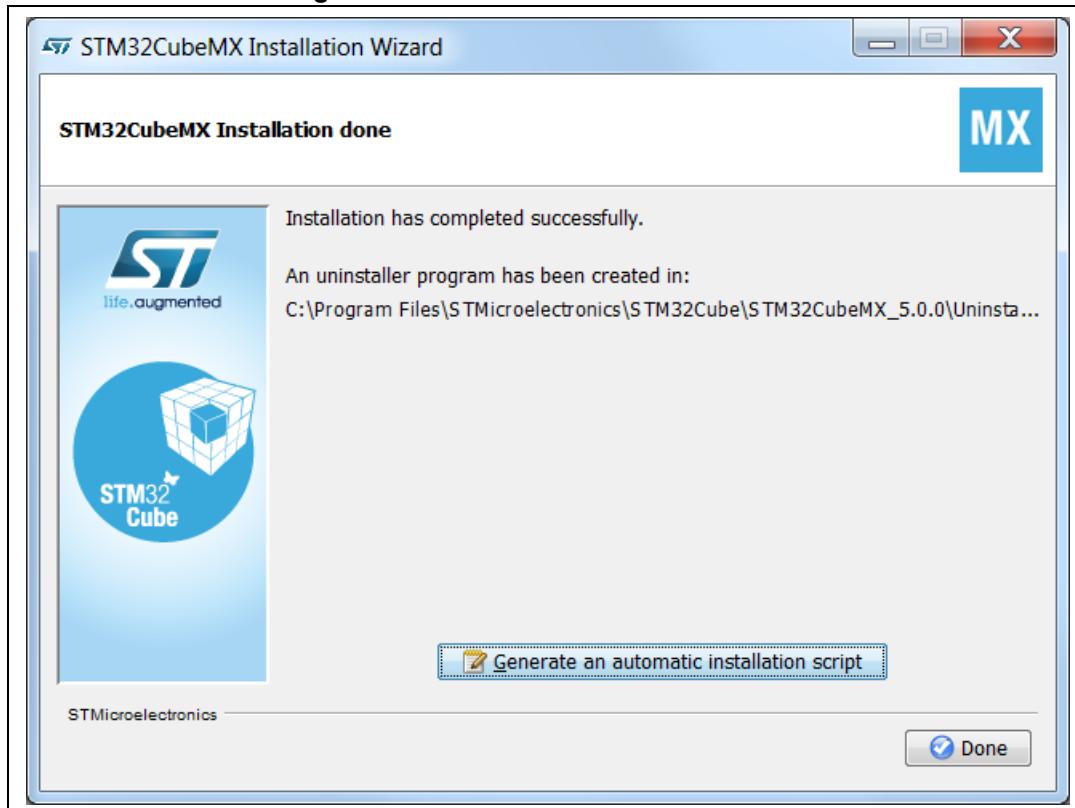
Press 1 to continue, 2 to quit, 3 to redisplay
1
Create shortcuts in the Start-Menu
Enter Y for Yes, N for No:
n
Create additional shortcuts on the desktop
Enter Y for Yes, N for No:
n
create shortcut for: all users
Enter Y for Yes, N for No:
n
[ Starting to unpack ]
[ Processing package: Core <1/3> ]
[ Processing package: Old DataBases <2/3> ]
[ Processing package: Help <3/3> ]
[ Unpacking finished ]
Generate an automatic installation script
Enter Y for Yes, N for No:
n
Installation was successful
application installed on C:\Program Files\MX
[ Writing the uninstaller data ... ]
[ Console installation done ]

C:\Users\>
```

### Auto-install mode

At end of an installation, performed either using STM32CubeMX graphical wizard or console mode, it is possible to generate an auto-installation script containing user preferences (see [Figure 4](#)).

**Figure 4. STM32Cube Installation Wizard**



You can then launch the installation by typing, from a console window with administrator rights, the following command:

```
SetupSTM32CubeMX-VERSION-Win.exe ABSOLUTE_PATH_TO_AUTO_INSTALL.xml
```

### 3.2.3 Uninstalling STM32CubeMX standalone version

#### Uninstalling STM32CubeMX on macOS®

There are two different ways to uninstall STM32CubeMX on Mac:

1. Move STM32CubeMX.VERSION.app to the trash
2. Use the following command line:
  - a) For STM32CubeMX 6.2.x and later versions only:

```
cd SetupSTM32CubeMX-VERSION.app/Contents/Resources/Uninstaller  
.uninstall.sh
```
  - b) For STM32CubeMX 6.1.x and older versions only:

```
java -jar SetupSTM32CubeMX-  
VERSION.app/Contents/Resources/Uninstaller/uninstaller.jar.
```

## Uninstalling STM32CubeMX on Linux®

There are two different ways to uninstall STM32CubeMX on Linux:

1. From a shell prompt by launching the uninstall script
  - a) For STM32CubeMX 6.2.x and later versions:  
cd <STM32CubeMX installation path>/Uninstaller  
uninstall.sh
  - b) For STM32CubeMX 6.1.x and older versions:  
java -jar <STM32CubeMX installation path>/Uninstaller/uninstaller.jar.
2. From a file explorer
  - a) Go to <STM32CubeMX installation path>/Uninstaller
  - b) For STM32CubeMX 6.2.x and later versions:  
Double-click the uninstall.sh script
  - c) For STM32CubeMX 6.1.x and older versions:  
Double-click the start uninstall desktop shortcut.

## Uninstalling STM32CubeMX on Windows®

There are three different ways to uninstall STM32CubeMX on Windows:

1. Through the Windows Control Panel:
  - a) Select **Programs and Features** from the **Windows Control** Panel to display the list of programs installed on your computer.
  - b) Right-click **STM32CubeMX** and select **uninstall**.
2. From a shell prompt with administrator rights, by using the following commands
  - a) For STM32CubeMX 6.2.x and later versions:  
cd <STM32CubeMX installation path>/Uninstaller  
uninstall.bat
  - b) For STM32CubeMX 6.1.x and older versions:  
java -jar <STM32CubeMX installation path>/Uninstaller/uninstaller.jar
3. Through a Windows File Explorer window:
  - a) For STM32CubeMX 6.2.x and later versions:  
Go to the Uninstaller folder in STM32CubeMX installation directory.  
Right-click the uninstall.bat and “run as administrator”
  - b) For STM32CubeMX 6.1.x and older versions only:  
Go to the Uninstaller folder in STM32CubeMX installation directory.  
Double-click startuninstall.exe, or double-click the uninstall shortcut on the desktop.

### 3.3 Launching STM32CubeMX

#### 3.3.1 Running STM32CubeMX as standalone application

To run STM32CubeMX as a standalone application on Windows:

- select STM32CubeMX from Program Files > ST Microelectronics > STM32CubeMX.
- or double-click STM32CubeMX icon on your desktop.

To run STM32CubeMX as a standalone application on Linux, launch the STM32CubeMX executable from STM32CubeMX installation directory.

To run STM32CubeMX as a standalone application on macOS, launch the STM32CubeMX application from the launchpad.

*Note:* There is no STM32CubeMX desktop icon on macOS.

#### 3.3.2 Running STM32CubeMX in command-line mode

To facilitate its integration with other tools, STM32CubeMX provides a command-line mode.

Using a set of commands, you can:

- load an MCU
- load an existing configuration
- save a current configuration
- set project parameters and generate corresponding code
- generate user code from templates
- load a board identified through its part number
- refresh the list of embedded software packages (packs and STM32Cube MCU packages) and install/remove a package
- select additional software (packs) components to add to the project.

Three command-line modes are available:

- To run STM32CubeMX in interactive command-line mode, use the following command lines:

– On Windows:

```
cd <STM32CubeMX installation path>
jre\bin\java -jar STM32CubeMX.exe -i
```

– On Linux and macOS:

```
STM32CubeMX -i
```

The “MX>” prompt is then displayed to indicate that the application is ready to accept commands.

- To run STM32CubeMX in command-line mode getting commands from a script, use the following command lines:

– On Windows:

```
cd <STM32CubeMX installation path>
jre\bin\java -jar STM32CubeMX.exe -s <script filename>
```

- On Linux and macOS:

```
STM32CubeMX -s <script filename>
```

All the commands to be executed must be listed in the script file. An example of script file content is shown below:

```
load STM32F417VETx
project name MyFirstMXGeneratedProject
project toolchain "MDK-ARM v4"
project path C:\STM32CubeProjects\STM32F417VETx
project generate
exit
```

- To run STM32CubeMX in command-line mode getting commands from a scripts and without UI, use the following command lines:

- On Windows:

```
cd <STM32CubeMX installation path>
jre\bin\java -jar STM32CubeMX.exe -q <script filename>
```

- On Linux and macOS:

```
STM32CubeMX -q <script filename>
```

Here again, the user can enter commands when the MX prompt is displayed.

See [Table 1](#) for the list of available commands.

**Table 1. Command line summary**

Command line	Purpose	Example
help	Displays the list of available commands.	help
swmgr refresh	Refreshes the list of embedded software package versions available for download.	swmgr refresh
swmgr install stm32cube_<series> -<version> <license-mode (accept ask)>	Installs the specified STM32Cube MCU package version.  The second parameter license-mode is mandatory but really matters for packages coming with a license: – <b>accept</b> : the license is automatically accepted. – <b>ask</b> : the license is presented in a popup window for the user to accept.	swmgr install stm32cube_f1_1.8.0 accept
swmgr remove stm32cube_<series> -<version>	Removes the specified STM32Cube MCU package version.	swmgr remove stm32cube_f1_1.8.0
swmgr install <packVendor>.<packName>. <packVersion> <license-mode (accept ask)>	Installs the specified pack version.  The second parameter license-mode is mandatory but really matters for packages coming with a license: – <b>accept</b> : the license is automatically accepted. – <b>ask</b> : the license is presented in a popup window for the user to accept.	swmgr install STMicroelectronics. X-CUBE-NFC4.1.4.1 ask

**Table 1. Command line summary (continued)**

<b>Command line</b>	<b>Purpose</b>	<b>Example</b>
<code>swmgr remove &lt;packVendor&gt;.&lt;packName&gt;. &lt;packVersion&gt;</code>	Removes the specified pack version.	<code>swmgr remove STMicroelectronics. X-CUBE-BLE1.4.2.0</code>
<code>swmgr install &lt;filename path&gt; &lt;license-mode (accept ask)&gt;</code>	Installs an embedded software package.	<code>swmgr install "C:\repo\packs\STMicroelectronics. X-CUBE-BLE1.4.2.0.pack" accept</code>
<code>pack enable &lt;vendor&gt; &lt;pack&gt;[/bundle] &lt;version&gt; &lt;class&gt; &lt;group&gt;[/subgroup] [variant]</code>	Selects a software pack component to add in the project. The presence of the "/" in the second and/or the fifth parameter(s) indicates respectively the explicit mention of a bundle and/or a subgroup (reference: ARM CMSIS pack pdsc format). To find out the pack/bundle/class/group/subgroup names of the component to enable, select the component and click "Hide/Show details" from the Additional Software window.	<code>pack enable STMicroelectronics "X-CUBE-BLE1/BlueNRG-MS" 1.0.0 "Wireless" "Controller"</code>
<code>pack validate</code>	Applies in the project all pack components enabled since the "pack validate" command was last called.	<code>pack validate</code>
<code>load &lt;mcu&gt;</code>	Loads the selected MCU.	<code>load STM32F101RCTx load STM32F101Z(F-G)Tx</code>
<code>load &lt;board part number&gt; &lt;allmodes nomode&gt;</code>	Loads the selected board with all peripherals configured in their default mode (allmodes) or without any peripheral configuration (nomode).	<code>loadboard NUCLEO-F030R8 allmodes loadboard NUCLEO-F030R8 nomode</code>
<code>config load &lt;filename&gt;</code>	Loads a previously saved configuration.	<code>config load C:\Cube\ccmram\ccmram.ioc</code>
<code>config save &lt;filename&gt;</code>	Saves the current configuration.	<code>config save C:\Cube\ccmram\ccmram.ioc</code>
<code>config saveext &lt;filename&gt;</code>	Saves the current configuration with all parameters, including those for which values have been kept to default (unchanged by the user).	<code>config saveext C:\Cube\ccmram\ccmram.ioc</code>
<code>config saveas &lt;filename&gt;</code>	Saves the current project under a new name.	<code>config saveas C:\Cube\ccmram2\ccmram2.ioc</code>
<code>csv pinout &lt;filename&gt;</code>	Exports the current pin configuration as a csv file. This file can be (later) imported into a board layout tool.	<code>Csv pinout mypinout.csv</code>
<code>script &lt;filename&gt;</code>	Runs all commands in the script file. There must be one command per line.	<code>script myscript.txt</code>

**Table 1. Command line summary (continued)**

<b>Command line</b>	<b>Purpose</b>	<b>Example</b>
project couplefilesbyip <0 1>	This code generation option allows the user to choose between 0 (to generating the peripheral initializations in the main) or 1 (to generate each peripheral initialization in dedicated .c/.h files).	project couplefilesbyip 1
setDriver <Peripheral Name> <HAL   LL>	For supported Series, STM32CubeMX can generate peripheral initialization code based on LL drivers or on HAL drivers.  This command line allows the user to choose, for each peripheral, between HAL-based and LL-based code generation.  By default code generation is based on HAL drivers.	setDriver ADC LL setDriver I2C HAL
generate code <path>	Generates only "STM32CubeMX generated" code and not a complete project that would include STM32Cube firmware libraries and Toolchains project files.  To generate a project, use "project generate".	generate code C:\mypath
set tpl_path <path>	Sets the path to the source folder containing the .ftl user template files. All the template files stored in this folder are used for code generation.	set tpl_path C:\myTemplates\
set dest_path <path>	Sets the path to the destination folder that will hold the code generated according to user templates.	set dest_path C:\myMXProject\inc\
get tpl_path	Retrieves the path name of the user template source folder	get tpl_path
get dest_path	Retrieves the path name of the user template destination folder.	get dest_path
SetStructure <Advanced/Basic>	Selects the project structure to generate.	SetStructure Basic
SetCopyLibrary <copy all/ copy only / copy as reference>	Selects how the reference libraries are copied to the projects.	SetCopyLibrary "copy all"
project setCustomFwPath <CustomFwLocation>	Specifies a path to STM32Cube MCU software libraries different from STM32Cube repository path (specified under Help > Updater settings).	project SetCustomFwPath "F:/SharedRepository/STM32Cube_FW_F0_V1.11.0"

**Table 1. Command line summary (continued)**

Command line	Purpose	Example
project toolchain <toolchain>	Specifies the toolchain to be used for the project. Use the “project generate” command to generate the project for that toolchain.	project toolchain EWARM project toolchain “MDK-ARM V4” project toolchain “MDK-ARM V5” project toolchain TrueSTUDIO project toolchain SW4STM32
project name <name>	Specifies the project name.	project name ccmram
project path <path>	Specifies the path where to generate the project.	project path C:\Cube\ccmram
project generate	Generates the full project.	project generate
exit	Ends STM32CubeMX process.	exit

## 3.4 Getting updates using STM32CubeMX

STM32CubeMX implements a mechanism to access the Internet and to:

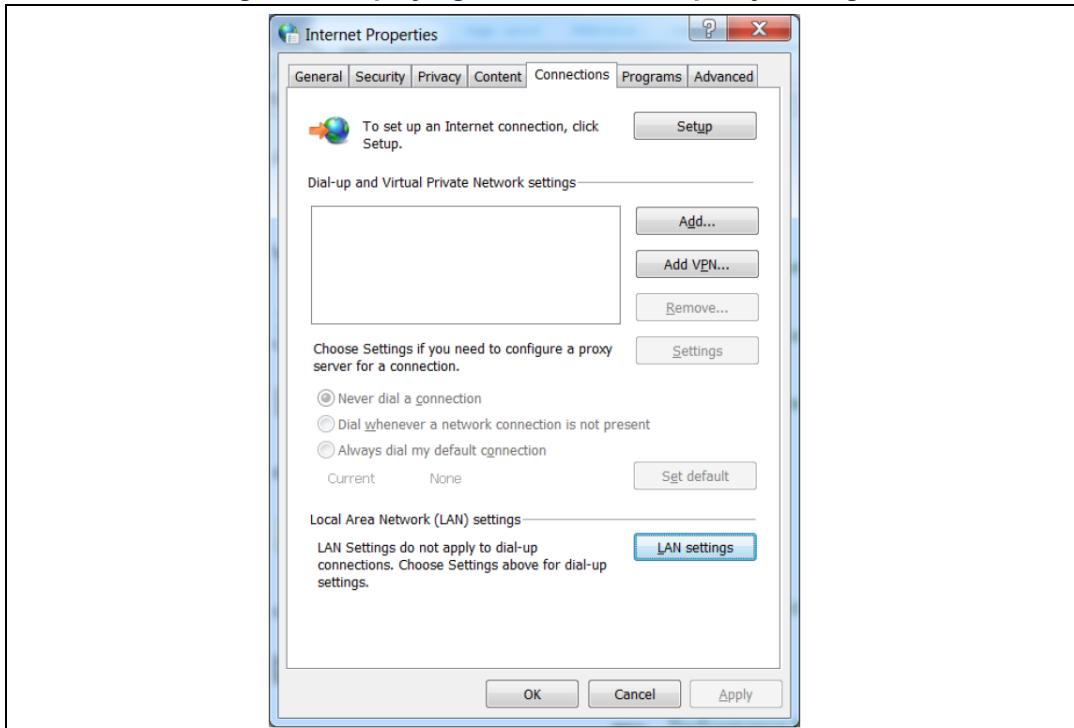
- download embedded software packages: STM32Cube MCU packages (full releases and patches) and third-party packages (.pack) based on the Arm® CMIS pack format
- manage a user-defined list of third-party packs
- check for STM32CubeMX and embedded software packages updates
- perform self-updates of STM32CubeMX
- refresh STM32 MCUs descriptions and documentation offer.

Installation and update related submenus are available under the **Help** menu and from the home page as well.

Off-line updates can also be performed on computers without Internet access (see [Section 3.4.2](#)). This is done by browsing the filesystem and selecting available STM32Cube MCU packages.

If the PC on which STM32CubeMX runs is connected to a computer network using a proxy server, STM32CubeMX needs to connect to that server to access the Internet, get self-updates and download firmware packages. Refer to [Section 3.4.1](#) for a description of this connection configuration.

To view Windows default proxy settings, select Internet options from the Control panel and select LAN settings from the **Connections** tab (see [Figure 5](#)).

**Figure 5. Displaying Windows default proxy settings**

Several proxy types exist and different computer network configurations are possible:

- Without proxy: the application directly accesses the web (Windows default configuration).
- Proxy without login/password
- Proxy with login/password: when using an Internet browser, a dialog box opens and prompts the user to enter its login/password.
- Web proxies with login/password: when using an Internet browser, a web page opens and prompts the user to enter its login/password.

If needed, contact your IT administrator for proxy information (proxy type, http address, port).

STM32CubeMX does not support web proxies. In this case, the user cannot benefit from the update mechanism and has to manually copy the STM32Cube MCU packages from <http://www.st.com/stm32cube> to the repository. To do it, follow the sequence below:

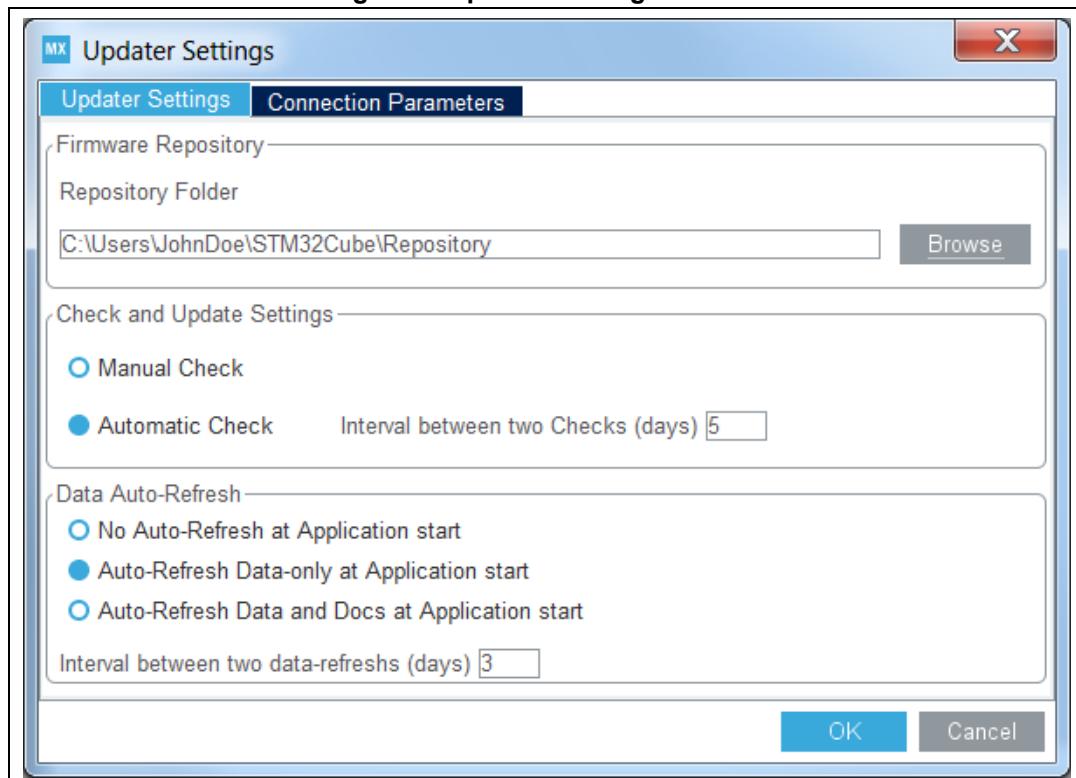
1. Go to <http://www.st.com/stm32cube> and download the relevant STM32Cube MCU package from the **Associated Software** section.
2. Unzip the zip package to your STM32Cube repository. Find out the default repository folder location in the **Updater settings** tab as shown in [Figure 6](#) (you might need to update it to use a different location or name).

### 3.4.1 Updater configuration

To perform STM32Cube new library package installation or updates, the tool must be configured as follows:

1. Select **Help > Updater Settings** to open the **Updater Settings** window.
2. From the **Updater Settings** tab (see *Figure 6*)
  - a) Specify the repository destination folder where the downloaded packages will be stored.
  - b) Enable/Disable the automatic check for updates.

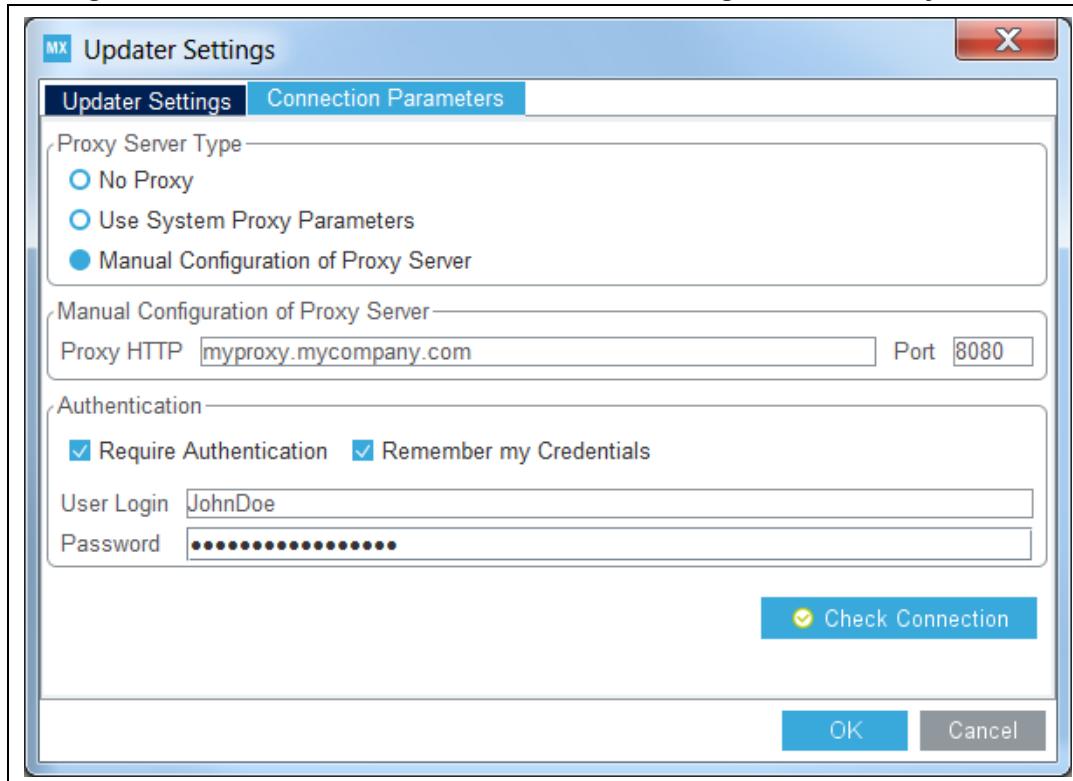
**Figure 6. Updater Settings window**



3. In the **Connection Parameters** tab, specify the proxy server settings appropriate for your network configuration by selecting a proxy type among the following possibilities (see *Figure 7*):
  - No Proxy
  - Use System Proxy ParametersOn Windows, proxy parameters are retrieved from the PC system settings.  
Uncheck “Require Authentication” if a proxy server without login/password configuration is used.

- Manual Configuration of Proxy Server  
Enter the Proxy server http address and port number. Enter login/password information or uncheck “Require Authentication” if a proxy server without login/password configuration is used.
4. Optionally uncheck **Remember my credentials** to prevent STM32CubeMX to save encrypted login/password information in a file. This implies reentering login/password information each time STM32CubeMX is launched.
  5. Click the **Check Connection** button to verify if the connection works. A green check mark appears to confirm that the connection operates correctly  Check Connection

Figure 7. Connection Parameters tab - Manual Configuration of Proxy Server



6. Select **Help > Install New Libraries** submenu to select among a list of possible packages to install.
7. If the tool is configured for manual checks, select **Help > Check for Updates** to find out about new tool versions or firmware library patches available to install.

### 3.4.2 Installing STM32 MCU packages

To download new STM32 MCU packages, follow the steps below:

1. Select **Help > Manage embedded software packages** to open the **Embedded Software Packages Manager** (see [Figure 8](#)), or use Install/Remove button from the Home page.

Expand/collapse buttons expands/collapses the list of packages, respectively.

If the installation was performed using STM32CubeMX, all the packages available for download are displayed along with their version including the version currently installed on the user PC (if any), and the latest version available from [www.st.com](http://www.st.com).

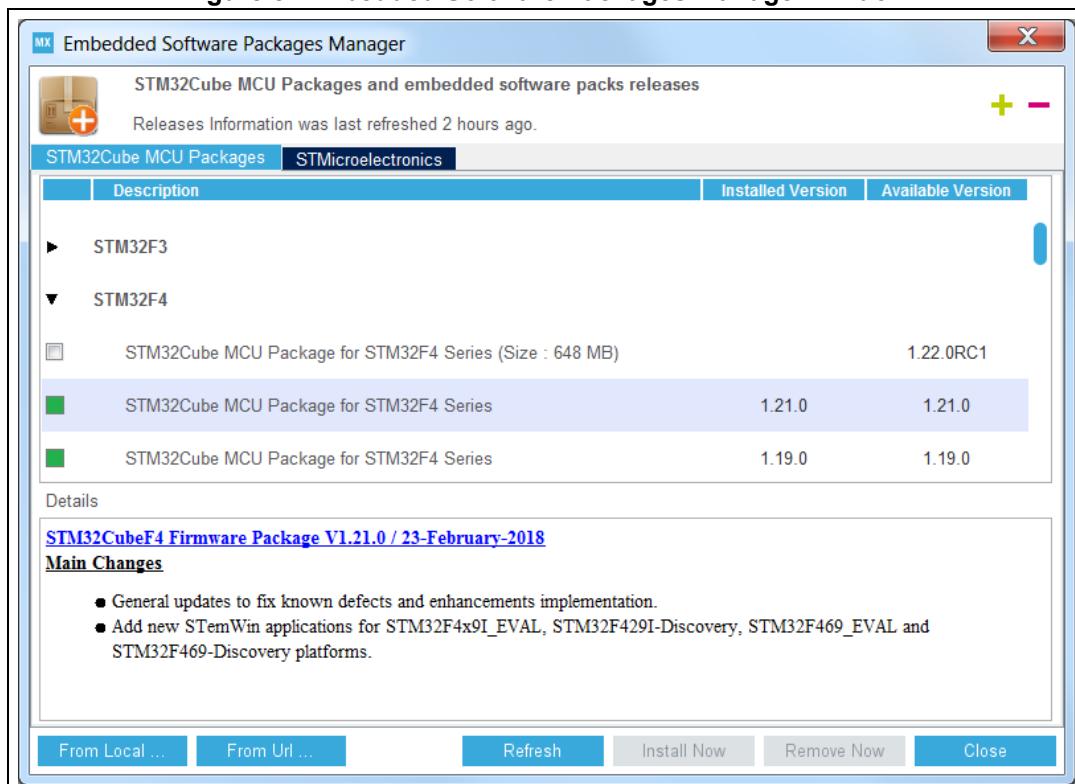
If no Internet access is available at that time, choose “From Local ...”, then browse to select the zip file of the desired STM32Cube MCU package that has been previously downloaded. An integrity check is performed on the file to ensure that it is fully supported by STM32CubeMX.

The package is marked in green when the version installed matches the latest version available from [www.st.com](http://www.st.com).

2. Click the checkbox to select a package then “Install Now” to start the download.

See [Figure 8](#) for an example.

**Figure 8. Embedded Software Packages Manager window**



### 3.4.3 Installing STM32 MCU package patches

Use the procedure described in [Section 3.4.2](#) to download STM32 MCU package patches.

A library patch, such as STM32Cube\_FW\_F7\_1.4.1, can be easily identified by its version number which third digit is non-null (e.g. '1' for the 1.4.1 version).

The patch is not a complete library package but only the set of library files that need to be updated. The patched files go on top of the original package (e.g. STM32Cube\_FW\_F7\_1.4.1 complements STM32Cube\_FW\_F7\_1.4.0 package).

Prior to 4.17 version, STM32CubeMX copies the patches within the original baseline directory (e.g. STM32Cube\_FW\_F7\_V1.4.1 patched files are copied within the directory called STM32Cube\_FW\_F7\_V1.4.0).

Starting with STM32CubeMX 4.17, downloading a patch leads to the creation of a dedicated directory. As an example, downloading STM32Cube\_FW\_F7\_V1.4.1 patch creates the STM32Cube\_FW\_F7\_V1.4.1 directory that contains the original STM32Cube\_FW\_F7\_V1.4.0 baseline plus the patched files contained in STM32Cube\_FW\_F7\_V1.4.1 package.

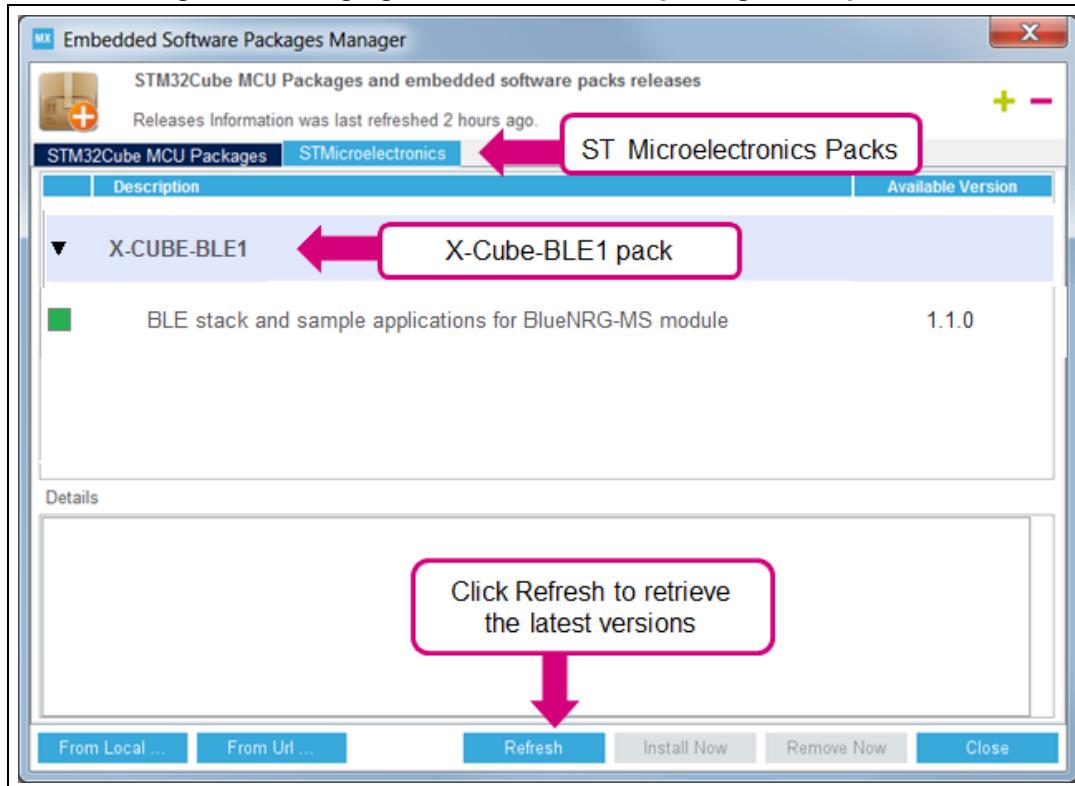
Users can then choose to go on using the original package (without patches) for some projects and upgrade to a patched version for others projects.

### 3.4.4 Installing embedded software packs

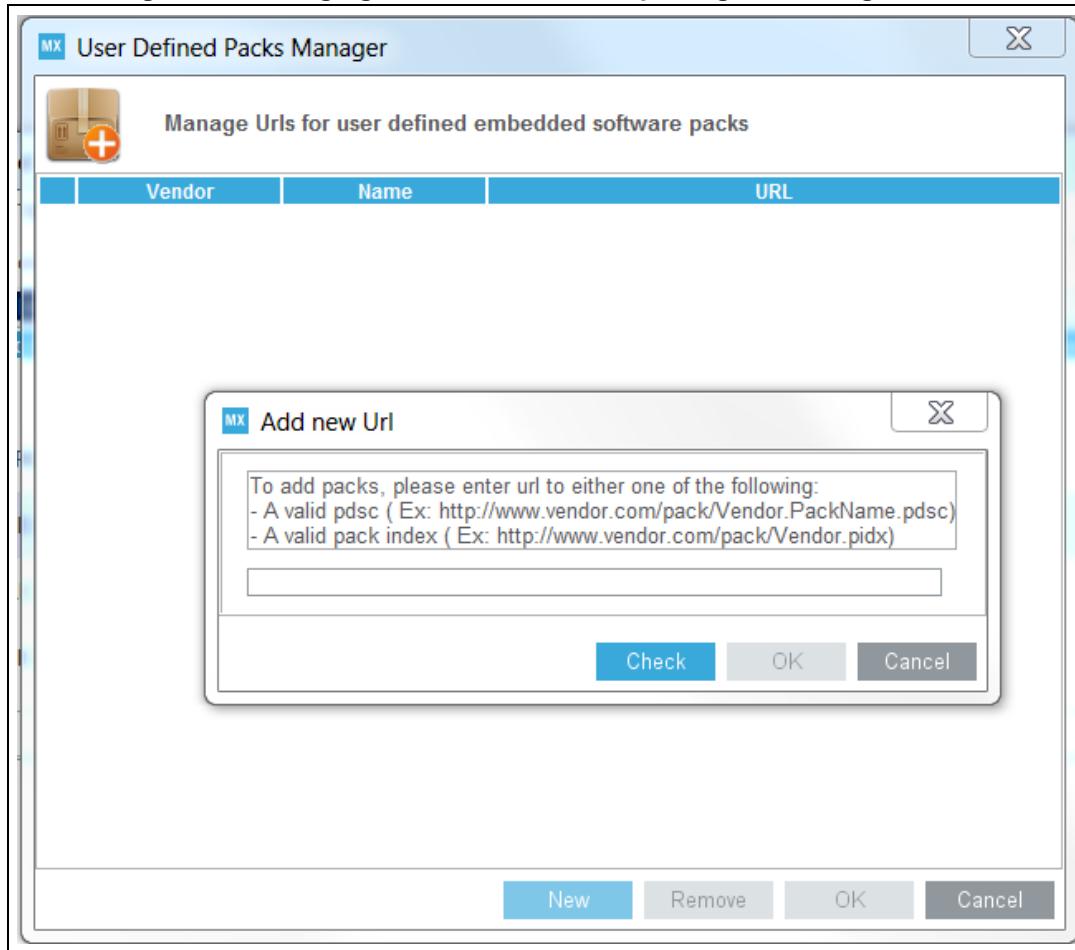
Starting from the release 4.24, STM32CubeMX offers the possibility to select third-party embedded software packages coming in the Arm® Keil™ CMSIS-Pack format (.pack), whose contents are described thanks to the pack description (.pdsc) file. Reference documentation is available from <http://www.keil.com>.

1. Select **Help > Manage embedded software packages** to open the **New Libraries Manager window** (see [Figure 9](#)), or use Install/Remove button from the Home page, or from the project Pinout & Configuration view (select **Software Packs > Manage Software Packs**).

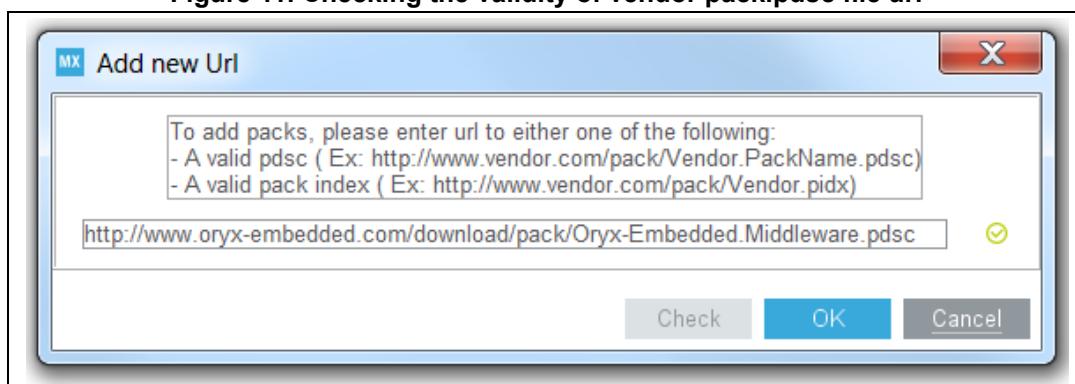
Use Expand/collapse buttons   to expand/collapse the list of packages, respectively.

**Figure 9. Managing embedded software packages - Help menu**

2. Click **From Local ...** button to browse the computer filesystem and select an embedded software package. STM32Cube MCU packages come as zip archives and embedded software packs come as .pack archives.  
This action is required in the following cases:
  - No Internet access is possible but the embedded software package is available locally on the computer.
  - The embedded software package is not public and hence not available on Internet. For such packages, STM32CubeMX cannot detect and propose updates.
3. Click **From URL...** button to specify the download location from Internet for either one of the pack .pdsc file or the vendor pack index (.pidx).  
Proceed as follow:
  - a) Choose **From URL ...** and click **New** (see [Figure 10](#)).
  - b) Specify the .pdsc file url. As an example, the url of Oryx-Embedded middleware pack is <https://www.oryx-embedded.com/download/pack/Oryx-Embedded.Middleware.pdsc> (see [Figure 11](#)).

**Figure 10. Managing embedded software packages - Adding new url**

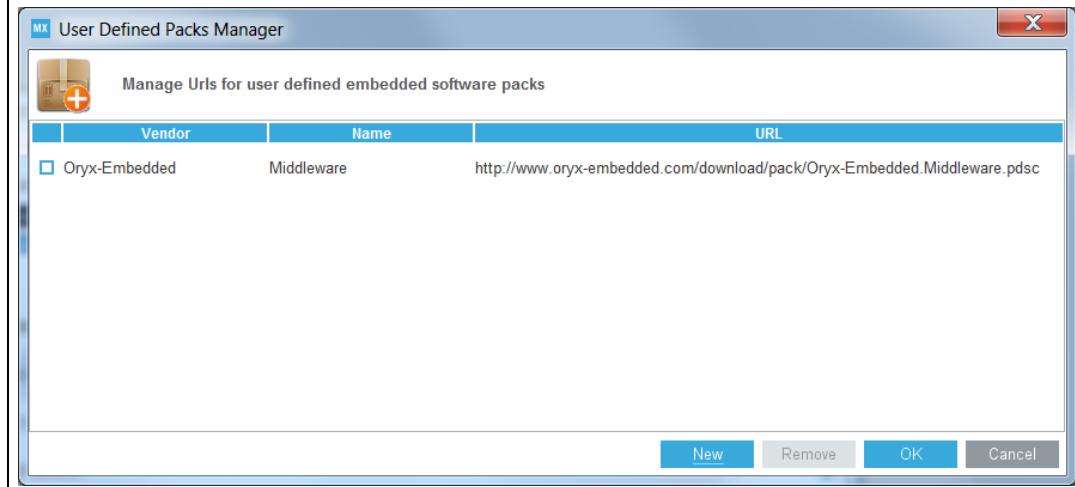
- c) Click the **Check** button to verify that the provided url is valid (see [Figure 11](#)).

**Figure 11. Checking the validity of vendor pack.pdsc file url**

- d) Click **OK**. The pack pdsc information is now available in the user defined pack list (see [Figure 12](#)).

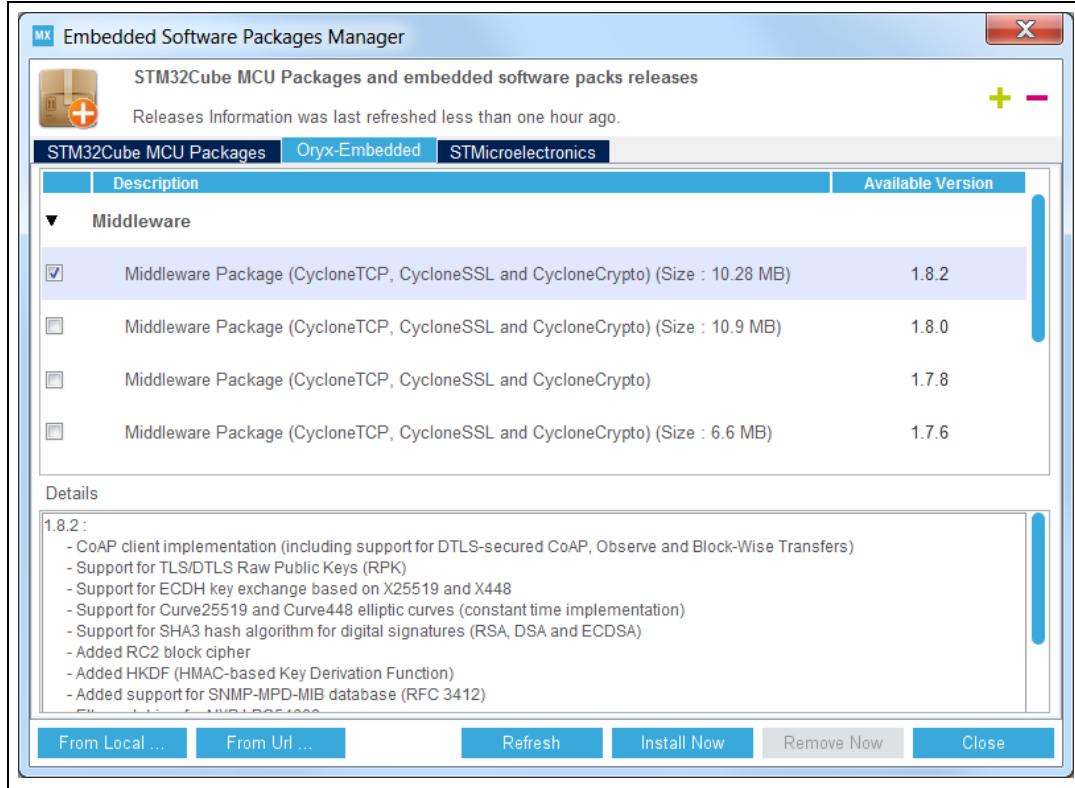
To delete a url from the list, select the url checkbox and click **Remove**.

**Figure 12. User-defined list of software packs**



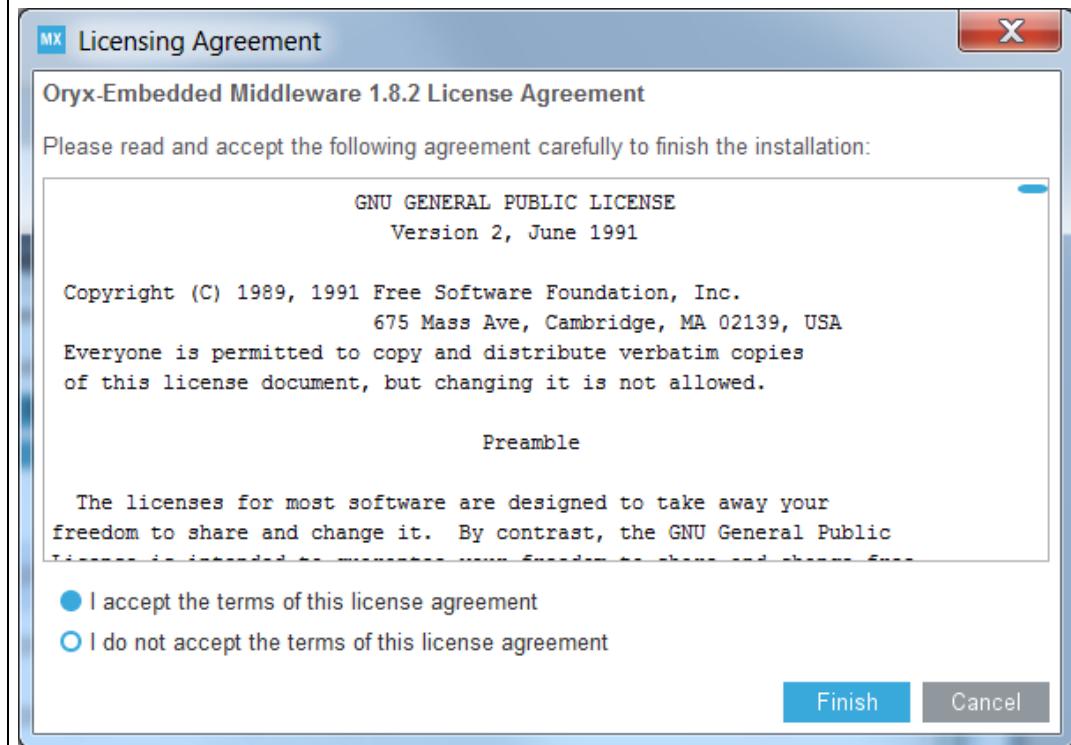
- e) Click **OK** to close the window and start retrieving psdc information. Upon successful completion, the available pack versions are shown in the list of libraries that can be installed. Use the corresponding checkbox to select a given release.

**Figure 13. Selecting an embedded software pack release**

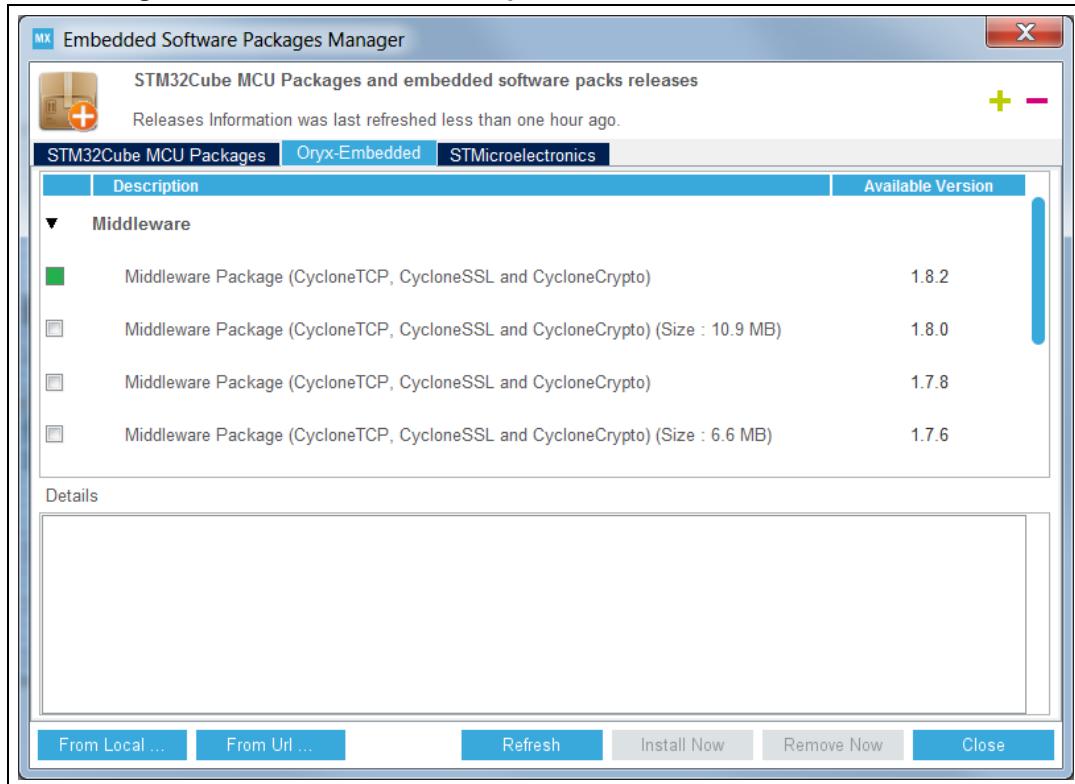


- f) Click **Install Now** to start downloading the software pack. A progress bar opens to indicate the installation progress. If the pack comes with a license agreement, a window pops up to ask for user's acceptance (see *Figure 14*). When the installation is successful, the check box turns green (see *Figure 15*).  
The user can then add software components from this pack to its projects.

**Figure 14. License agreement acceptance**



**Figure 15. Embedded software pack release - Successful installation**



### 3.4.5

#### Removing already installed embedded software packages

Proceed as follows (see figures 16 to 18) to clean up the repository from old library versions, thus saving disk space:

1. Select **Help > Manage embedded software packages** to open the **Embedded Software Packages Manager**, or use Install/Remove button from the Home page.
2. Click a green checkbox to select a package available in stm32cube repository.
3. Click the **Remove Now** button and confirm. A progress window then opens to show the deletion status.

Figure 16. Removing libraries

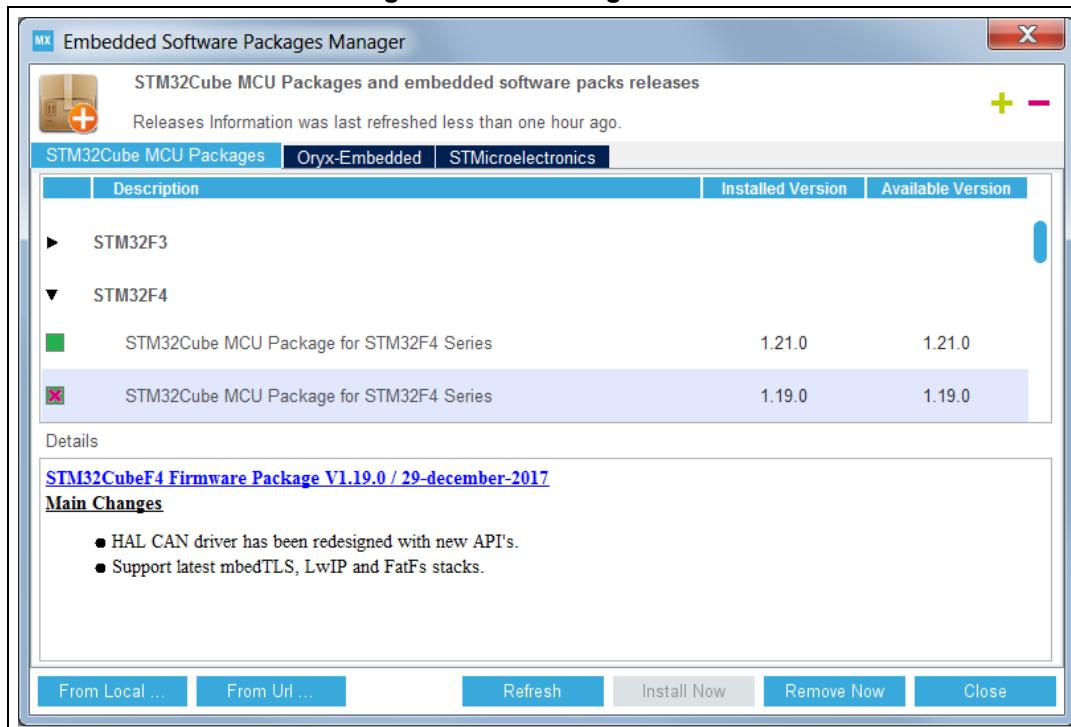


Figure 17. Removing library confirmation message

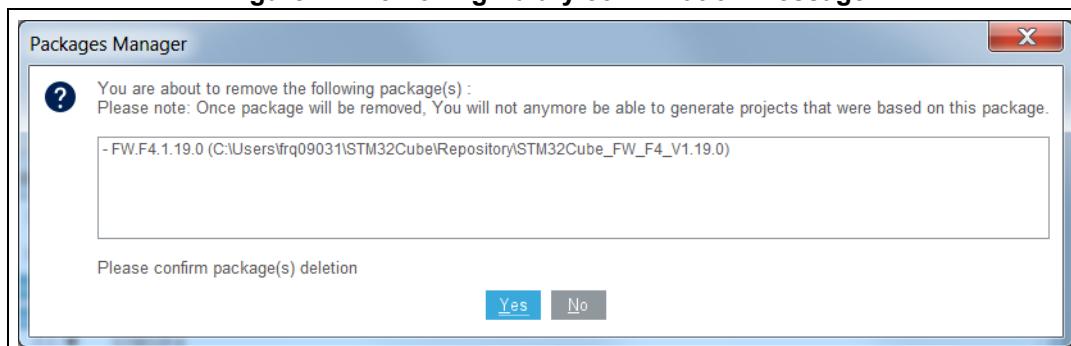
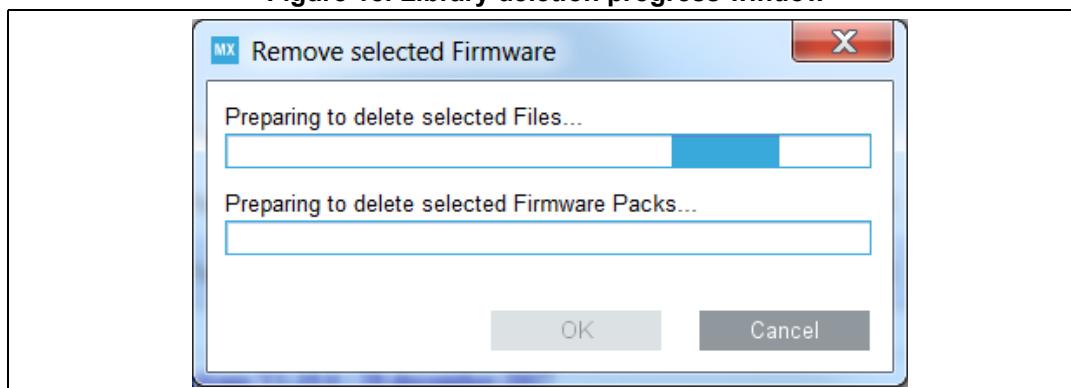


Figure 18. Library deletion progress window



### 3.4.6 Checking for updates

STM32CubeMX can check if updates are available for STM32CubeMX currently installed version or for the embedded software packages installed in the repository folder ([Figure 19](#)).

When the updater is configured for automatic checks, it regularly verifies if updates are available.

When automatic checks have been disabled in the updater settings window, the user can manually check if updates are available:

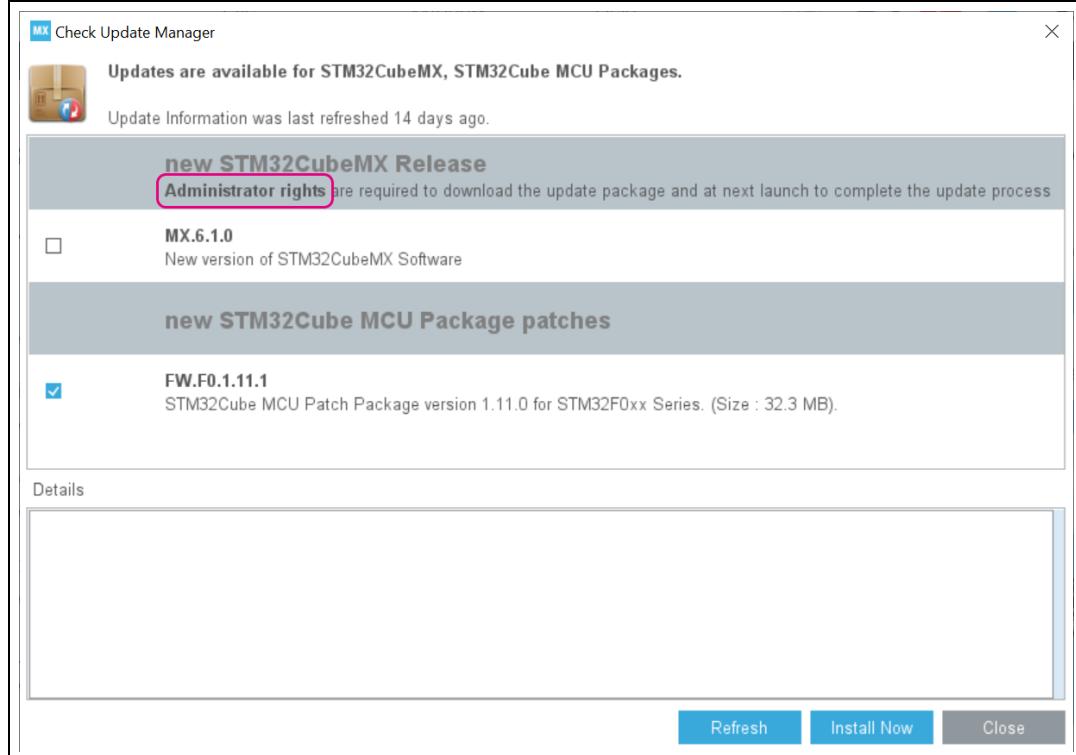
1. Click the icon to open the **Update Manager** window or Select **Help > Check for Updates**. All the updates available for the user current installation are listed.
2. Click the check box to select a package, and then **Install Now** to download the update.

---

**Warning:** When performing STM32CubeMX self-updates, administrator rights are required when downloading the self-update package and during the STM32CubeMX launch that completes the update process:

1. Launch STM32CubeMX with administrator account
  2. Go to Help > Check for updates menu, select MX update package and click "Install now" to start the download.
  3. Re-launch STM32CubeMX with the administrator account to finish the update process
- 

**Figure 19. Help menu: checking for updates**



## 4 STM32CubeMX user interface

STM32CubeMX user interface comes with three main views the user can navigate through using convenient breadcrumbs:

1. the **Home** page
2. the **New project** window
3. the project page

They come with panels, buttons and menus allowing users to take actions and make configuration choices with a single click.

The user interface is detailed in the following sections.

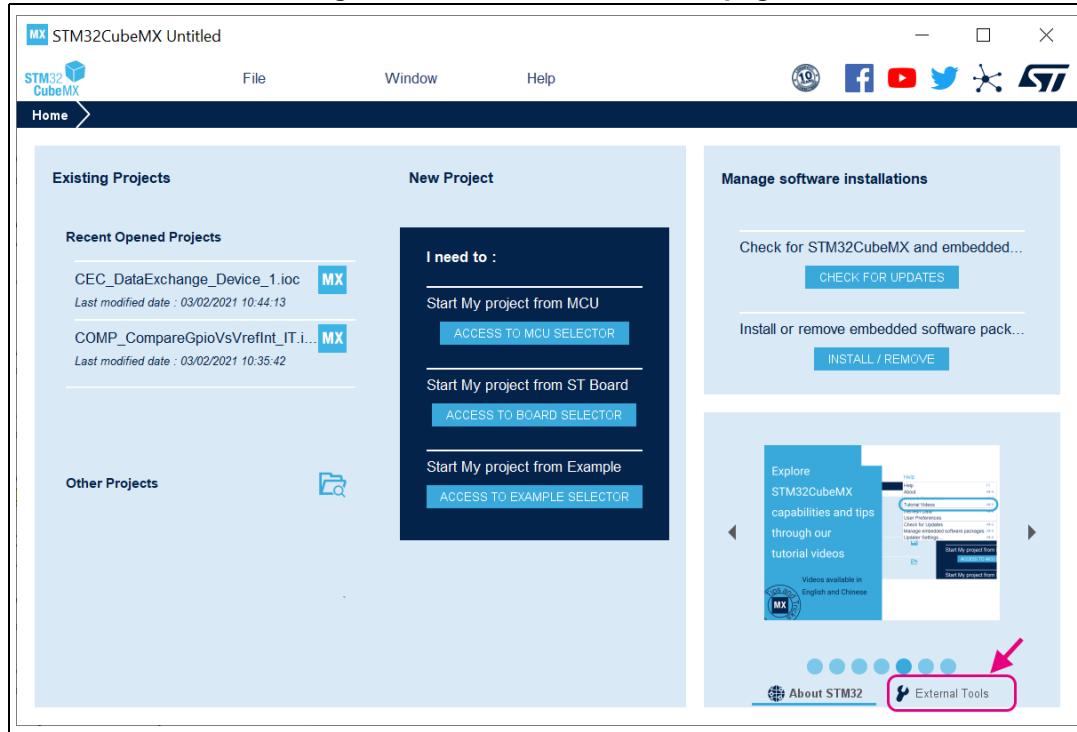
For C code generation, although the user can switch back and forth between the different configuration views, it is recommended to follow the sequence below:

1. From the **Project Manager** view, configure the project settings.
2. From the **Mode** panel in the **Pinout & Configuration** view, configure the RCC peripheral by enabling the external clocks, master output clocks, audio input clocks (when relevant for your application). This automatically displays more options on the **Clock configuration** view (see [Figure 96](#)). Then, select the features (peripherals, middlewares) and their operating modes relevant to the application.
3. If necessary, adjust the clock tree configuration from the clock configuration view.
4. From the Configuration panel in the **Pinout & Configuration** view configure the parameters required to initialize the peripherals and middleware operating modes.
5. Generate the initialization C code by clicking **GENERATE CODE**.

## 4.1 Home page

The Home page is the first window that opens up when launching STM32CubeMX (see [Figure 20](#)). Closing it closes down the application. It offers shortcuts for some top level menus, an image carousel displaying STM32 latest news, as well as links to social network sites and external tools. Top-level menus and social network links remain accessible from the subsequent project page and are detailed in the following sections.

**Figure 20. STM32CubeMX Home page**



#### 4.1.1 File menu

Refer to [Table 2](#) for a description of the **File menu** and shortcuts.

**Table 2. Home page shortcuts**

Name <b>Keyboard shortcut</b>	Description	Home page shortcut
<b>New Project...</b> Ctrl-N	Opens a new project window showing all supported MCUs and a set of STMicroelectronics boards to choose from <sup>(1)</sup> .	To create a new project starting from a board click  To create a new project starting from an MCU click 
<b>Load Project...</b> Ctrl-L	Loads an existing STM32CubeMX project configuration by selecting an STM32CubeMX configuration .ioc file (see <a href="#">Caution:</a> ).	Under Other project, click browse icon 
<b>Import Project...</b> Ctrl-I	Opens a new window to select the configuration file to be imported as well as the import settings. The import is possible only if you start from an empty MCU configuration. Otherwise, the menu is disabled <sup>(2)</sup> .	None
<b>Save Project</b> Ctrl-S	Saves current project configuration (pinout, clock tree, peripherals, middlewares, Power Consumption Calculator) as a new project. This action creates a project folder including an .ioc file, according to user defined project settings.	None
<b>Save Project as...</b> Ctrl-A	Saves the current project.	None
<b>Close Project</b> Ctrl-C	Closes the current project and switches back to the welcome page.	None
<b>Recent Projects</b> <i>none</i>	Displays the list of the five most recently saved projects.	Under <b>Recent Project</b> , click  icon next to the project name.
<b>Generate Report</b> Ctrl-R	Saves the project current configuration as two documents (pdf and text formats).	None
<b>Exit</b> Ctrl-X	Proposes to save the project (if needed), then closes the application.	To close the window and the application click on 

1. On **New project**: to avoid any popup error messages at this stage, make sure an Internet connection is available (Connection Parameters tab under Help > Updater settings menu) or that Data Auto-refresh settings are set to No Auto-Refresh at application start (Updater Settings tab under Help > Updater Settings menu).
2. On **Import**, a status window displays the warnings or errors detected when checking for import conflicts. The user can then decide to cancel the import.

**Caution:** **On project load:** STM32CubeMX detects if the project was created with an older version of the tool and if this is the case, it proposes the user to either migrate to use the latest STM32CubeMX database and STM32Cube firmware version, or to continue. Prior to STM32CubeMX 4.17, clicking Continue still upgrades to the latest database “compatible” with the STM32Cube firmware version used by the project. Starting from STM32CubeMX 4.17, clicking Continue keeps the database used to create the project untouched. If the required database version is not available on the computer, it is automatically downloaded. When upgrading to a new version of STM32CubeMX, make sure to always backup your projects before loading the new project (especially when the project includes user code).

#### 4.1.2 Window menu and Outputs tabs

The **Window** menu allows the user to access the **Outputs** function.

**Table 3. Window menu**

Name	Description
Outputs	Selecting/deselecting <b>Outputs</b> from the <b>Window</b> menu hides/shows the following Outputs tabs at the bottom of STM32CubeMX project page (see <a href="#">Figure 21</a> ) <ul style="list-style-type: none"> <li>– <b>MCUs selection</b> tab that lists the MCUs of a given family matching the user criteria (Series, peripherals, package,...) when an MCU was selected last<sup>(1)</sup>.</li> <li>– <b>Outputs</b> tab that displays a non-exhaustive list of the actions performed, raised errors and warnings (see <a href="#">Figure 22</a>) found upon user actions.</li> </ul>
Font size	Makes possible to change STM32CubeMX font size settings. STM32CubeMX must be re-launched for changes to take effect.

1. Selecting a different MCU from the list resets the current project configuration and switches to the new MCU. The user is then prompted to confirm this action before proceeding.

Figure 21. Window menu

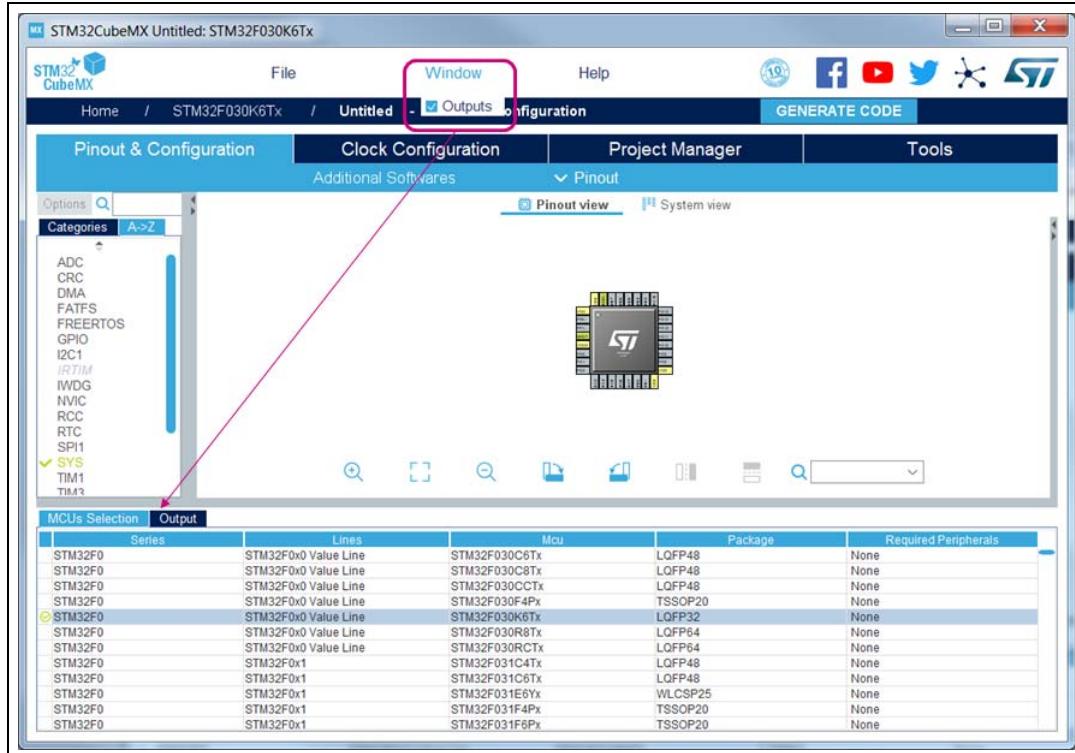
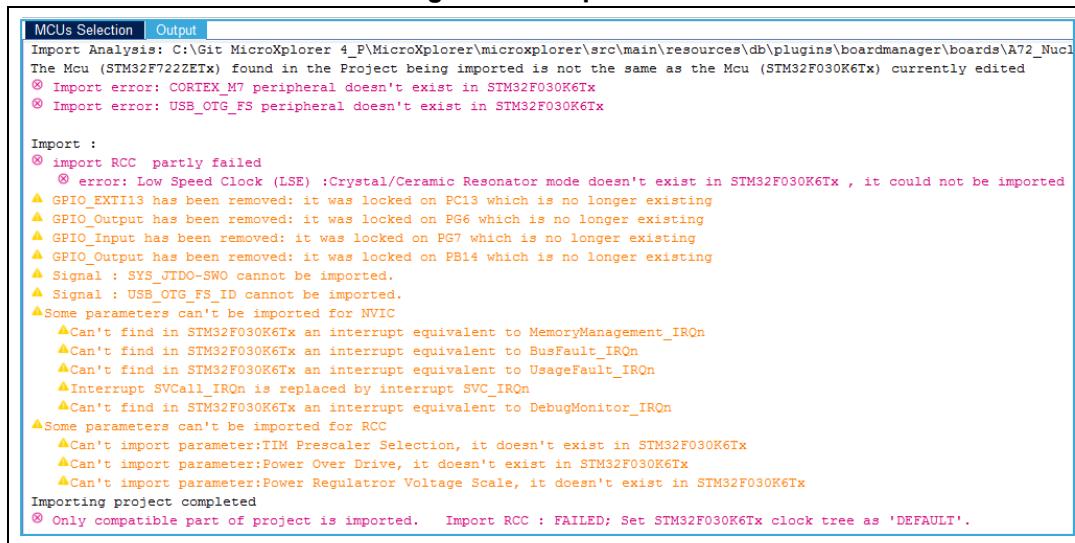


Figure 22. Output view



#### 4.1.3 Help menu

Refer to [Table 4](#) for a description of the **Help** menu and shortcuts.

**Table 4. Help menu shortcuts**

Name Keyboard shortcut	Description	Home page shortcut
<b>Help</b> <i>F1</i>	Opens the STM32CubeMX user manual.	None
<b>About</b> <i>Alt-A</i>	Shows version information.	None
<b>Docs &amp; Resources</b> <i>Alt-D</i>	Displays the official documentation available for the MCU used in the current project.	None
<b>Video Tutorials</b> <i>Alt-V</i>	Opens the Video Tutorial browser that proposes a list of videos and allows the user to launch a video in one click.	None
<b>Refresh Data</b> <i>Alt-R</i>	Opens a dialog window that proposes to refresh STM32CubeMX database with STM32 MCU latest information (description and list of official documents), and allows the user to download of all official documentation in one shot.	None
<b>Check for Updates</b> <i>Alt-C</i>	Shows the software and firmware release updates available for download.	Click <b>CHECK FOR UPDATES</b>
<b>Manage embedded software packages</b> <i>Alt-U</i>	Shows all the embedded software packages available for installation. A green check box indicates that the package is already installed in the user repository folder (the repository folder location is specified under Help > Updater Settings menu).	Click <b>INSTALL/REMOVE</b>
<b>Updater Settings...</b> <i>Alt-S</i>	Opens the updater settings window to configure manual versus automatic updates, proxy settings for Internet connections, repository folder where the downloaded software and firmware releases will be stored.	None
<b>User Preferences</b>	Opens the user preference window to enable or disable collect of features usage statistics.	None

#### 4.1.4 Social links

Developer communities on popular social platforms such as Facebook™, Twitter™, STM32 YouTube™ channel, as well as ST Community can be accessed from the STM32CubeMX toolbar (see [Figure 23](#)).

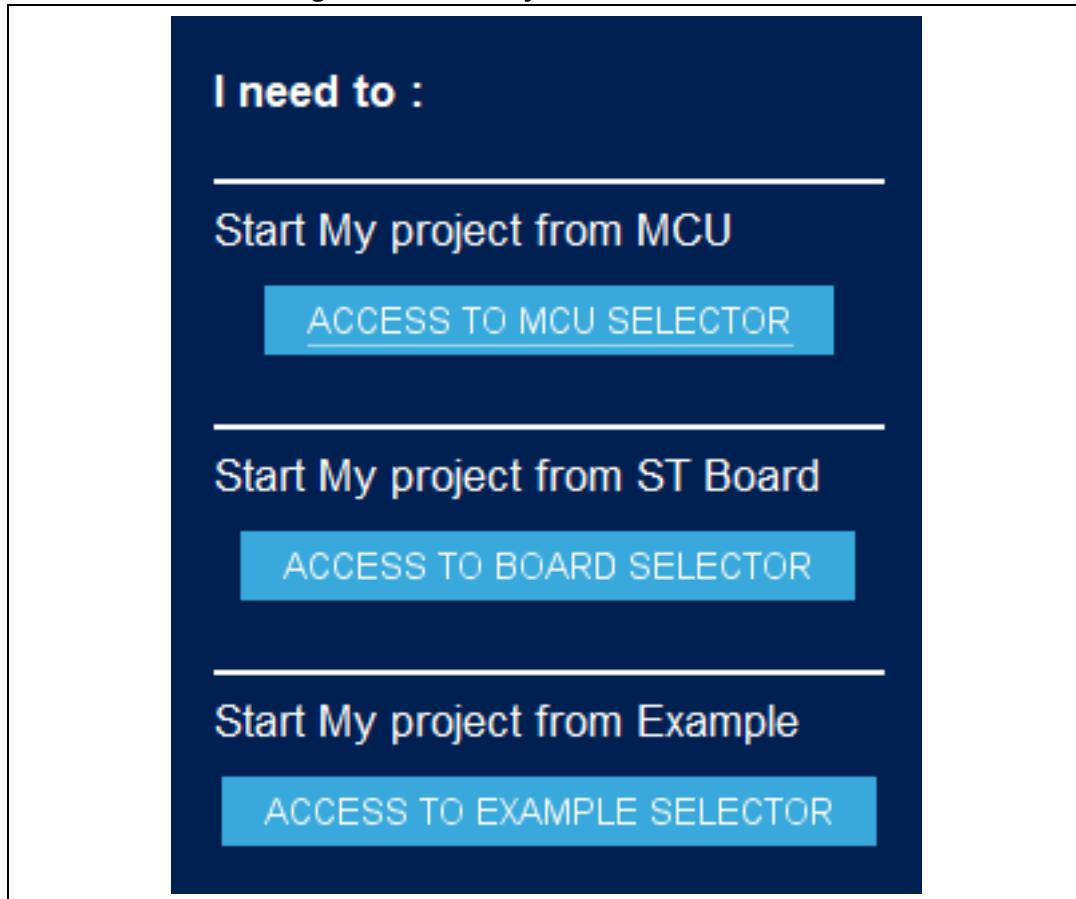
**Figure 23. Link to social platforms**



## 4.2 New Project window

The New Project window is accessible through the File Menu or directly through shortcuts from the Home page (see [Figure 24](#)).

**Figure 24. New Project window shortcuts**



The main purpose here is to select from the STM32 portfolio a microcontroller or board part number that best fits the user application needs, or simply to get started using an example project.

This window shows three tabs to choose from:

- an **MCU selector** tab (offering a list of target processors)
- a **Board selector** tab (showing a list of STMicroelectronics boards)
- an **Example selector** tab (allows the user to browse and open an example project)

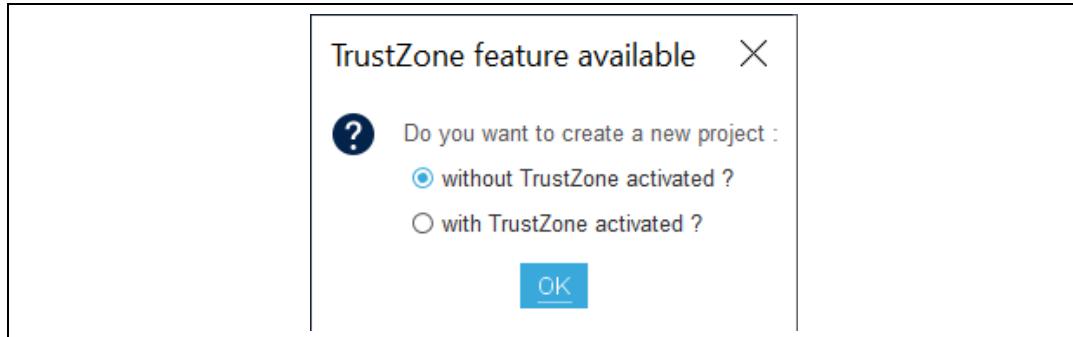
The new project window also features a **Cross selector** tab (allows the user to find, for a given MCU/MPU part number and for a set of criteria, the best replacement within the STM32 portfolio)

For STM32L5 Series the security features of the Arm Cortex-M33 processor and its TrustZone for Armv8-M are combined with ST security implementation. Selecting an

STM32L5 MCU or board requires to choose whether to activate TrustZone (hardware security) or not (see [Figure 25](#)). The project is adjusted accordingly:

- if Trustzone is not activated, the solution is the same as for other STM32Lx Series
- if TrustZone is activated, the project configuration and the generated project shows specificities related to the security features (refer to dedicated sections in this manual).

**Figure 25. Enabling TrustZone for STM32L5 Series**

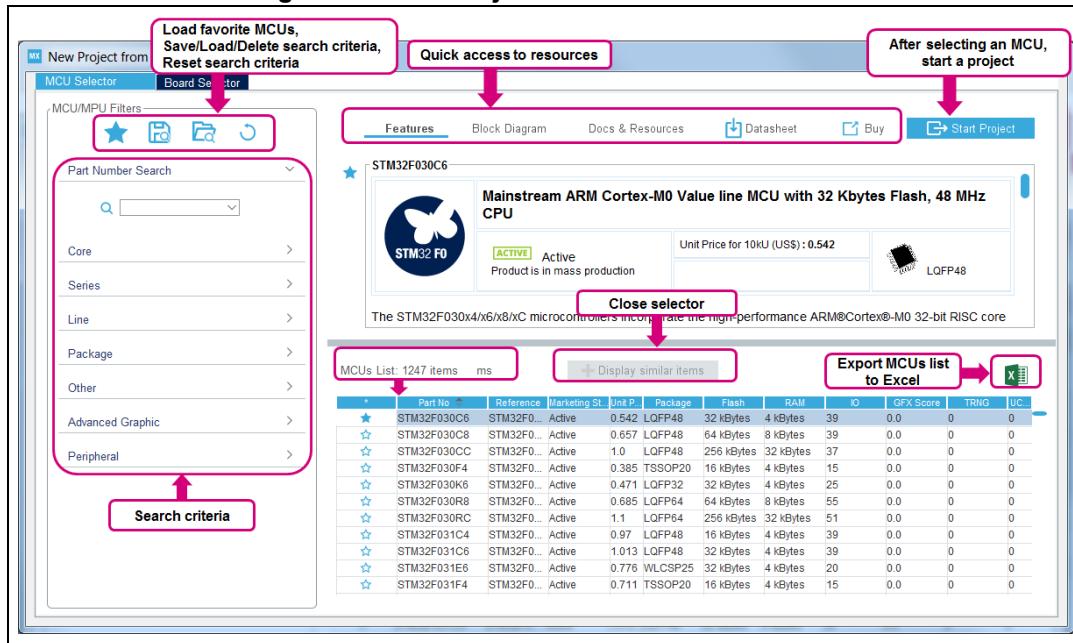


## 4.2.1 MCU selector

### MCU selection

The MCU selector enables filtering on a combination of criteria: series, lines, packages, peripherals, or additional characteristics such as price, memory size or number of I/Os (see [Figure 26](#)), and on their graphics capabilities as well.

**Figure 26. New Project window - MCU selector**



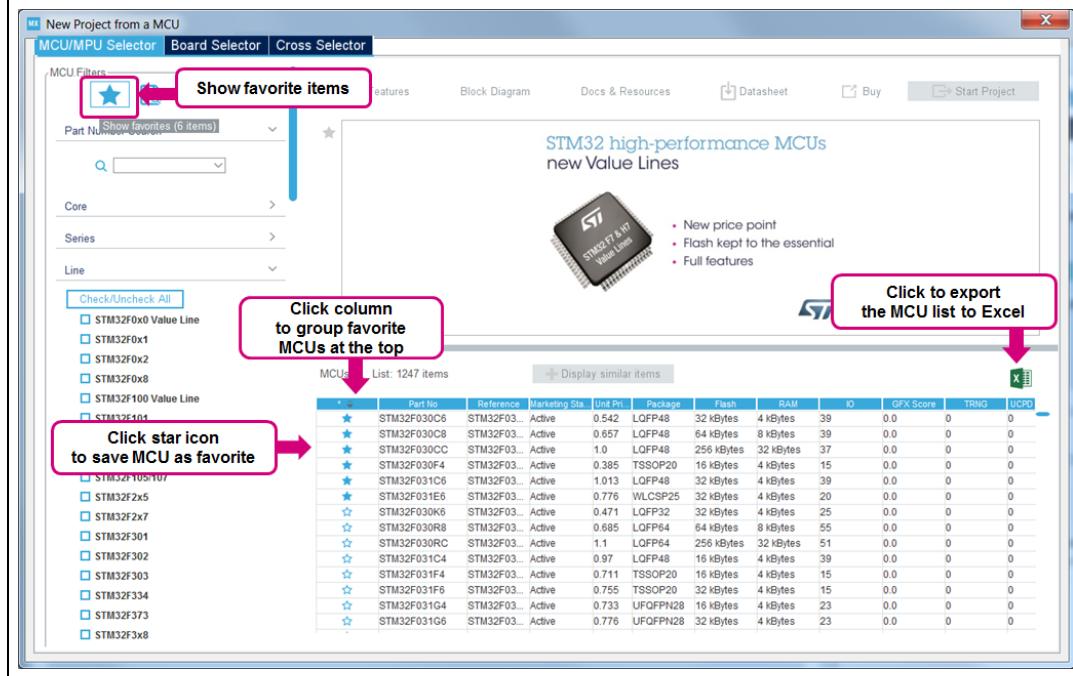
### Export to Excel feature

Clicking on the icon allows the user to save the MCU table information to an Excel file.

## Show favorite MCUs feature

Clicking the  icon for an MCU from the list marks it as favorite, see [Figure 27](#).

**Figure 27. Marking an MCU as favorite**



## MCU close selector feature

When the number of MCUs found is lower than 50, the selector offers to list the MCUs with close features (see [Figure 28](#)). Clicking the **Display similar items** button displays them (see [Figure 29](#)): by default, MCUs are sorted first by matching ratio, then by part number. For close MCUs (those with a matching ratio lower than 100%) rows are shown in gray and non matching cells are highlighted in dark gray.

Figure 28. New Project window - MCU list with close function

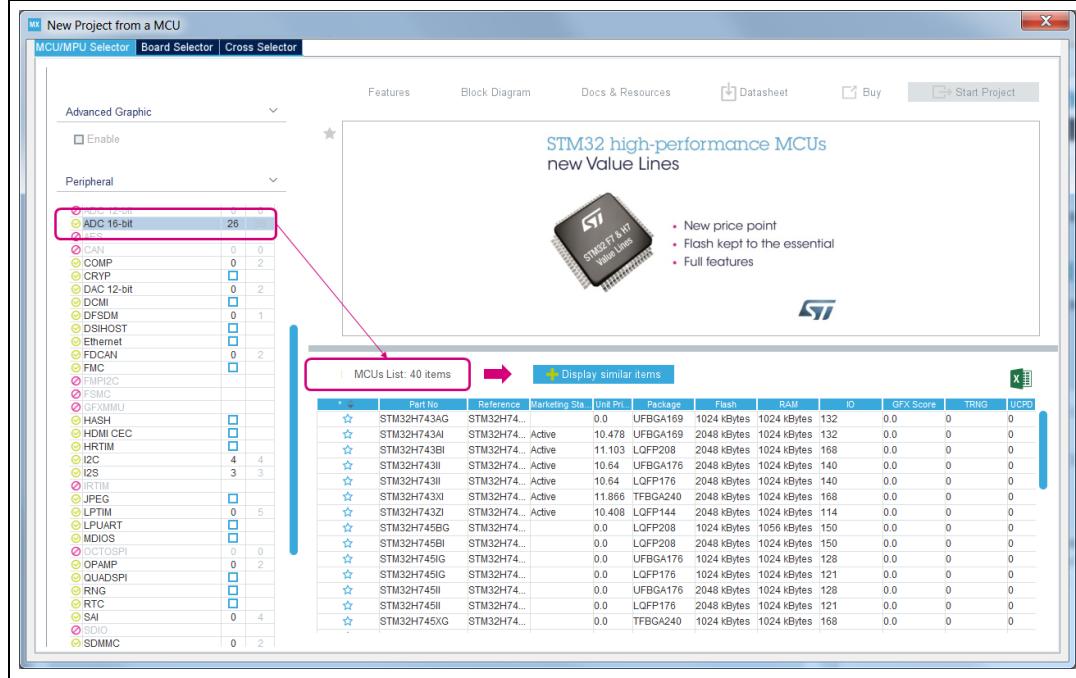
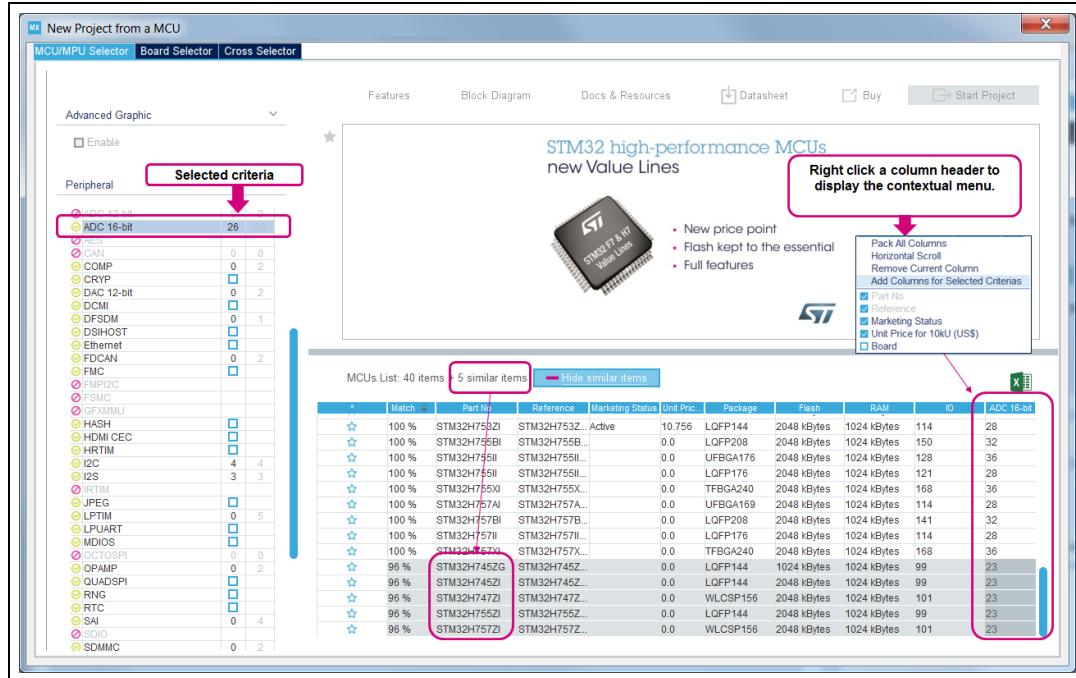


Figure 29. New Project window - List showing close MCUs

**Note:**

A matching percentage is computed for each user selected criteria, for example:

- when requesting four instances of the CAN peripheral, the MCUs with only three instances reaches a 75% match on the CAN criteria

- if the maximum price criteria is selected, the matching ratio for a given MCU is the

*maximum requested price divided by the actual MCU price. In the case of a minimum price criteria, the matching ratio is the MCU price divided by the minimum requested price. Finally, all criteria ratios are averaged to give the Match column percentage value.*

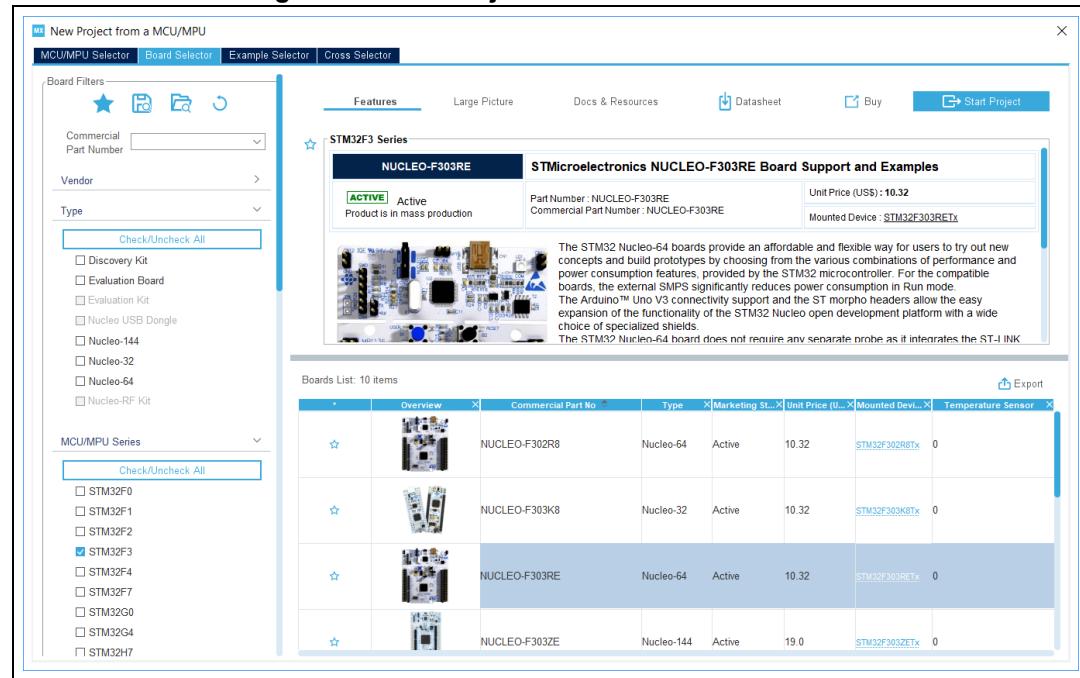
## 4.2.2 Board selector

The **Board selector** enables filtering on STM32 board types, Series and peripherals (see [Figure 30](#)). Only the default board configuration is proposed. Alternative board configurations obtained by reconfiguring jumpers or by using solder bridges are not supported.

When a board is selected, the **Pinout** view is initialized with the relevant MCU part number along with the pin assignments for the LCD, buttons, communication interfaces, LEDs, and other functions. Optionally, the user can choose to initialize it with the default peripheral modes.

When a board configuration is selected, the signals change to 'pinned', i.e. they cannot be moved automatically by STM32CubeMX constraint solver (user action on the peripheral tree, such as the selection of a peripheral mode, does not move the signals). This ensures that the user configuration remains compatible with the board.

**Figure 30. New Project window - Board selector**



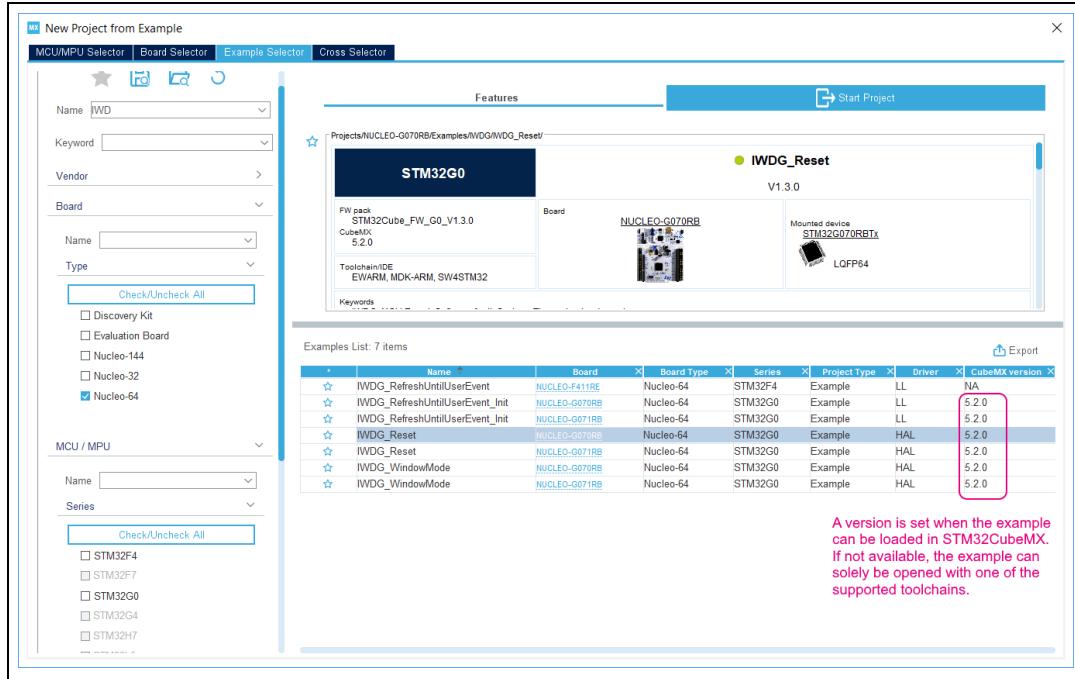
## 4.2.3 Example selector

The Example selector allows the user to browse a large set of examples and to start a new project from a selected example.

**Note:** *An example is always for a specific board and consequently for the MCU available with that board.*

Thanks to the filter panel it is possible to filter down the example list for a specific board type, series, peripheral or middleware as well as other characteristics (see [Figure 31](#)).

Figure 31. New project window - Example selector



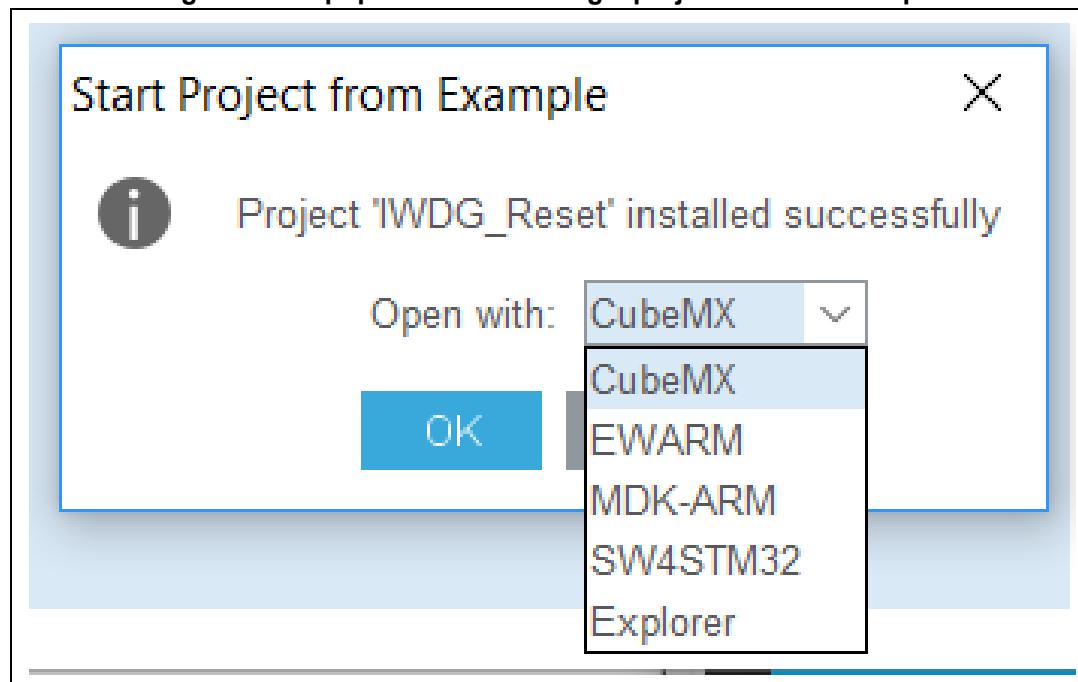
Selecting an example and clicking "Start project" allows STM32CubeMX to copy the example as a new project (the user can change the default location at this stage).

**Warning:** For some examples the "Start Project" button is shown with an "Under Development" warning icon. Projects created from these examples may be not functional (they do not compile). Fixes are in development.

Several options are available to open the newly created project (see [Figure 32](#)):

- with STM32CubeMX (available only for examples listed with a CubeMX version set)
- with a File explorer
- with one of the supported toolchains (provided the toolchain is already installed on your computer)

Figure 32. Popup window - Starting a project from an example



**Note:** If the STM32Cube MCU package necessary for the example is missing from the repository STM32CubeMX automatically starts the download process.

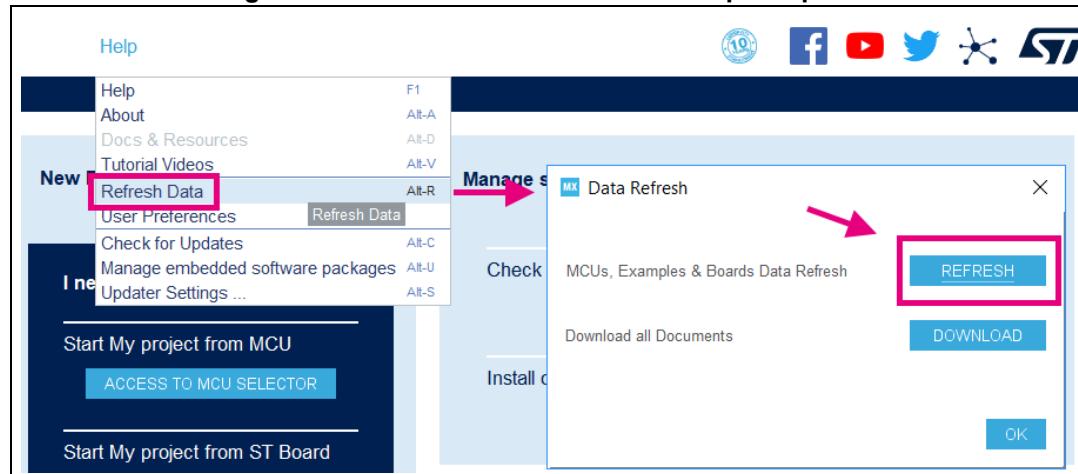
#### 4.2.4 Cross selector

##### Part number selection

The Cross selector allows users to find products of the STM32 portfolio that best replace the MCU or MPU they are currently using (from ST or other silicon vendors).

To access this functionality, STM32CubeMX data must be up to date. This is ensured using Refresh Data from the Help menu (see [Figure 33](#)).

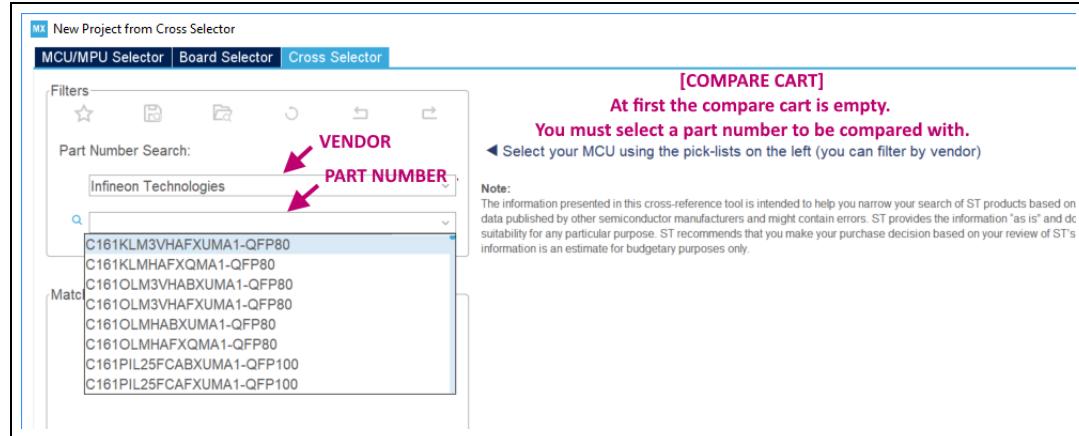
Figure 33. Cross selector - Data refresh prerequisite



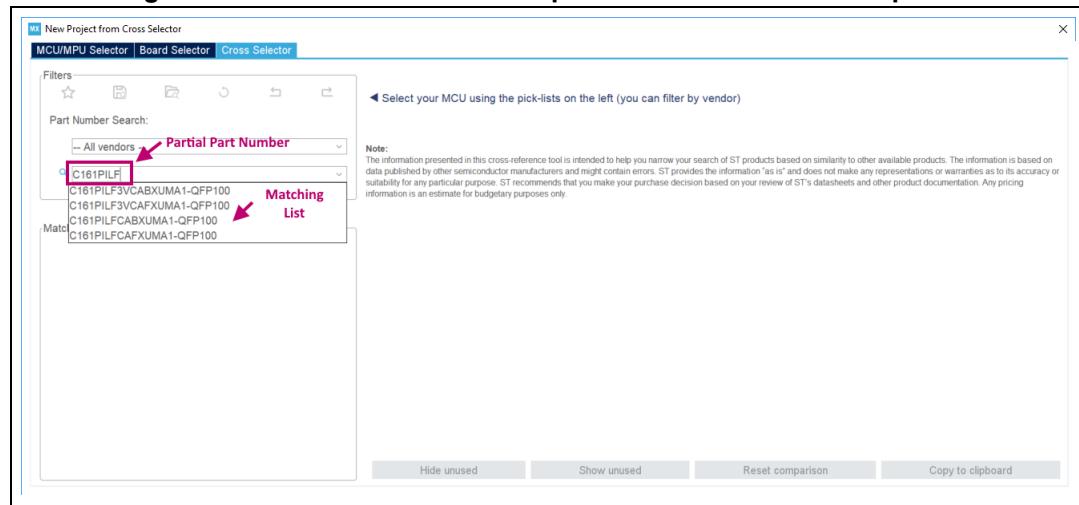
Clicking “ACCESS TO CROSS SELECTOR” under the “Start my project from Cross Selector” section of the main page opens the New Project window on the Cross selector tab.

Two drop downs menus allow the user to select the vendor and the part number of the product to be compared to (see [Figure 34](#)). A part number can also be entered partially: STM32CubeMX proposes a list of matching products (see [Figure 35](#)).

**Figure 34. Cross selector - Part number selection per vendor**



**Figure 35. Cross selector - Partial part number selection completion**

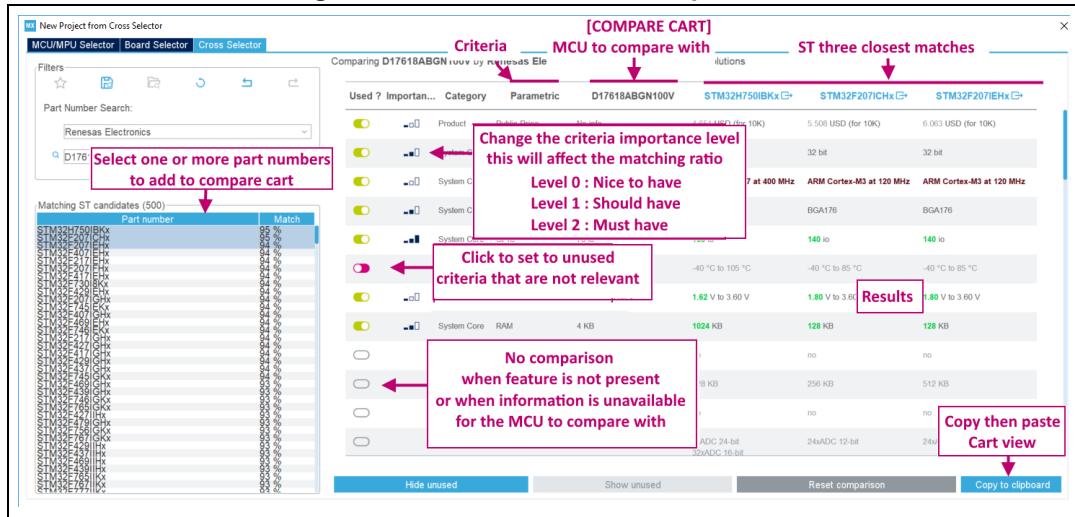


### Compare cart

Once a part number is selected, a list of matching ST part number candidates is displayed along with their matching ratio in the Matching ST candidates panel.

By default, the three closest matches are selected and added to the compare cart along with the part number to be compared to (see [Figure 36](#)).

Figure 36. Cross selector - Compare cart



This selection can be changed anytime in the Matching ST candidates panel.

The comparison can be customized: the features to be used for comparison can be unselected when considered as irrelevant and their level of importance can be adjusted. These choices affect the computed matching ratio.

The comparison is disabled for features that are not supported on the part number to be compared with, or when the feature information is unavailable.

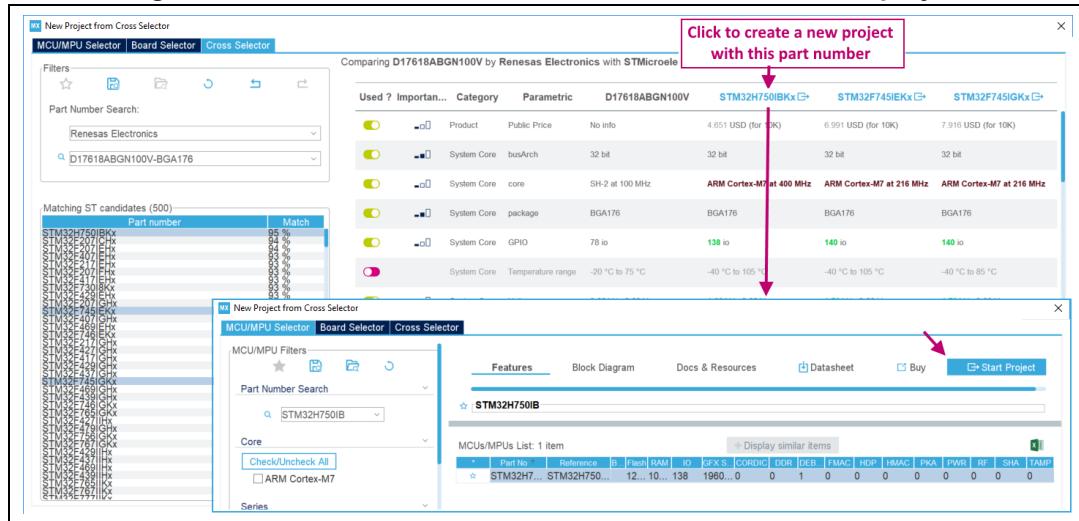
Buttons are available to manipulate and save a copy of the compare cart view:

- to hide criteria that are not used for the comparison or show all criteria.
- to come back to default STM32CubeMX comparison settings
- to copy and paste the current cart view in a document or email.

### MCU/MPU selection for a new project

Clicking an STM32 part number from the compare cart selects it in the MCU/MPU Selector tab, and clicking on **Start Project** creates a new project for that part number (see [Figure 37](#)).

Figure 37. Cross selector - Part number selection for a new project



Clicking the Cross Selector Tab allows the user to go back to the cart and change the current selection for another part number.

## 4.3 Project page

Once an STM32 part number or a board has been selected or a previously saved project has been loaded, the project page opens, showing the following set of views (refer to dedicated sections for their detailed description):

- **Pinout & Configuration**
- **Clock Configuration**
- **Project Manager**
- **Tools**

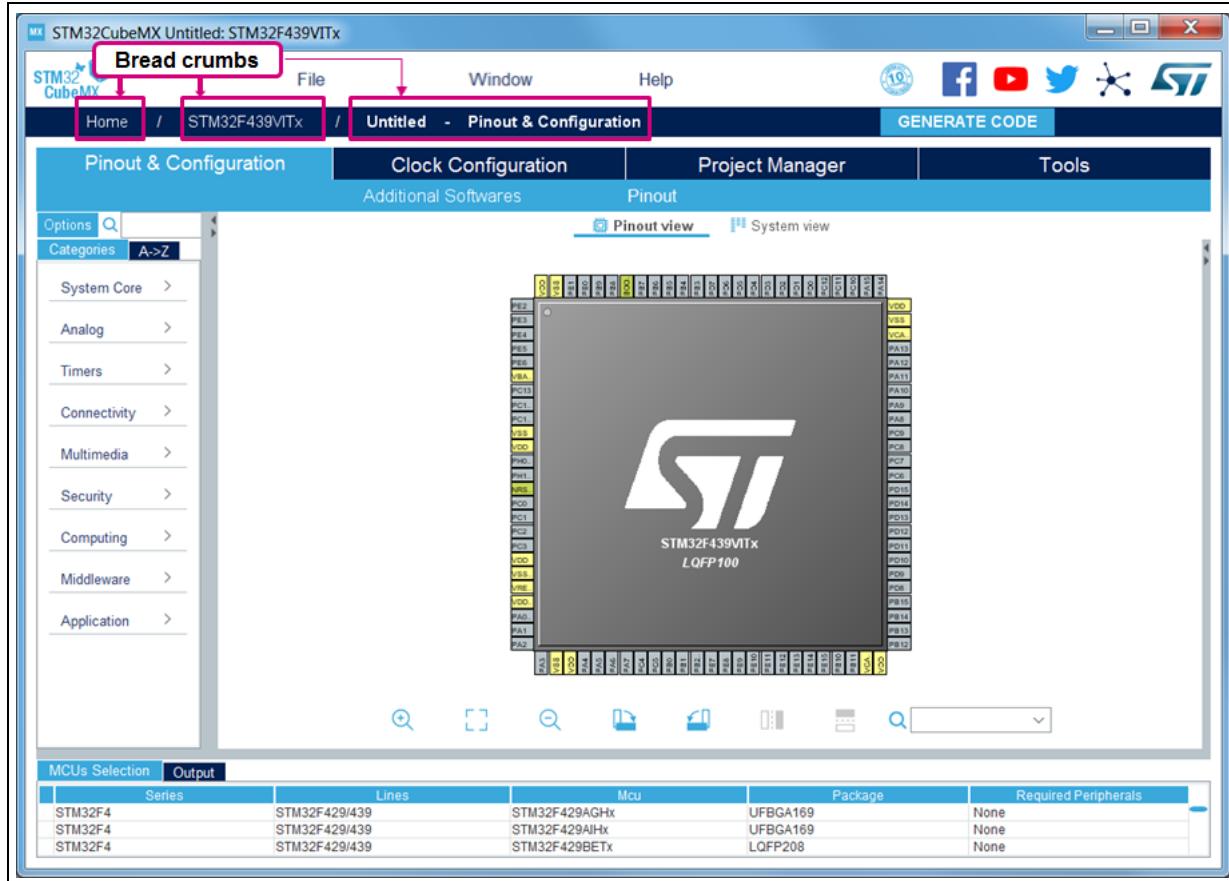
The user can move across them without impacting his currently saved configuration.

A **GENERATE CODE** button is always accessible for the user to click and allows to generate the code corresponding to the current project configuration.

Moreover, thanks to convenient navigation breadcrumbs (see [Figure 38](#)), the user can detect what its current location is in STM32CubeMX user interface, and can move to other locations:

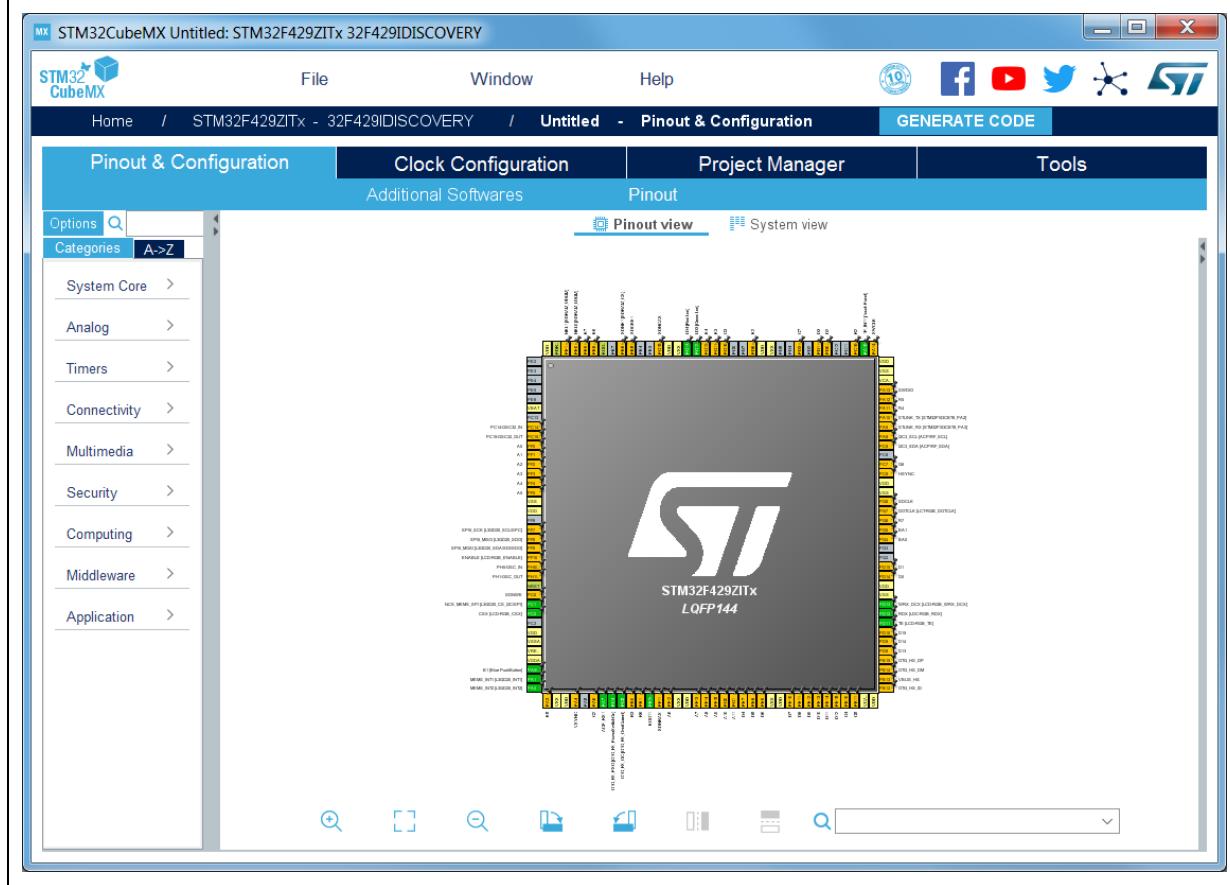
- to the home page by clicking the Home breadcrumb
- to the new project window by clicking the part number
- back to the project page by clicking the project name (or Untitled if the project does not have a name yet).

Figure 38. STM32CubeMX Main window upon MCU selection



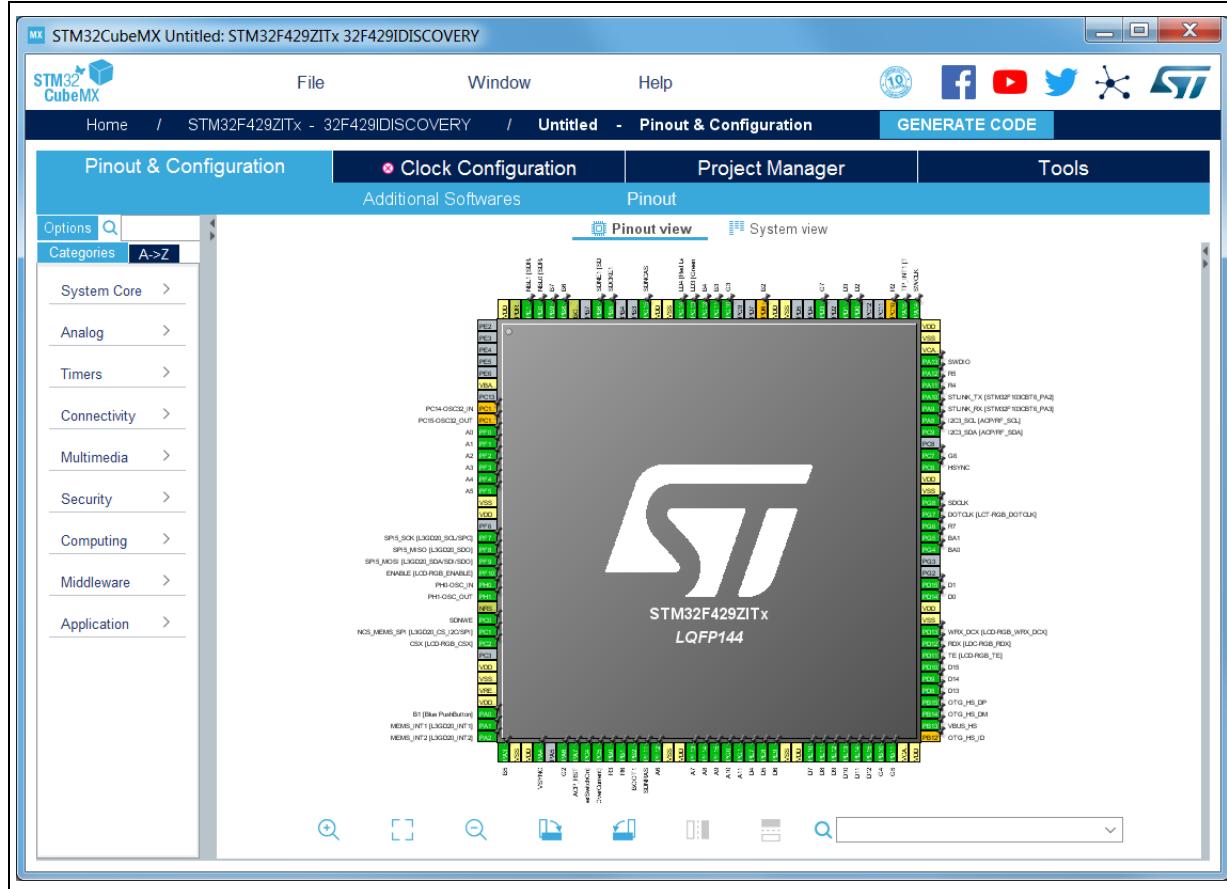
Selecting a board, then answering **No** in the dialog window requesting to initialize all peripherals to their default mode, automatically sets the pinout for this board. However, only the pins set as GPIOs are marked as configured, i.e. highlighted in green, while no peripheral mode is set. The user can then manually select from the peripheral tree the peripheral modes required for its application (see [Figure 39](#)).

**Figure 39. STM32CubeMX Main window upon board selection (peripherals not initialized)**



Selecting a board and accepting to initialize all peripherals to their default mode automatically sets both the pinout and the default modes for the peripherals available on the board. This means that STM32CubeMX generates the C initialization code for all the peripherals available on the board and not only for those relevant to the user application (see [Figure 40](#)).

**Figure 40. STM32CubeMX Main window upon board selection  
(peripherals initialized with default configuration)**



## 4.4 Pinout & Configuration view

The **Pinout & Configuration** view comes with the following main panels, function and menu:

- A **Component list** that can be visualized in alphabetical order and per categories. By default, it consists of the list of peripheral and middleware that the selected MCU supports. Selecting a component from that list opens two additional panels (**Mode** and **Configuration**) that allow the user to set its functional mode and configure the initialization parameters that will be included in the generated code.
- A **Pinout view** that shows a graphic representation of the pinout for the selected package (e.g. BGA, QFP) where each pin is represented with its name (e.g. PC4) and its current alternate function assignment, if any.
- A **System view** that gives an overview of all the software configurable components: GPIOs, peripherals, middleware and additional software components. Clickable

buttons allow opening the configuration options for the given component (Mode and Configuration panels). The button icon color reflects the status of the configuration status.

- A **Software Packs** menu with two sub-menus:
  - **Select Components** to select, for the current project, software components not available by default. This selection updates the **Pinout & Configuration** view accordingly
  - **Manage Software Packs** to install/uninstall software packs.
- An **Additional Software** function that allows to select, for the current project, software components that are not available by default. Selecting an additional software component updates the **Pinout & Configuration** view accordingly.
- A **Pinout** menu that allows the user to perform pinout related actions such as clear pinout configuration or export pinout configuration as csv file.

### Tips

- You can resize the different panels at will: hovering the mouse over a panel border displays a two-ended arrow: right-click and pull in a direction to either extend or reduce the panel.
- You can show/hide the Configuration, Mode, Pinout and System views using the open  and close  arrows.

## 4.4.1 Component list

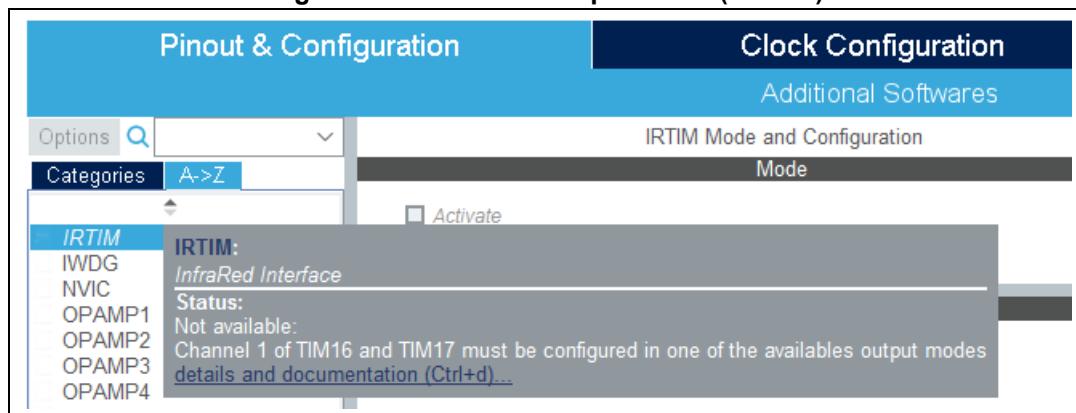
The component list shows all the components available for the project. Selecting a component from the component list, opens the Mode and Configuration panels.

### Contextual help

The **Contextual Help** window is displayed when hovering the mouse over a peripheral or a middleware short name.

By default, the window displays the extended name and source of configuration conflicts if any (see [Figure 41](#)).

**Figure 41. Contextual Help window (default)**

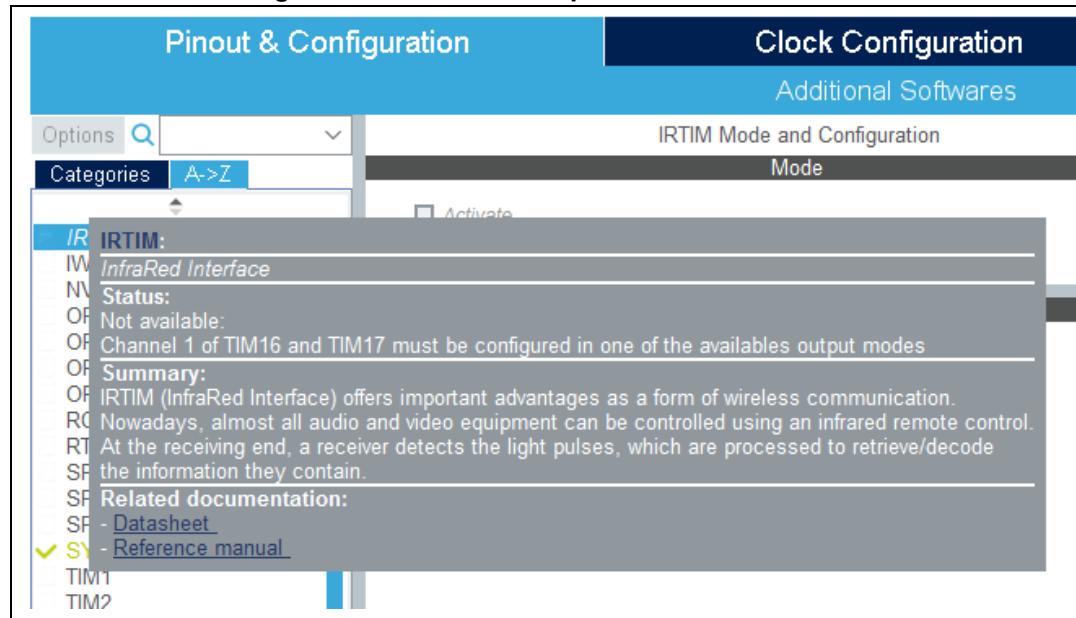


Clicking the *details and documentation* link (or CTRL+d) provides additional information such as summary and reference documentation links (see [Figure 42](#)). For a given

peripheral, clicking *Datasheet* or *Reference manual* opens the corresponding document, stored in STM32CubeMX repository folder, at the relevant chapter. Since microcontrollers datasheets and reference manuals are downloaded to STM32CubeMX repository only upon user request, a functional Internet connection is required:

- To check your Internet connection, open the **Connection** tab from the **Help > Updater Settings** menu.
- To request the download of reference documentation for the currently selected microcontroller, click **Refresh** from the **Help > Refresh Data** menu window.

**Figure 42. Contextual Help detailed information**



### Icons and color schemes

**Table 5** shows the icons and color scheme used in the component list view and the corresponding color scheme in the Mode panel.

**Table 5. Component list, mode icons and color schemes**

Display	Component status	Corresponding Mode view / Tooltips
Plain black text Example: <b>UART5</b>	The peripheral is not configured (no mode is set) and all modes are available.	
Gray italic text Example: <b>LWIP</b>	Peripheral is not available because some constraints are not solved. See tooltip.	

Table 5. Component list, mode icons and color schemes (continued)

Display	Component status	Corresponding Mode view / Tooltips
 Example: ETH	The peripheral is configured (at least one mode is set) and all other modes are available. The green check mark indicates that all parameters are properly configured, a cross indicates they are not.	
 Example: USB_OTG_HS	The peripheral is not configured (no mode is set) and at least one of its modes is unavailable.	
 Example: USB_OTG_HS	The peripheral is configured (one mode is set) and at least one of its other modes is unavailable.	
 Example: I2C2	The peripheral is not configured (no mode is set) and no mode is available. Move the mouse over the peripheral name to display the tooltip describing the conflict.	
Example: IRTIM	Peripheral is not available because of constraints.	

#### 4.4.2 Component Mode panel

Select a component from the component list on the left panel to open the **Mode** panel.

The **Mode** panel helps the user configuring the MCU pins based on a selection of peripherals and of their operating modes. Since STM32 MCUs allow a same pin to be used by different peripherals and for several functions (alternate functions), the tool searches for the pinout configuration that best fits the set of peripherals selected by the user.

STM32CubeMX highlights the conflicts that cannot be solved automatically (see [Table 5](#)).

The **Mode** panel also allows to enable middleware and other software components for the project.

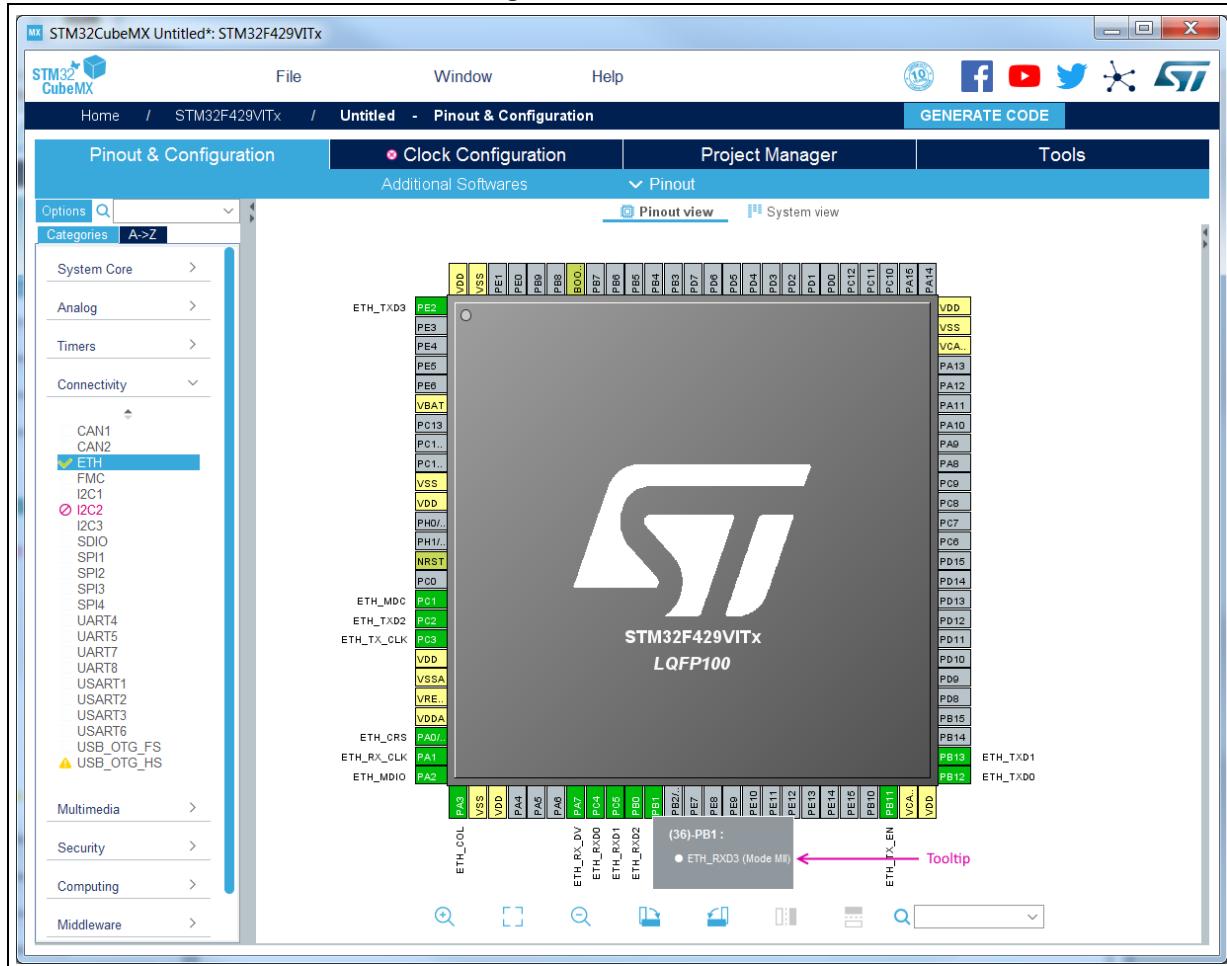
**Note:** *For some middleware (USB, FATS, LwIP), a peripheral mode must be enabled before activating the middleware mode. Tooltips guide the user through the configuration. For FatFs, a user-defined mode has been introduced. This allows STM32CubeMX to generate*

*FatFs code without a predefined peripheral mode. Then, it is up to the user to connect the middleware with a user-defined peripheral by updating the generated user\_diskio.c/h driver files with the necessary code.*

#### 4.4.3 Pinout view

Select  **Pinout view** to show for the selected part number, a graphic representation of the pinout for the selected package (e.g. BGA, QFP...) where each pin is represented with its name (e.g. PC4), its configuration state and its current alternate function assignment if any (e.g. ETH\_MII\_RXD0), see [Figure 43](#) for an example.

**Figure 43. Pinout view**



The **Pinout** view is automatically refreshed to match the user's component configuration performed in the **Mode** panel.

Assigning pins directly through the **Pinout** view instead of the **Mode** panel requires a good knowledge of the MCU since each individual pin can be assigned to a specific function.

## Tips and tricks

See [Table 2: Home page shortcuts](#) for list of menus and shortcuts.

- Use the mouse wheel to zoom in and out.
- Click and drag the chip diagram to move it.
- Click best fit to reset it to best suited position and size.
- Use Pinout > Export pinout menus to export the pinout configuration as .csv text format.
- Some basic controls, such as insuring blocks of pins consistency, are built-in. See [Appendix A: STM32CubeMX pin assignment rules](#) for details.

### 4.4.4 Pinout menu and shortcuts

**Table 6. Pinout menu and shortcuts**

Name or Icon	Shortcut	Description
Keep Current Signals Placement	Ctrl-K	Prevents moving pin assignments to match a new peripheral operating mode. It is recommended to use the new pinning feature that can block each pin assignment individually and leave this checkbox unchecked.
Show User Label	None	Displays user defined labels in the Pinout view.
Undo Mode and pinout	Ctrl-Z	Undoes last configuration steps (one by one).
Redo Mode and pinout	Ctrl-Y	Redoes steps that have been undone (one by one). <b>Warning</b> (limitation): configurations in the platform settings tabs are not restored.
Disable All Modes	Ctrl-D	Resets to “Disabled” all peripherals and middleware modes that have been enabled. The pins configured in these modes (green color) are consequently reset to “Unused” (gray color). Peripheral and middleware labels change from green to black (when unused) or gray (when not available).
Clear Pinouts	Ctrl-P	Clears user pinout configuration in the Pinout view. Note that this action puts all configured pins back to their reset state and disables all the peripheral and middleware modes previously enabled (whether they were using signals on pins or not).
Pins/Signals Option	Ctrl-O	Opens a window showing the list of all the configured pins together with the name of the signal on the pin and a Label field allowing the user to specify a label name for each pin of the list. For this menu to be active, at least one pin must have been configured. Click the pin icon to pin/unpin signals individually. Select multiple rows then right click to open contextual menu and select action to pin or unpin all selected signals at once. Click column header names to sort alphabetically by name or according to placement on MCU.
Clear Single Mapped Signals	Ctrl-M	Clears signal assignments to pins for signals that have no associated mode (highlighted in orange and not pinned).

**Table 6. Pinout menu and shortcuts (continued)**

Name or Icon	Shortcut	Description
List Pinout Compatible MCUs	Alt-L	<p>Provides a list of MCUs that best match the pin configuration of the current project. The matching can be:</p> <ul style="list-style-type: none"> <li>– An exact match</li> <li>– A partial match with hardware compatibility: pin locations are the same, pin names may have been changed</li> <li>– A partial match without hardware compatibility: all signals can be mapped but not all at the same pin location</li> </ul> <p>Refer to <a href="#">Section 15: Tutorial 5: Exporting current project configuration to a compatible MCU.</a></p>
Export pinout with Alternate functions	-	Generates pin configuration as a .csv text file including alternate functions information.
Export pinout without Alternate functions	Ctrl-U	Generates pin configuration as a .csv text file excluding alternate functions information.
Reset used GPIOs	Alt-G	Opens a window to specify the number of GPIOs to be freed among the total number of GPIO pins that are configured.
Set unused GPIOs	Ctrl-G	<p>Opens a window to specify the number of GPIOs to be configured among the total number of GPIO pins that are not used yet.</p> <p>Specify their mode: Input, Output or Analog (recommended configuration to optimize power consumption).</p> <p><b>Caution:</b> Before using this menu, make sure that debug pins (available under SYS peripheral) are set to access microcontroller debug facilities.</p>
Layout reset	-	-
	-	Zooms-in the pinout view.
	-	Adjusts the chip pinout diagram to the best fit size.
	-	Zooms-out the pinout view.
	-	Rotates 90 degrees clock wise.
	-	Rotate 90 degrees counter-clock wise.
	-	Flips horizontally between bottom view and top view.
	-	Flips vertically between bottom view and top view.
	-	<p>This Search field allows the user to search the Pinout view for a pin name, a signal name, a signal label or an alternate pin name</p> <p>When it is found, the pin or set of pins matching the search criteria blinks on the Pinout view.</p> <p>Click the Pinout view to stop blinking.</p>

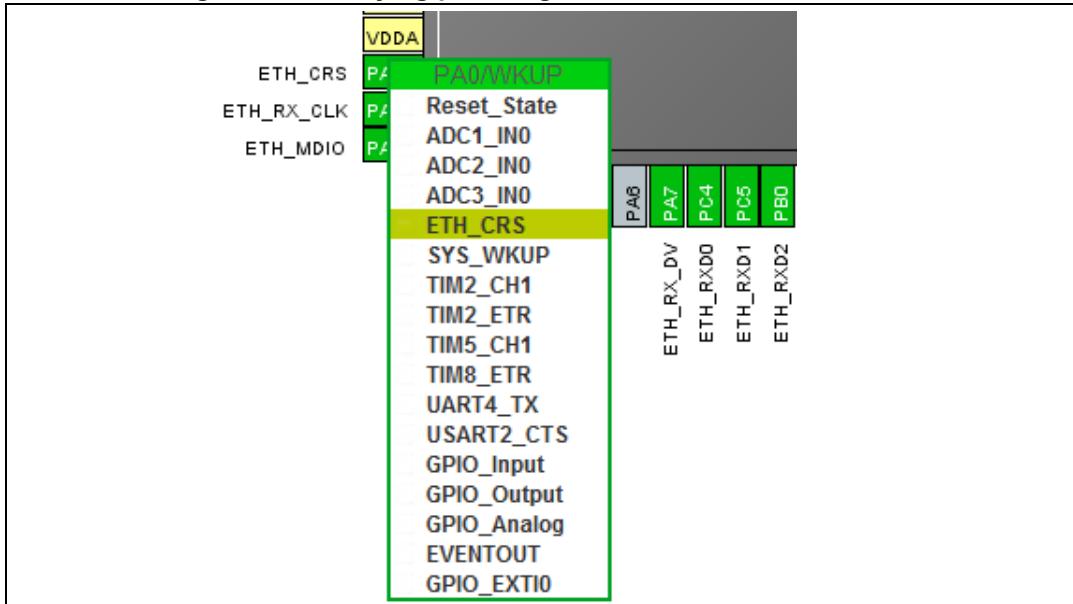
#### 4.4.5 Pinout view advanced actions

##### Manually modifying pin assignments

To manually modify a pin assignment, follow the sequence below:

1. Click the pin in the **Pinout** view to display the list of all other possible alternate functions together with the current assignment highlighted in blue (see [Figure 44](#)).
2. Click to select the new function to assign to the pin.

**Figure 44. Modifying pin assignments from the Pinout view**



##### Manually remapping a function to another pin

To manually remap a function to another pin, follow the sequence below:

1. Press the CTRL key and click the pin in the **Pinout** view. Possible pins for relocation, if any, are highlighted in blue.
2. Drag the function to the target pin.

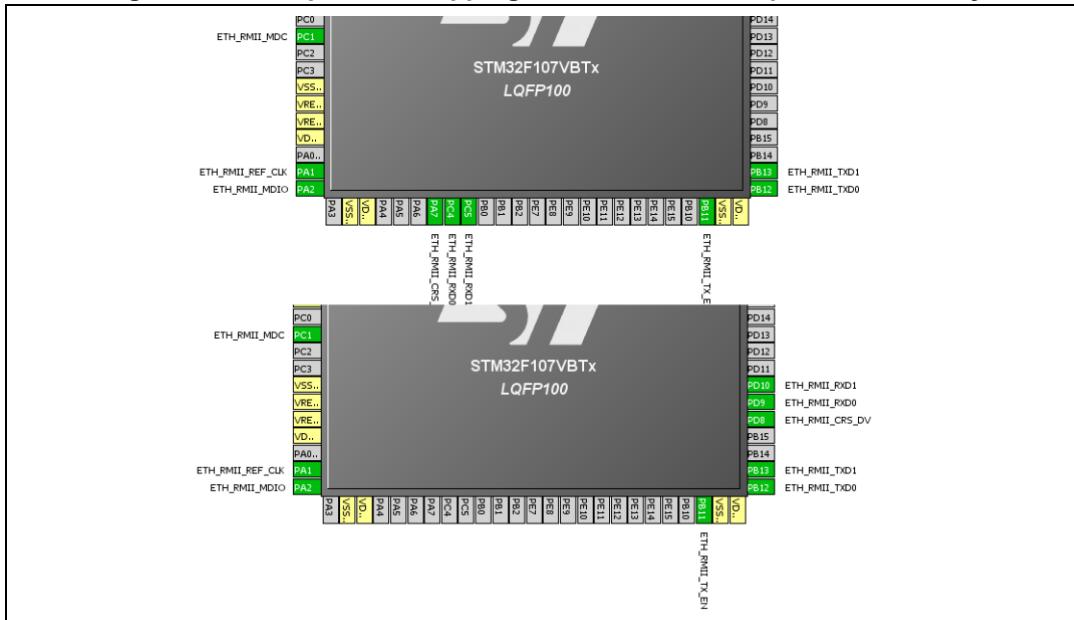
**Caution:** A pin assignment performed from the **Pinout** view overwrites any previous assignment.

##### Manual remapping with destination pin ambiguity

For MCUs with block of pins consistency (STM32F100x / F101x / F102x / F103x and STM32F105x / F107x), the destination pin can be ambiguous, e.g. there can be more than one destination block including the destination pin. To display all the possible alternative remapping blocks, move the mouse over the target pin.

**Note:** A “block of pins” is a group of pins that must be assigned together to achieve a given peripheral mode. As shown in [Figure 45](#), two blocks of pins are available on a STM32F107xx MCU to configure the Ethernet peripheral in RMII synchronous mode: {PC1, PA1, PA2, PA7, PC4, PC5, PB11, PB12, PB13, PB5} and {PC1, PA1, PA2, PD10, PD9, PD8, PB11, PB12, PB13, PB5}.

**Figure 45. Example of remapping in case of block of pins consistency**



# Resolving pin conflicts

To resolve the pin conflicts that may occur when some peripheral modes use the same pins, STM32CubeMX attempts to reassign the peripheral mode functions to other pins. The peripherals for which pin conflicts cannot be solved are highlighted in fuchsia with a tooltip describing the conflict.

If the conflict cannot be solved by remapping the modes, the user can try the following:

- If the **Keep Current Signals Placement** box is checked, try to select the peripherals in a different sequence.
  - Uncheck the **Keep Current Signals Placement** box and let STM32CubeMX try all the remap combinations to find a solution.
  - **Manually remap** a mode of a peripheral when you cannot use it because there is no pin available for one of the signals of that mode.

4.4.6

## Keep Current Signals Placement

This checkbox is available from the **Pinout** menu. It can be selected or deselected at any time during the configuration. It is unselected by default.

It is recommended to keep the checkbox unchecked for an optimized placement of the peripherals (maximum number of peripherals concurrently used).

The **Keep Current Signals Placement** checkbox should be selected when the objective is to match a board design.

**Keep Current Signals Placement is unchecked**

This allows STM32CubeMX to remap previously mapped blocks to other pins in order to serve a new request (selection of a new peripheral mode or a new peripheral mode function) which conflicts with the current pinout configuration.

### Keep Current Signals Placement is checked

This ensures that all the functions corresponding to a given peripheral mode remain allocated (mapped) to a given pin. Once the allocation is done, STM32CubeMX cannot move a peripheral mode function from one pin to another. New configuration requests are served if feasible within current pin configuration.

This functionality is useful to:

- lock all the pins corresponding to peripherals that have been configured using the **Peripherals** panel
- maintain a function mapped to a pin while doing manual remapping from the **Pinout** view.

#### Tip

If a mode becomes unavailable (highlighted in fuchsia), try to find another pin remapping configuration for this mode by following the steps below:

1. From the Pinout view, deselect the assigned functions one by one until the mode becomes available again.
2. Then, select the mode again and continue the pinout configuration with the new sequence (see [Appendix A: STM32CubeMX pin assignment rules](#) for a remapping example). This operation being time consuming, it is recommended to deselect the **Keep Current Signals Placement** checkbox.

*Note:* Even if **Keep Current Signals Placement** is unchecked, GPIO\_ functions (excepted GPIO\_EXTI functions) are not moved by STM32CubeMX.

## 4.4.7 Pinning and labeling signals on pins

STM32CubeMX comes with a feature allowing the user to selectively lock (or pin) signals to pins. This prevents STM32CubeMX from automatically moving pinned signals to other pins when resolving conflicts. Labels, that are used for code generation, can also be assigned to the signals (see [Section 6.1](#) for details).

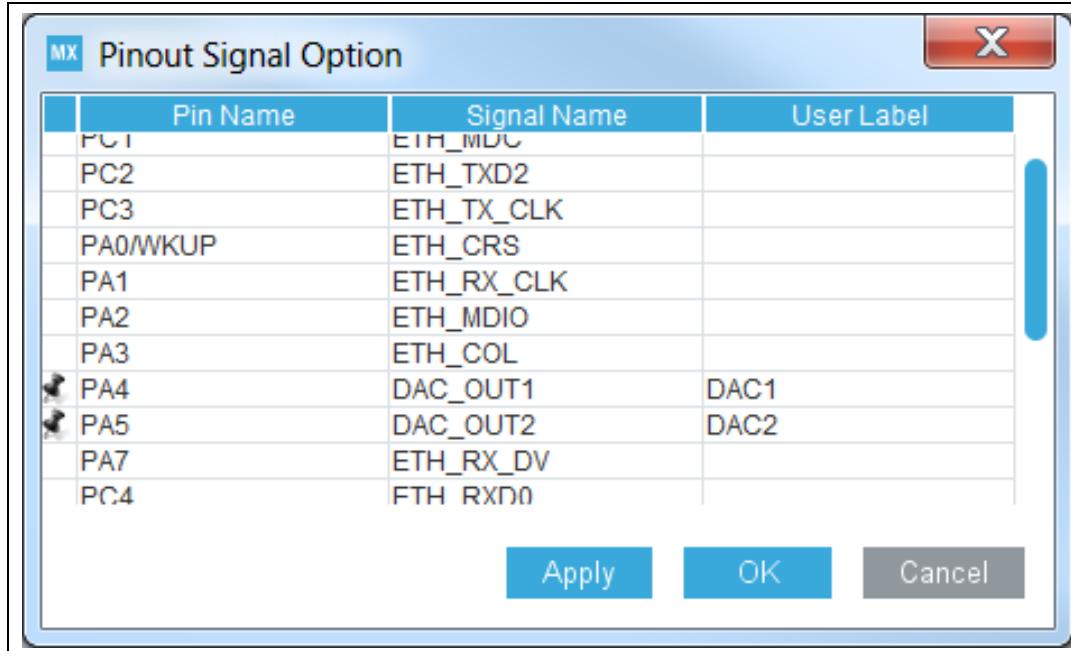
There are several ways to pin, unpin and label the signals:

1. From the **Pinout** view, right-click a pin with a signal assignment. This opens a contextual menu:
  - a) For unpinned signals, select **Signal Pinning** to pin the signal. A pin icon is then displayed on the relevant pin. The signal can no longer be moved automatically (for example when resolving pin assignment conflicts).
  - b) For pinned signals, select **Signal Unpinning** to unpin the signal. The pin icon is removed. From now on, to resolve a conflict (such as peripheral mode conflict), this signal can be moved to another pin, provided the Keep user placement option is unchecked.
  - c) Select **Enter User Label** to specify a user defined label for this signal. The new label replaces the default signal name in the **Pinout** view.

2. From the **Pinout** menu, select **Pins/Signals Options**

The Pins/Signals Options window (see *Figure 46*) lists all configured pins.

**Figure 46. Pins/Signals Options window**



The screenshot shows a dialog box titled "Pinout Signal Option". It contains a table with four columns: "Pin Name", "Signal Name", and "User Label", plus a header row. The table lists the following pins:

Pin Name	Signal Name	User Label
PC1	ETH_MDC	
PC2	ETH_RXD2	
PC3	ETH_TX_CLK	
PA0/WKUP	ETH_CRS	
PA1	ETH_RX_CLK	
PA2	ETH_MDIO	
PA3	ETH_COL	
PA4	DAC_OUT1	DAC1
PA5	DAC_OUT2	DAC2
PA7	ETH_RX_DV	
PC4	FTH_RXD0	

At the bottom of the dialog are three buttons: "Apply", "OK", and "Cancel".

- Click the first column to individually pin/unpin signals.
- Select multiple rows and right-click to open the contextual menu and select **Signal(s) Pinning or Unpinning**.
- Select the User Label field to edit the field and enter a user-defined label.
- Order list alphabetically by Pin or Signal name by clicking the column header. Click once more to go back to default i.e. to list ordered according to pin placement on MCU.

**Note:**

*Even if a signal is pinned, it is still possible however to manually change the pin signal assignment from the Pinout view: click the pin to display other possible signals for this pin and select the relevant one.*

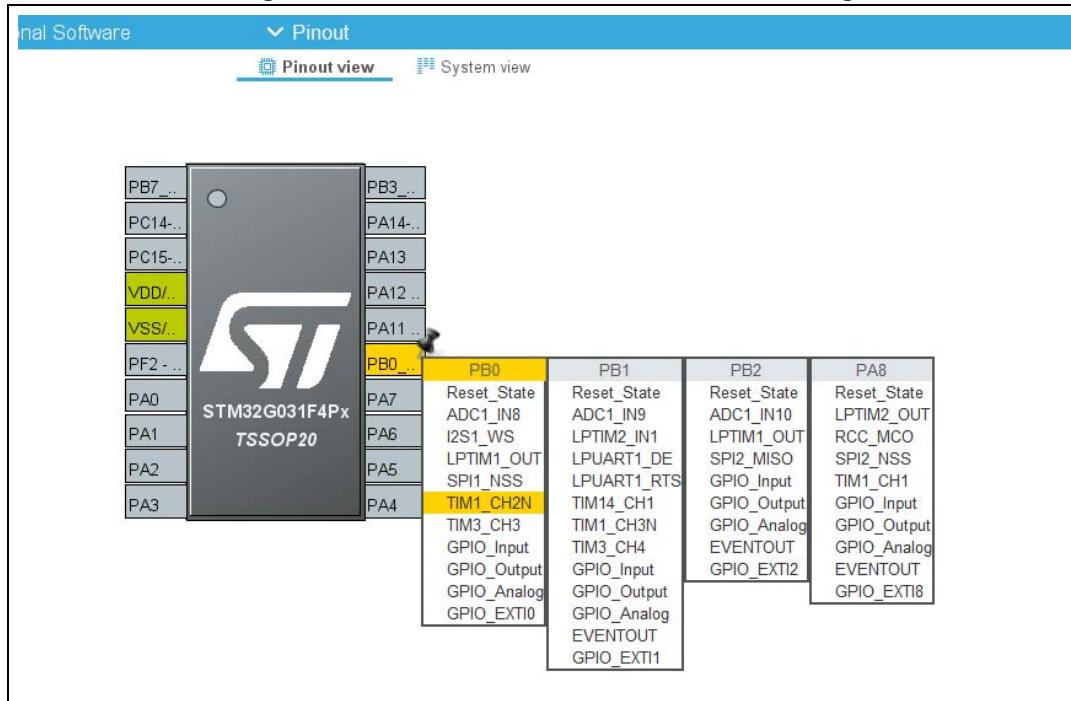
#### 4.4.8 Pinout for multi-bonding packages

Multi-bonding has been introduced for packages with low pin counts (less than 20 pins) such as SO8N, TSSOP20 and WLCSP18 packages. It consists of having several MCU pads share a same pin on the package.

Multi-bonding has been introduced on the STM32G0 series for the STM32G031/G041 MCUs.

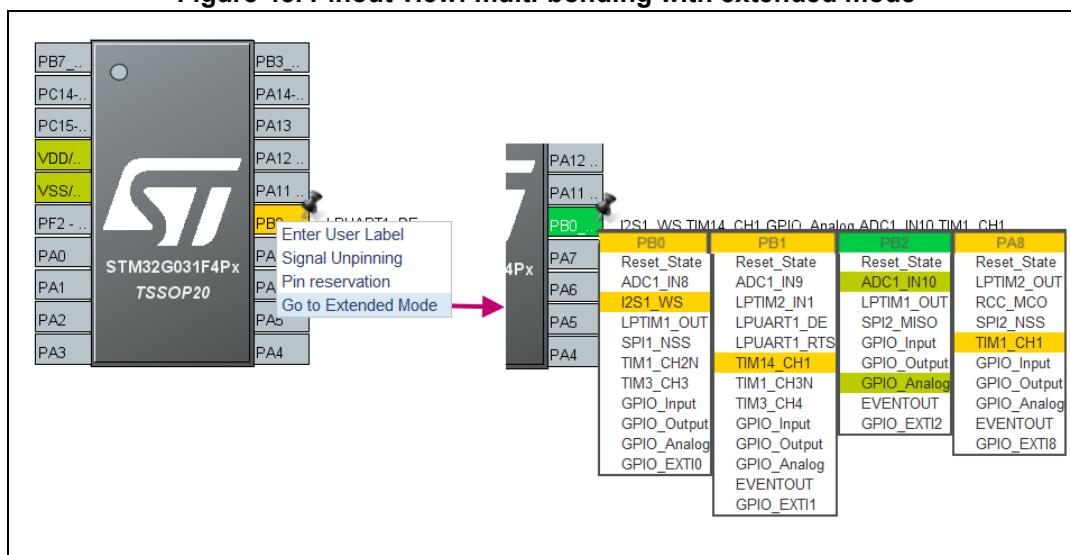
STM32CubeMX pinout view allows to displays all signals arriving on the pin and allows to select only one per pin, except for analog signals that can be combined with other analog GPIOs.

Figure 47. Pinout view: MCUs with multi-bonding



STM32CubeMX offers also an extended mode selected by right-clicking the pin: it allows to select more than one signal per pin. This mode is meant for test purposes such as loopback tests. It is to be used with caution as it can lead to electrical conflicts or increased power consumption that can damage the device.

Figure 48. Pinout view: multi-bonding with extended mode



#### 4.4.9 System view

Select **System view** to show all the software configurable components: GPIOs, peripherals and middleware. Clickable buttons allow the user to open the mode and

configuration options of the component. The button icon reflects the component configuration status (see [Table 7](#) for configuration states and Figure System view).

When the user changes the component configuration from the Configuration panel, the system view is automatically refreshed with the new configuration state.

If the user disables the component from the Mode panel, the system view is automatically refreshed and there is no longer a button showing for that component.

**Figure 49. System view**

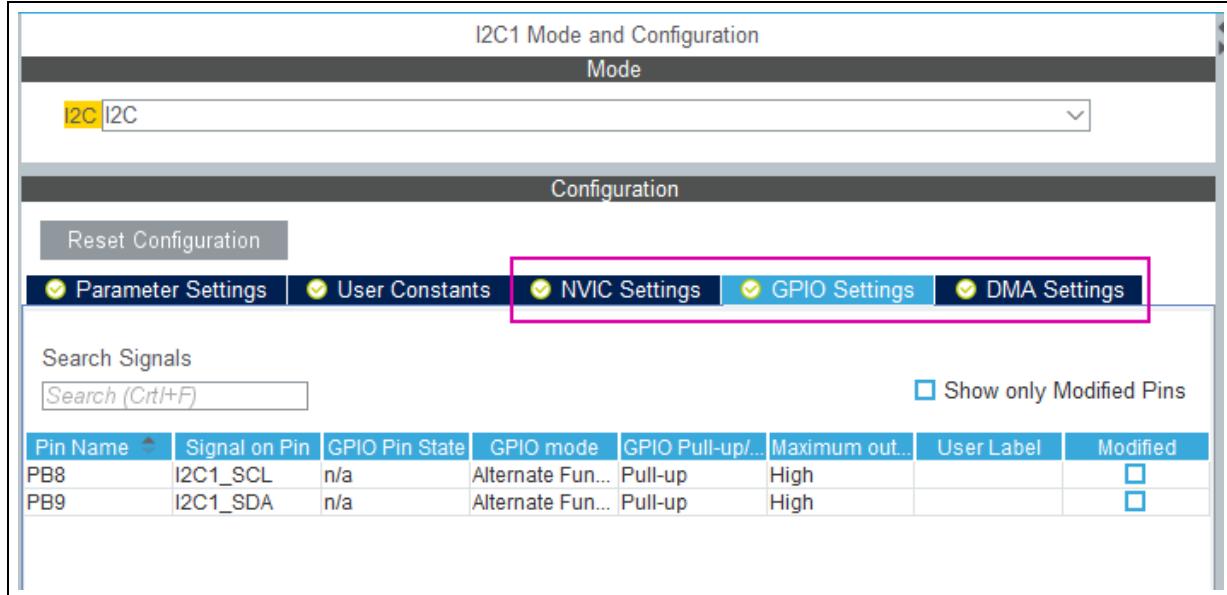


**Table 7. Configuration states**

Icon	Description
	Configuration is complete and correct.
	Configuration is correct but some parts remain to be configured (may be optional).
	Configuration is invalid and needs to be fixed for the generated C project to be functional.

GPIO, DMA and NVIC settings can be accessed either via a dedicated button (like other peripherals or via a tab in the Configuration panel (see [Figure 50](#)).

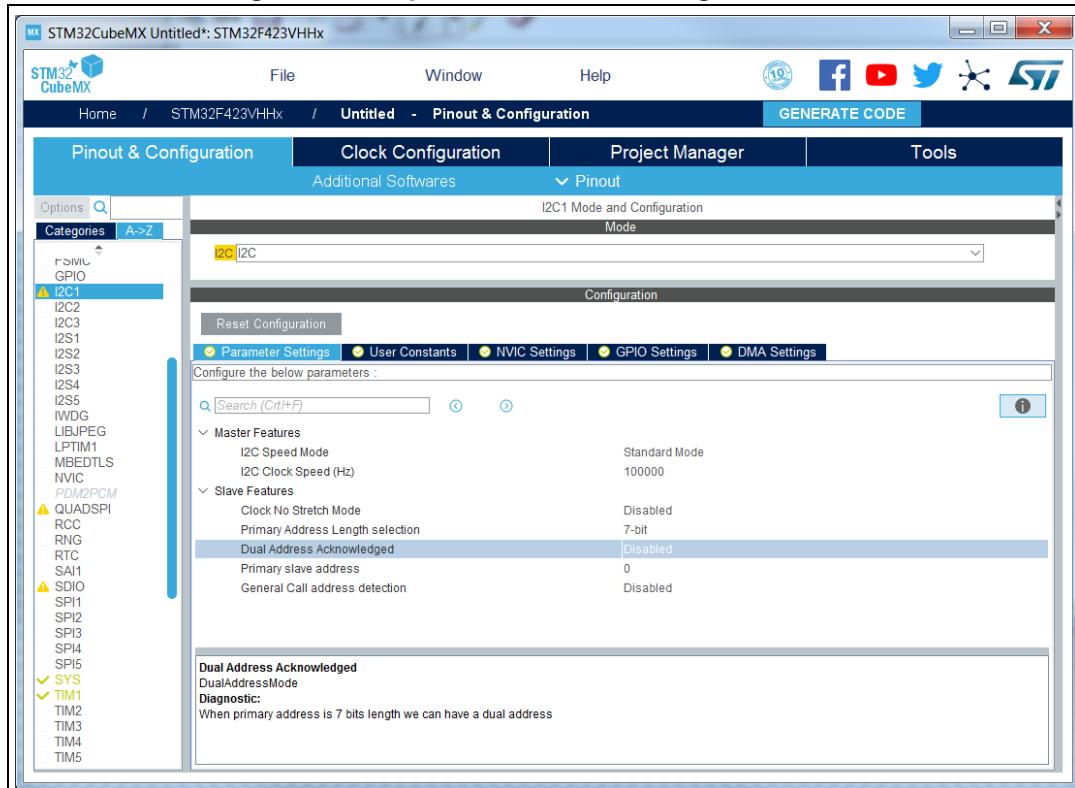
**Figure 50. Configuration window tabs (GPIO, DMA and NVIC settings for STM32F4 Series)**



#### 4.4.10 Component Configuration panel

This panel appears when clicking on a component name in the left panel. It allows the user to configure the functional parameters required to initialize the peripheral or the middleware in the selected operating mode (see [Figure 51](#)). STM32CubeMX uses these settings to generate the corresponding initialization C code.

Figure 51. Peripheral Mode and Configuration view



The configuration window includes several tabs:

- **Parameter settings** to configure library dedicated parameters for the selected peripheral or middleware,
- **NVIC, GPIO and DMA settings** to set the parameters for the selected peripheral (see [Section 4.4.14](#), [Section 4.4.12](#) and [Section 4.4.13](#) for configuration details).
- **User constants** to create one or several user defined constants, common to the whole project (see [Section 4.4.11](#) for user constants details).

Invalid settings are detected and are:

- reset to minimum / maximum valid value if user choice is, respectively, smaller / larger than minimum / maximum threshold
- reset to previous valid value if the previous value is neither a maximum nor a minimum threshold value
- highlighted in fuchsia.

**Table 8** describes peripheral and middleware configuration buttons and messages.

**Table 8. Peripheral and Middleware Configuration window buttons and tooltips**

Buttons and messages	Action
	Shows and Hides the description panel.
Tooltip  Enabled Disabled Enabled  Disabled I2C_DUALADDRESS_ENABLE	Guides the user through the settings of parameters with valid min-max range. To display it, move the mouse over a parameter value from a list of possible values.
I2C Clock Speed (Hz) 100000  ✓ Decimal Hexadecimal No check	Clicking on the gear icon allows to select whether to display hexadecimal or decimal values, or any value unchecked (No check option).
Search (Ctrl+F)	Search
Reset Configuration	Resets the component back to its default configuration (initial settings from STM32CubeMX).

### No check option

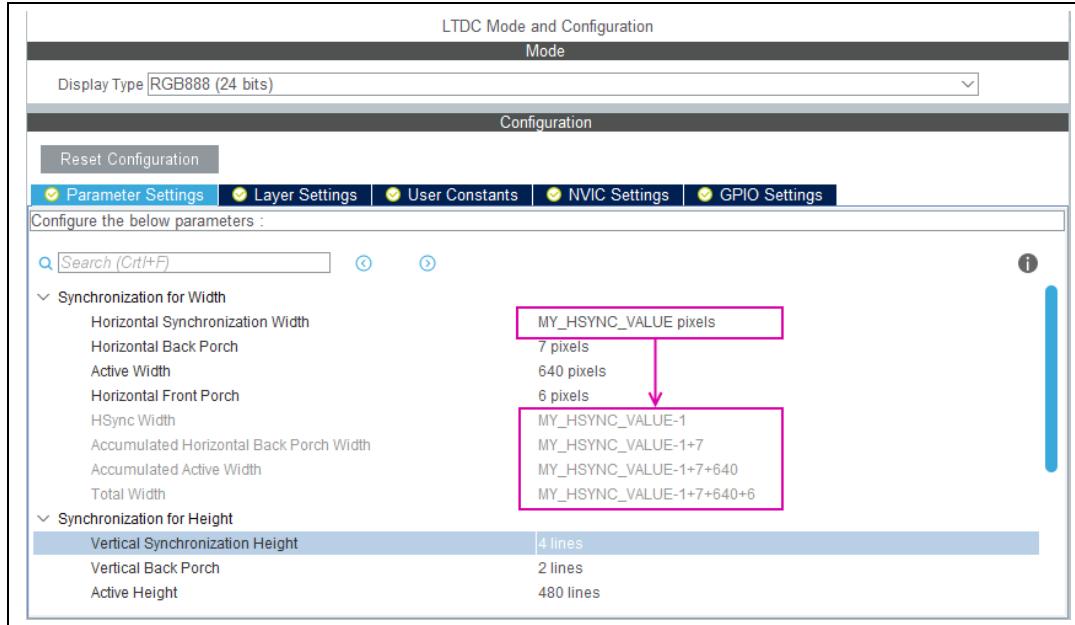
By default, STM32CubeMX checks that the parameter values entered by the user are valid. You can bypass this check by selecting the option No Check for a given parameter. This allows entering you any value (such as a constant) that might not be known by STM32CubeMX configuration.

The validity check can be bypassed only on parameters whose values are of integer type (either hexadecimal or decimal). It cannot be bypassed on parameters coming from a predefined list of possible values or on those which are of non-integer or text type.

To go back to the default mode (decimal or hexadecimal values with validity check enabled), enter a decimal or hexadecimal value and check the relevant option (hexadecimal or decimal check).

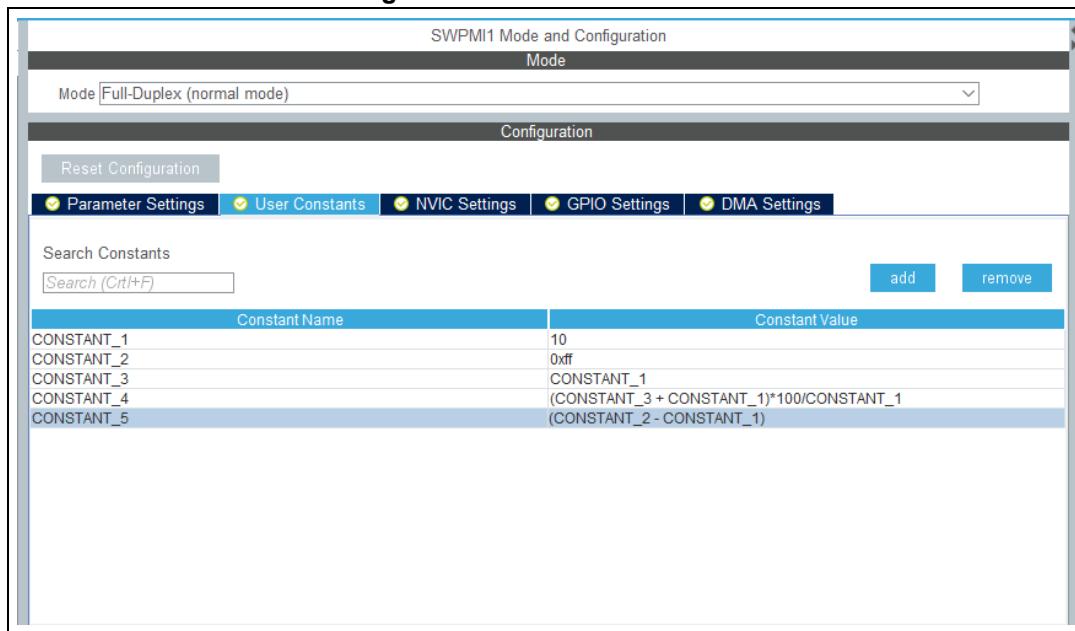
**Caution:** When a parameter depends upon another parameter that is set to No Check:

- Case of a parameter depending on another parameter for the evaluation of its minimum or maximum possible value: If the other parameter is set to No Check, the minimum or maximum value is no longer evaluated and checked.
- Case of a parameter depending on another parameter for the evaluation of its current value: If the other parameter is set to No Check, the value is no longer automatically derived. Instead, it is replaced with the formula text showing as variable the string of the parameter set to No check (see [Figure 52](#)).

**Figure 52. Formula when input parameter is set in No Check mode**

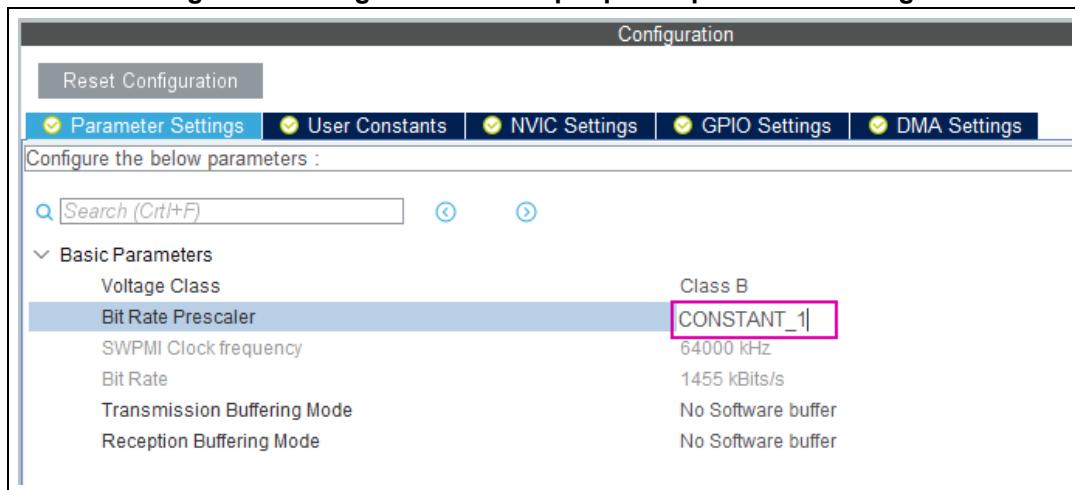
#### 4.4.11 User Constants configuration window

An **User Constants** tab is available to define user constants (see [Figure 53](#)). Constants are automatically generated in the STM32CubeMX user project within the main.h file (see [Figure 54](#)). Once defined, they can be used to configure peripheral and middleware parameters (see [Figure 55](#)).

**Figure 53. User Constants tab**

**Figure 54. Extract of the generated main.h file**

```
/* Includes ----- */  
  
/* USER CODE BEGIN Includes */  
  
/* USER CODE END Includes */  
  
/* Private define ----- */  
#define CONSTANT_1 10  
#define CONSTANT_2 0xff  
#define CONSTANT_3 CONSTANT_1  
#define CONSTANT_4 (CONSTANT_3+CONSTANT_1)*100/CONSTANT_1  
#define CONSTANT_5 (CONSTANT_2 - CONSTANT_1)  
  
/* USER CODE BEGIN Private defines */  
  
/* USER CODE END Private defines */
```

**Figure 55. Using constants for peripheral parameter settings**

### Creating/editing user constants

Click the **Add** button to open the **User Constants** tab and create a new user-defined constant (see [Figure 56](#)).

A constant consists of:

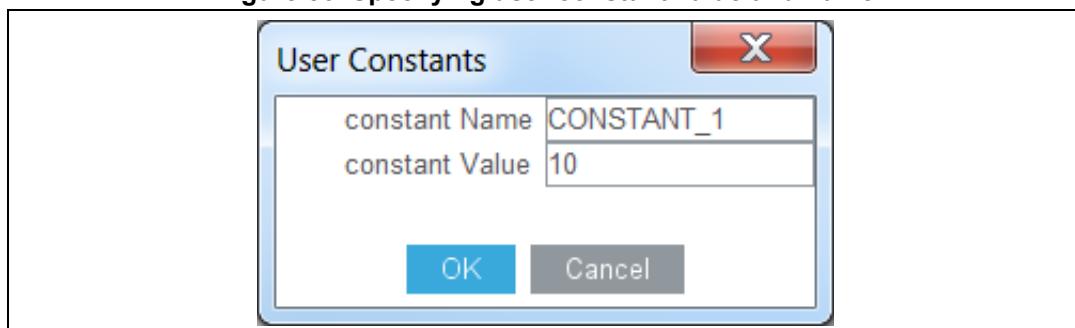
- A name that must comply with the following rules:
  - It must be unique.
  - It shall not be a C/C++ keyword.
  - It shall not contain a space.
  - It shall not start with digits.
- A value

The constant value can be (see [Figure 53](#) for examples):

- a simple decimal or hexadecimal value
- a previously defined constant
- a formula using arithmetic operators (subtraction, addition, division, multiplication, and remainder) and numeric value or user-defined numeric constants as operands
- a character string: the string value must be between double quotes (example: "constant\_for\_usart").

Once a constant is defined, its name and/or its value can still be changed: double- click the row that specifies the user constant to be modified. This opens the **User Constants** tab for edition. The change of constant name is applied wherever the constant is used. This does not affect the peripheral or middleware configuration state. However changing the constant value impacts the parameters that use it and might result in invalid settings (e.g. exceeding a maximum threshold). Invalid parameter settings are highlighted in fuchsia.

**Figure 56. Specifying user constant value and name**



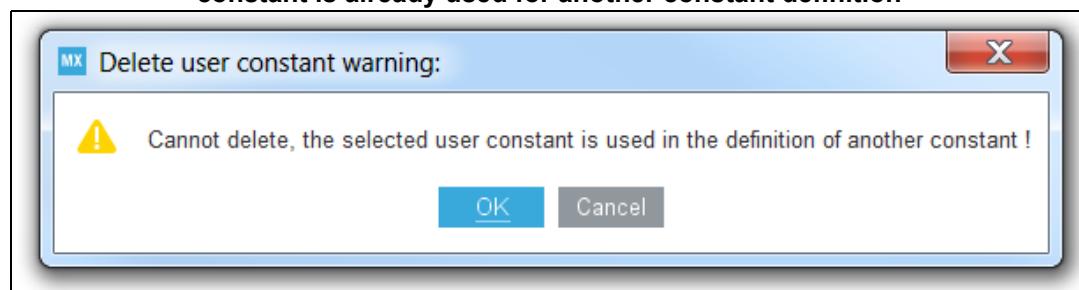
## Deleting user constants

Click the **Remove** button to delete an existing user-defined constant.

The user constant is then automatically removed except in the following cases:

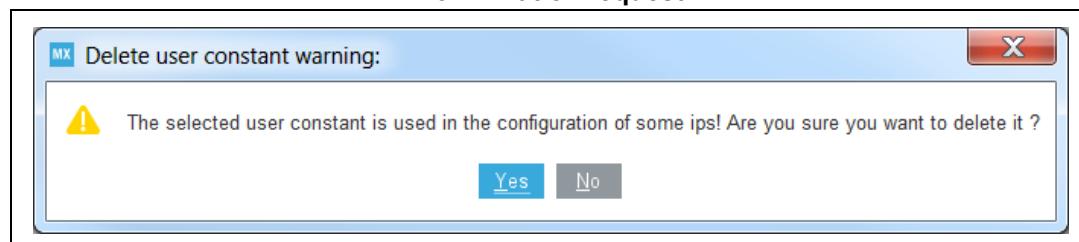
- When the constant is used for the definition of another constant. In this case, a popup window displays an explanatory message (see [Figure 57](#)).

**Figure 57. Deleting an user constant is not allowed when the constant is already used for another constant definition**



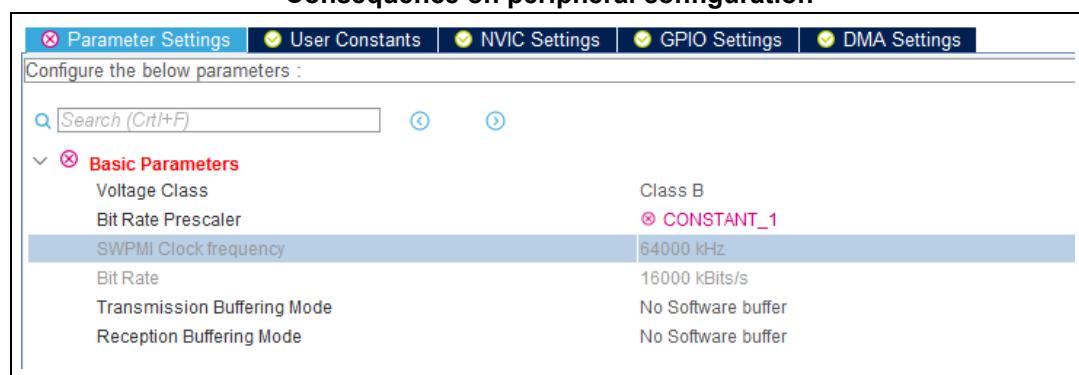
- When the constant is used for the configuration of a peripheral or middleware library parameter. In this case, the user is requested to confirm the deletion since the constant removal results in an invalid peripheral or middleware configuration (see [Figure 58](#)).

**Figure 58. Deleting an user constant used for parameter configuration - Confirmation request**



Clicking **Yes** leads to an invalid peripheral configuration (see [Figure 59](#))

**Figure 59. Deleting a user constant used for peripheral configuration - Consequence on peripheral configuration**



### Searching for user constants

The **Search Constants** field makes it possible the search of a constant name or value in the complete list of user constants (see [Figure 60](#) and [Figure 61](#)).

**Figure 60. Searching for a name in a user constant list**

NVIC Settings	GPIO Settings	DMA Settings	User Constants		
Parameter Settings		User Constants			
Search Constants					
<input type="text" value="CONSTANT_1"/>					
Constant Name	Constant Value				
CONSTANT_1	10	CONSTANT_1 + CONSTANT_2			
CONSTANT_3					

**Figure 61. Searching for a value in a user constant list**

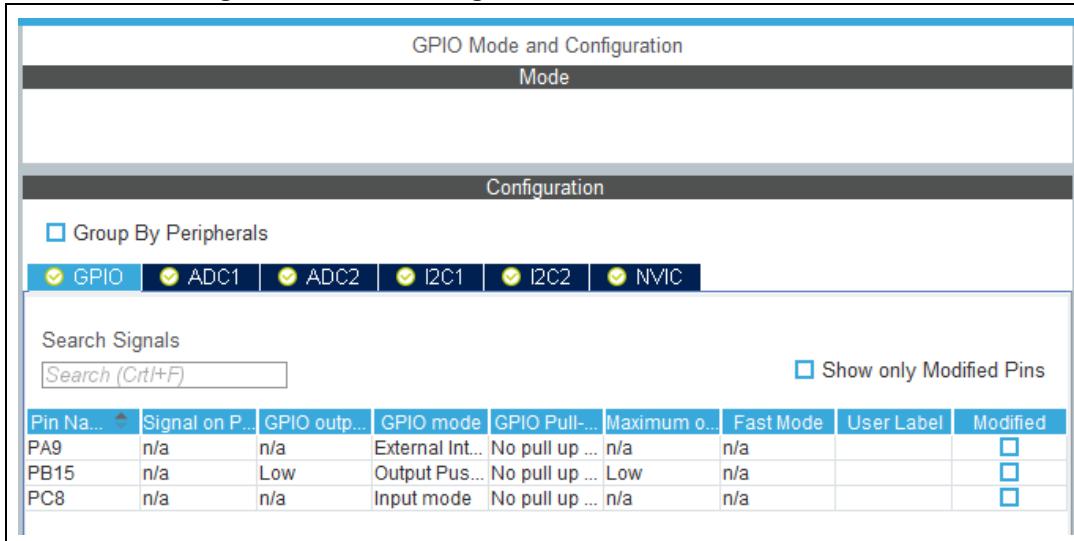
NVIC Settings	GPIO Settings	DMA Settings	User Constants		
Parameter Settings		User Constants			
Search Constants					
<input type="text" value="10"/>					
Constant Name	Constant Value				
CONSTANT_1	10				

#### 4.4.12 GPIO Configuration window

Click **GPIO** in the **System view** panel to open the **GPIO configuration** window that allows you to configure the GPIO pin settings (see [Figure 62](#)). The configuration is populated with default values that might not be adequate for some peripheral configurations. In particular, check if the GPIO speed is sufficient for the peripheral communication speed and select the internal pull-up whenever needed.

**Note:** *GPIO settings can also be accessed for a specific peripheral instance via the dedicated window in the peripheral instance configuration window. In addition, GPIOs can be configured in output mode (default output level). The generated code is updated accordingly.*

**Figure 62. GPIO Configuration window - GPIO selection**



Click on a row or select a set of rows to display the corresponding GPIO parameters:

- **GPIO PIN state**  
It changes the default value of the GPIO Output level. It is set to low by default and can be changed to high.
- **GPIO mode** (analog, input, output, alternate function)  
Selecting a peripheral mode in the **Pinout** view automatically configures the pins with the relevant alternate function and GPIO mode.
- **GPIO pull-up/pull-down**  
It is set to a default value and can be configured when other choices are possible.
- **GPIO maximum output speed** (for communication peripherals only)  
It is set to Low by default for power consumption optimization and can be changed to a higher frequency to fit application requirements.
- **User Label**  
It changes the default name (e.g. GPIO\_input) into a user defined name. The **Pinout** view is updated accordingly. The GPIO can be found under this new name via the **Find** menu.

The **Group by Peripherals** checkbox allows the user to group all instances of a peripheral under the same window (see [Figure 63](#)).

**Figure 63. GPIO configuration grouped by peripheral**

Pin Name	Signal...	GPIO output	GPIO mode	GPIO Pull...	Maximum ...	Fast Mode	User Label	Modified
PE9	n/a	Low	Output Pu...	No pull-u...	Low	n/a		<input type="checkbox"/>
PE14	n/a	n/a	Analog m...	No pull-u...	n/a	n/a		<input type="checkbox"/>
PF15	n/a	n/a	Input mode	No pull-u...	n/a	n/a		<input type="checkbox"/>

As shown in [Figure 64](#), row multi-selection can be performed to change a set of pins to a given configuration at the same time.

**Figure 64. Multiple Pins Configuration**

Pin Name	Signal...	GPIO output	GPIO mode	GPIO Pull...	Maximum ...	Fast Mode	User Label	Modified
PB6	I2C1_SCL	n/a	Alternate ...	No pull-u...	Low	Disable		<input type="checkbox"/>
PB9	I2C1_SDA	n/a	Alternate ...	Pull-up	Low	Disable		<input checked="" type="checkbox"/>
PF1	I2C2_SCL	n/a	Alternate ...	Pull-up	Low	n/a		<input checked="" type="checkbox"/>
PF0	I2C2_SDA	n/a	Alternate ...	Pull-up	Low	n/a		<input checked="" type="checkbox"/>
PA8	I2C3_SCL	n/a	Alternate ...	Pull-up	Low	n/a		<input checked="" type="checkbox"/>
PC9	I2C3_SDA	n/a	Alternate ...	No pull-u...	Low	n/a		<input type="checkbox"/>

PB9#PF1#PF0#PA8 Configuration :

GPIO mode	<input type="text"/>
GPIO Pull-up/Pull-down	<input type="text"/> Pull-up
Maximum output speed	<input type="text"/>
User Label	<input type="text"/>

#### 4.4.13 DMA Configuration window

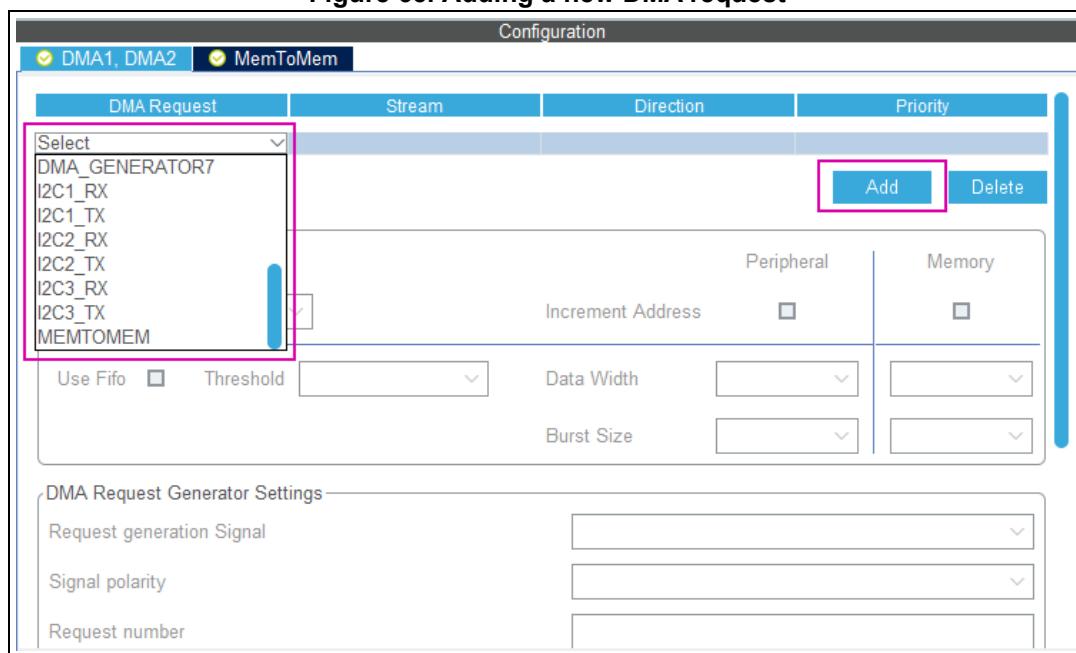
Click **DMA** in the **System** view to open the **DMA configuration** window.

This window is used to configure the generic DMA controllers available on the MCU. The DMA interfaces allow to perform data transfers between memories and peripherals while the CPU is running, and memory to memory transfers (if supported).

**Note:** Some peripherals (such as **USB** or **Ethernet**) have their own DMA controller, which is enabled by default or via the **Peripheral Configuration** window.

Clicking **Add** in the **DMA configuration** window adds a new line at the end of the DMA configuration window with a combo box proposing to choose between possible **DMA requests** to be mapped to peripherals signals (see [Figure 65](#)).

**Figure 65. Adding a new DMA request**

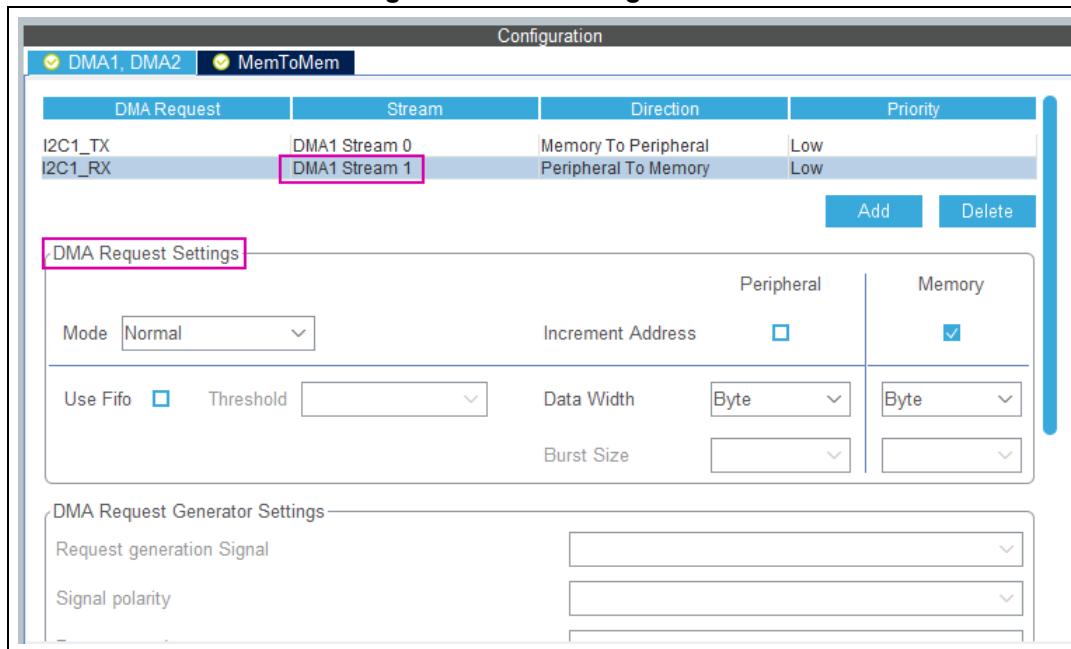


Selecting a DMA request automatically assigns a stream among all the streams available, a direction and a priority. When the DMA channel is configured, it is up to the application code to fully describe the DMA transfer run-time parameters such as the start address.

The DMA request (called channel for STM32F4 MCUs) is used to reserve a stream to transfer data between peripherals and memories (see [Figure 66](#)). The stream priority is used to decide which stream to select for the next DMA transfer.

DMA controllers support a dual priority system using the software priority first, and in case of equal software priorities, a hardware priority that is given by the stream number.

Figure 66. DMA configuration

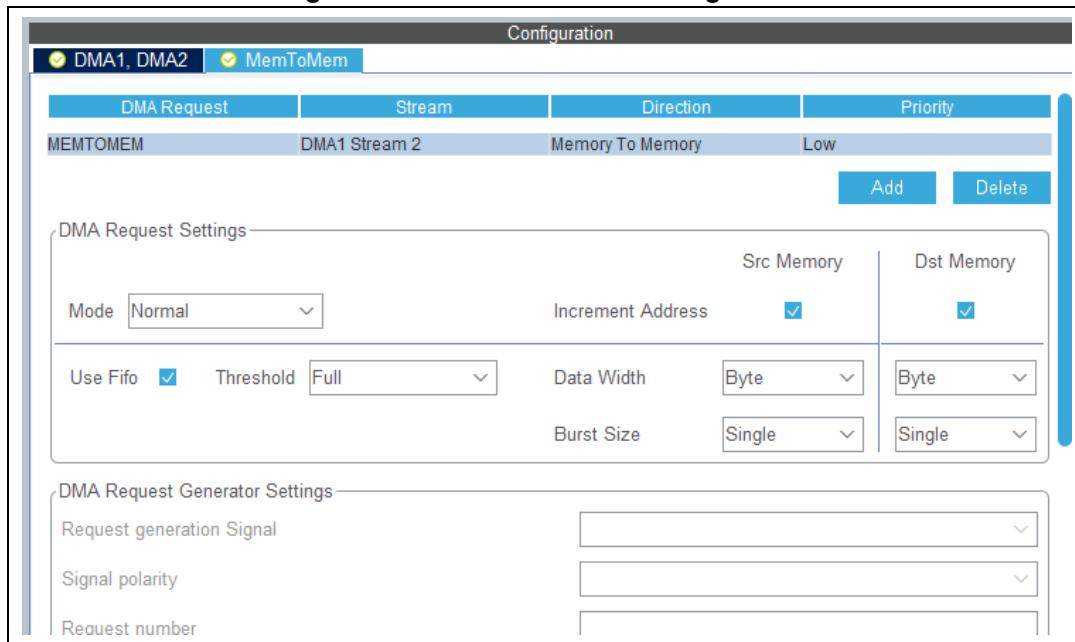


Additional DMA configuration settings can be done through the **DMA configuration** window:

- **Mode:** regular mode, circular mode, or peripheral flow controller mode (only available for the SDIO peripheral).
- **Increment Add:** the type of peripheral address and memory address increment (fixed or post-incremented in which case the address is incremented after each transfer). Click the checkbox to enable the post-incremented mode.
- **Peripheral data width:** 8, 16 or 32 bits
- Switching from the default direct mode to the *FIFO mode* with programmable *threshold*:
  - a) Click the **Use FIFO** checkbox.
  - b) Then, configure the **peripheral and memory data width** (8, 16 or 32 bits).
  - c) Select between **single transfer** and **burst transfer**. If you select burst transfer, choose a burst size (1, 4, 8 or 16).

In case of memory-to-memory transfer (MemToMem), the DMA configuration applies to a source memory and to a destination memory.

Figure 67. DMA MemToMem configuration



#### 4.4.14 NVIC Configuration window

Click **NVIC** in the **System** view to open the Nested Vector interrupt controller configuration window (see [Figure 68](#)).

Interrupt unmasking and interrupt handlers are managed within two tabs:

- The **NVIC** tab allows enabling peripheral interrupts in the NVIC controller and setting their priorities.
- The **Code generation** tab allows selecting options for interrupt related code generation.

##### Enabling interruptions using the NVIC tab view

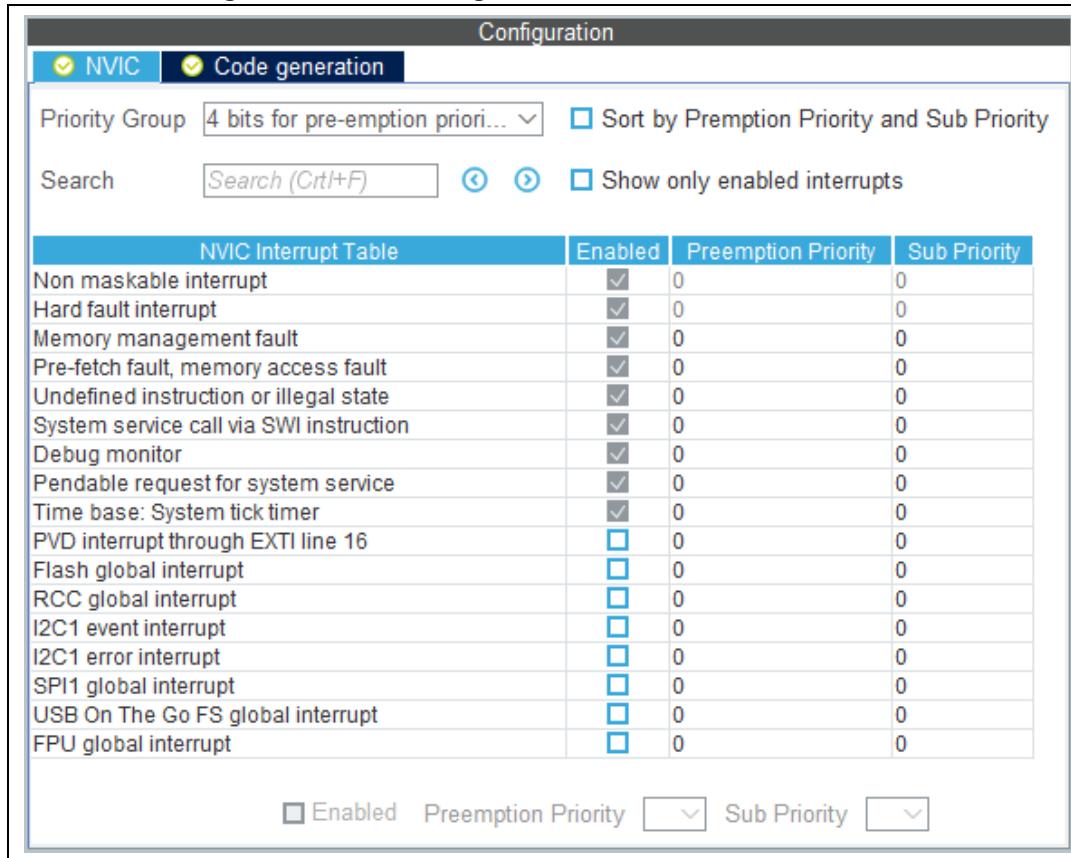
The **NVIC** view (see [Figure 68](#)) does not show all possible interrupts but only the ones available for the peripherals selected in the **Pinout & Configuration** panels. System interrupts are displayed but can never be disabled.

Check/Uncheck the **Show only enabled interrupts** box to filter or not enabled interrupts.

Use the **search field** to filter out the interrupt vector table according to a string value. As an example, after enabling UART peripherals from the **Pinout** panel, type **UART** in the NVIC search field and click the green arrow close to it: all UART interrupts are then displayed.

Enabling a **peripheral interrupt** generates NVIC function calls **HAL\_NVIC\_SetPriority** and **HAL\_NVIC\_EnableIRQ** for this peripheral.

Figure 68. NVIC Configuration tab - FreeRTOS disabled



The screenshot shows the NVIC Configuration tab in STM32CubeMX. The 'NVIC' tab is selected. At the top, there is a dropdown for 'Priority Group' set to '4 bits for pre-emption prior...', a checkbox for 'Sort by Preemption Priority and Sub Priority', and a search bar. Below these are two circular icons and a checkbox for 'Show only enabled interrupts'. The main area is a table titled 'NVIC Interrupt Table' with columns for 'Enabled', 'Preemption Priority', and 'Sub Priority'. The table lists various interrupt types, all of which are currently enabled (indicated by checked boxes in the 'Enabled' column). The 'Preemption Priority' and 'Sub Priority' columns are both set to 0 for all entries.

NVIC Interrupt Table	Enabled	Preemption Priority	Sub Priority
Non maskable interrupt	<input checked="" type="checkbox"/>	0	0
Hard fault interrupt	<input checked="" type="checkbox"/>	0	0
Memory management fault	<input checked="" type="checkbox"/>	0	0
Pre-fetch fault, memory access fault	<input checked="" type="checkbox"/>	0	0
Undefined instruction or illegal state	<input checked="" type="checkbox"/>	0	0
System service call via SWI instruction	<input checked="" type="checkbox"/>	0	0
Debug monitor	<input checked="" type="checkbox"/>	0	0
Pendable request for system service	<input checked="" type="checkbox"/>	0	0
Time base: System tick timer	<input checked="" type="checkbox"/>	0	0
PVD interrupt through EXTI line 16	<input type="checkbox"/>	0	0
Flash global interrupt	<input type="checkbox"/>	0	0
RCC global interrupt	<input type="checkbox"/>	0	0
I2C1 event interrupt	<input type="checkbox"/>	0	0
I2C1 error interrupt	<input type="checkbox"/>	0	0
SPI1 global interrupt	<input type="checkbox"/>	0	0
USB On The Go FS global interrupt	<input type="checkbox"/>	0	0
FPU global interrupt	<input type="checkbox"/>	0	0

Enabled     Preemption Priority     Sub Priority

When FreeRTOS is enabled, an additional column is shown (see [Figure 69](#)).

In this case, all the interrupt service routines (ISRs) that are calling the interrupt safe FreeRTOS APIs must have a priority lower than the priority defined in the LIBRARY\_MAX\_SYSCALL\_INTERRUPT\_PRIORITY parameter (the highest the value, the lowest the priority). The check in the corresponding checkbox guarantees that the restriction is applied.

If an ISR does not use such functions, the checkbox can be unchecked and any priority level can be set. It is possible to check/uncheck multiple rows (see rows highlighted in blue in [Figure 69](#)).

**Figure 69. NVIC Configuration tab - FreeRTOS enabled**

The screenshot shows the NVIC Configuration tab in STM32CubeMX with the "FreeRTOS" tab selected. The table displays the following data:

NVIC Interrupt Table	Enabl...	Preemption Pri...	Sub Prior...	Uses FreeRTOS fun...
Non maskable interrupt	<input checked="" type="checkbox"/>	0	0	<input type="checkbox"/>
Hard fault interrupt	<input checked="" type="checkbox"/>	0	0	<input checked="" type="checkbox"/>
Memory management fault	<input checked="" type="checkbox"/>	0	0	<input checked="" type="checkbox"/>
Pre-fetch fault, memory access fault	<input checked="" type="checkbox"/>	0	0	<input checked="" type="checkbox"/>
Undefined instruction or illegal state	<input checked="" type="checkbox"/>	0	0	<input checked="" type="checkbox"/>
System service call via SWI instruction	<input checked="" type="checkbox"/>	0	0	<input checked="" type="checkbox"/>
Debug monitor	<input checked="" type="checkbox"/>	0	0	<input checked="" type="checkbox"/>
Pendable request for system service	<input checked="" type="checkbox"/>	15	0	<input checked="" type="checkbox"/>
Time base: System tick timer	<input checked="" type="checkbox"/>	15	0	<input checked="" type="checkbox"/>
PVD interrupt through EXTI line 16	<input type="checkbox"/>	5	0	<input checked="" type="checkbox"/>
Flash global interrupt	<input type="checkbox"/>	5	0	<input checked="" type="checkbox"/>
RCC global interrupt	<input type="checkbox"/>	5	0	<input checked="" type="checkbox"/>
I2C1 event interrupt	<input type="checkbox"/>	5	0	<input checked="" type="checkbox"/>
I2C1 error interrupt	<input type="checkbox"/>	5	0	<input checked="" type="checkbox"/>
SPI1 global interrupt	<input type="checkbox"/>	5	0	<input checked="" type="checkbox"/>
USB On The Go FS global interrupt	<input type="checkbox"/>	5	0	<input checked="" type="checkbox"/>
FPU global interrupt	<input type="checkbox"/>	5	0	<input checked="" type="checkbox"/>

Below the table are filter buttons for Enabled, Preemption Priority, Sub Priority, and Uses FreeRTOS functions.

Peripheral dedicated interrupts can also be accessed through the NVIC window in the Peripheral Configuration window (see [Figure 70](#)).

**Figure 70. I2C NVIC Configuration window**

The screenshot shows the Peripheral Configuration window with the "NVIC Settings" tab selected. The table displays the following data:

NVIC Interrupt Table	Enabled	Preemption Priority	Sub Priority
I2C1 event interrupt	<input checked="" type="checkbox"/>	5	0
I2C1 error interrupt	<input type="checkbox"/>	5	0

STM32CubeMX NVIC configuration consists in selecting a priority group, enabling/disabling interrupts and configuring interrupts priority levels (preemption and sub-priority levels):

1. Select a **priority group**

Several bits allow to define NVIC priority levels. These bits are divided in two priority groups corresponding to two priority types: preemption priority and sub-priority. For example, in the case of STM32F4 MCUs, the NVIC priority group 0 corresponds to 0-bit preemption and 4-bit sub-priority.

2. In the interrupt table, click one or more rows to select one or more interrupt vectors. Use the widgets below the interrupt table to configure the vectors one by one or several at a time:
  - **Enable checkbox:** check/uncheck to enable/disable the interrupt.
  - **Preemption priority:** select a priority level. The preemption priority defines the ability of one interrupt to interrupt another.
  - **Sub-priority:** select a priority level. The sub-priority defines the interrupt priority level.

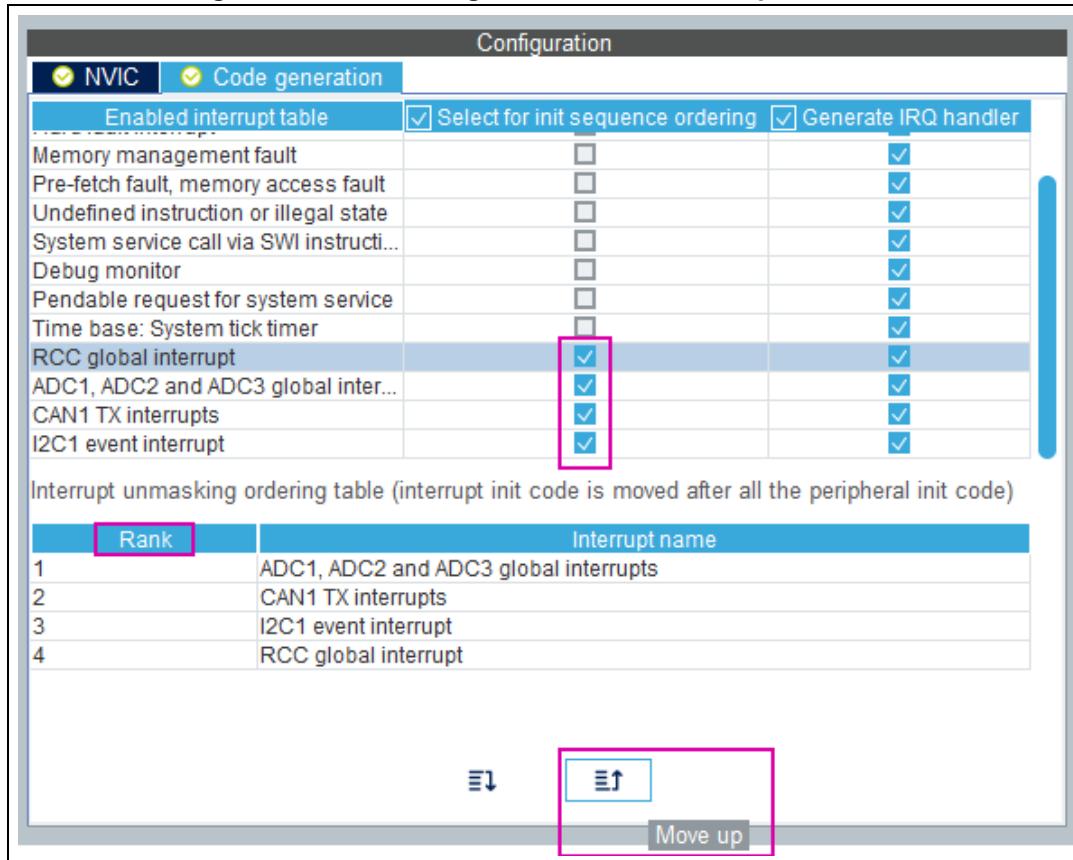
### Code generation options for interrupt handling

The **Code Generation** view allows customizing the code generated for interrupt initialization and interrupt handlers:

- **Selection/Deselection of all interrupts for sequence ordering and IRQ handler code generation**

Use the checkboxes in front of the column names to configure all interrupts at a time (see [Figure 71](#)). Note that system interrupts are not eligible for init sequence reordering as the software solution does not control it.

Figure 71. NVIC Code generation – All interrupts enabled



- **Default initialization sequence of interrupts**

By default, the interrupts are enabled as part of the peripheral MSP initialization function, after the configuration of the GPIOs and the enabling of the peripheral clock.

This is shown in the CAN example below, where *HAL\_NVIC\_SetPriority* and *HAL\_NVIC\_EnableIRQ* functions are called within *stm32xxx\_hal\_msp.c* file inside the peripheral *msp\_init* function.

Interrupt enabling code is shown in bold:

```
void HAL_CAN_MspInit(CAN_HandleTypeDef* hcan)
{
  GPIO_InitTypeDef GPIO_InitStruct;
  if(hcan->Instance==CAN1)
  {
    /* Peripheral clock enable */
    __CAN1_CLK_ENABLE();
    /**CAN1 GPIO Configuration
    PD0      -----> CAN1_RX
    PD1      -----> CAN1_TX
    */
    GPIO_InitStruct.Pin = GPIO_PIN_0|GPIO_PIN_1;
    GPIO_InitStruct.Mode = GPIO_MODE_AF_PP;
```

```

GPIO_InitStruct.Pull = GPIO_NOPULL;
GPIO_InitStruct.Speed = GPIO_SPEED_FREQ_VERY_HIGH;
GPIO_InitStruct.Alternate = GPIO_AF9_CAN1;
HAL_GPIO_Init(GPIOD, &GPIO_InitStruct);

/* Peripheral interrupt init */
HAL_NVIC_SetPriority(CAN1_TX_IRQn, 2, 2);
HAL_NVIC_EnableIRQ(CAN1_TX_IRQn);
}

}

For EXTI GPIOs only, interrupts are enabled within the MX_GPIO_Init function:

/*Configure GPIO pin : MEMS_INT2_Pin */
GPIO_InitStruct.Pin = MEMS_INT2_Pin;
GPIO_InitStruct.Mode = GPIO_MODE_EVT_RISING;
GPIO_InitStruct.Pull = GPIO_NOPULL;
HAL_GPIO_Init(MEMS_INT2_GPIO_Port, &GPIO_InitStruct);

/* EXTI interrupt init*/
HAL_NVIC_SetPriority(EXTI15_10_IRQn, 0, 0);
HAL_NVIC_EnableIRQ(EXTI15_10_IRQn);

```

For some peripherals, the application still needs to call another function to actually activate the interruptions. Taking the timer peripheral as an example, the *HAL\_TIM\_IC\_Start\_IT* function needs to be called to start the Timer input capture (IC) measurement in interrupt mode.

- **Configuration of interrupts initialization sequence**

Checking **Select for Init sequence ordering** for a set of peripherals moves the *HAL\_NVIC* function calls for each peripheral to a same dedicated function, named **MX\_NVIC\_Init**, defined in the main.c. Moreover, the *HAL\_NVIC* functions for each peripheral are called in the order specified in the **Code generation** view bottom part (see *Figure 72*).

As an example, the configuration shown in *Figure 72* generates the following code:

```

/** NVIC Configuration
*/
void MX_NVIC_Init(void)
{
    /* CAN1_TX_IRQn interrupt configuration */
    HAL_NVIC_SetPriority(CAN1_TX_IRQn, 2, 2);
    HAL_NVIC_EnableIRQ(CAN1_TX_IRQn);
    /* PVD_IRQn interrupt configuration */
    HAL_NVIC_SetPriority(PVD_IRQn, 0, 0);
    HAL_NVIC_EnableIRQ(PVD_IRQn);
    /* FLASH_IRQn interrupt configuration */
    HAL_NVIC_SetPriority(FLASH_IRQn, 0, 0);
    HAL_NVIC_EnableIRQ(FLASH_IRQn);
    /* RCC_IRQn interrupt configuration */
    HAL_NVIC_SetPriority(RCC_IRQn, 0, 0);
    HAL_NVIC_EnableIRQ(RCC_IRQn);
}

```

```

    HAL_NVIC_SetPriority(RCC_IRQn, 0, 0);
    HAL_NVIC_EnableIRQ(CAN1_IRQn);
    /* ADC_IRQn interrupt configuration */
    HAL_NVIC_SetPriority(ADC_IRQn, 0, 0);
    HAL_NVIC_EnableIRQ(ADC_IRQn);
}

```

- **Interrupts handler code generation**

By default, STM32CubeMX generates interrupt handlers within the `stm32xxx_it.c` file. As an example:

```

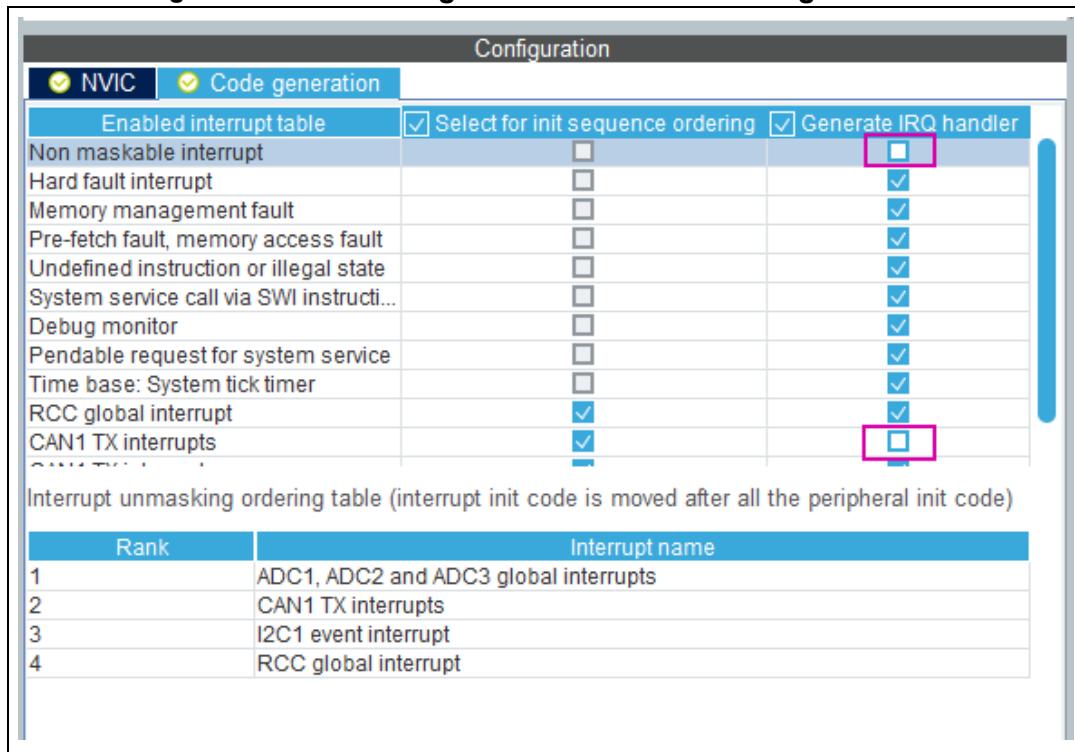
void NMI_Handler(void)
{
    HAL_RCC_NMI_IRQHandler();
}

void CAN1_TX_IRQHandler(void)
{
    HAL_CAN_IRQHandler(&hcan1);
}

```

The column **Generate IRQ Handler** allows the user to control whether the interrupt handler function call can be generated or not. Deselecting CAN1\_TX and NMI interrupts from the **Generate IRQ Handler** column as shown in [Figure 72](#) removes the code mentioned earlier from the `stm32xxx_it.c` file.

**Figure 72. NVIC Code generation – IRQ Handler generation**

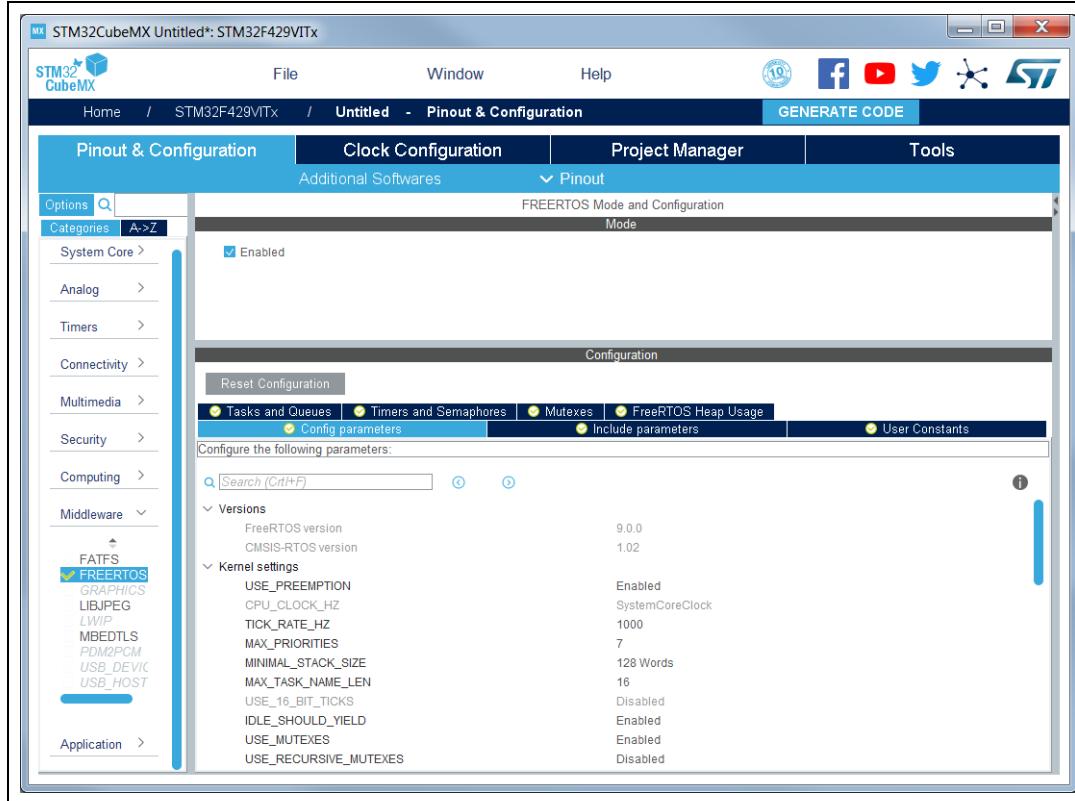


#### 4.4.15 FreeRTOS configuration panel

Through STM32CubeMX FreeRTOS configuration window, the user can configure all the resources required for a real-time OS application and reserve the corresponding heap. FreeRTOS elements are defined and created in the generated code using CMSIS-RTOS API functions. Follow the sequence below:

1. In the **Pinout & Configuration** tab, click FreeRTOS to reveal the Mode and configuration panels (see *Figure 73*).
2. Enable freeRTOS in the Mode panel.
3. Go to the configuration panel to proceed with configuring FreeRTOS native parameters and objects, such as tasks, timers, queues, and semaphores. In the Config tab, configure Kernel and Software settings. In the Include parameters tab, select the API functions required by the application and this way, optimize the code size. Both Config and Include parameters are part of the FreeRTOSConfig.h file.

**Figure 73. FreeRTOS configuration view**



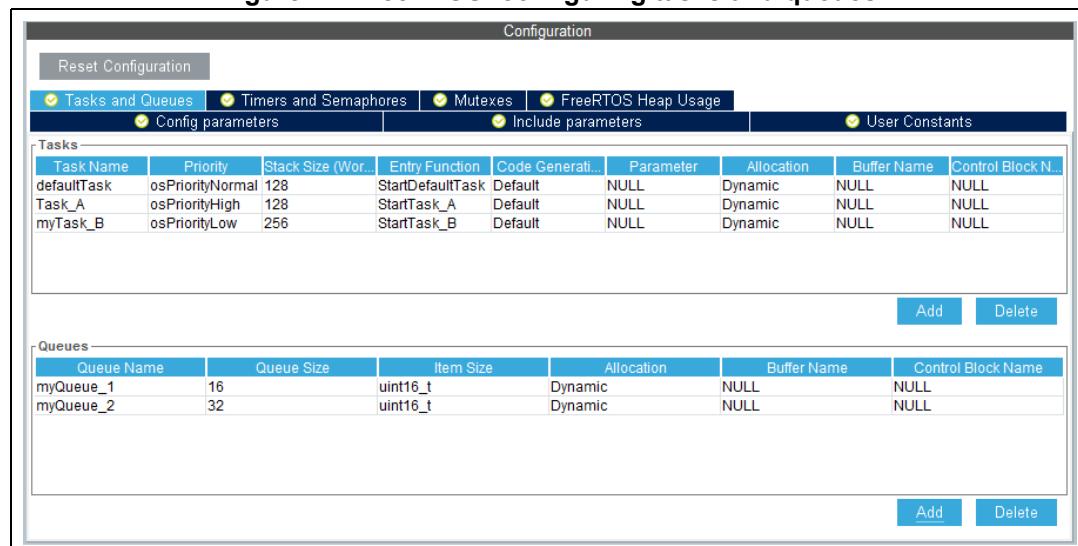
## Tasks and Queues Tab

As any RTOS, FreeRTOS allows structuring a real-time application into a set of independent tasks, with only one task being executed at a given time. Queues are meant for inter-task communications: they allow to exchange messages between tasks or between interrupts and tasks.

In STM32CubeMX, the **FreeRTOS Tasks and Queues** tab enables the creation and configuration of such tasks and queues (see [Figure 74](#)). The corresponding initialization code is generated within main.c or freeRTOS.c if the option “generate code as pair of .c/.h files per peripherals and middleware” is set in the **Project Settings** menu.

The corresponding initialization code is generated within main.c by default or within freeRTOS.c if the option “generate code as pair of .c/.h files per peripherals and middleware” is set in the **Project Manager** menu.

**Figure 74. FreeRTOS: configuring tasks and queues**



- Tasks

Under the **Tasks** section, click the **Add** button to open the **New Task** window where **task name**, **priority**, **stack size** and **entry function** can be configured (see [Figure 75](#)). These settings can be updated at any time: double-clicking a task row opens again the new task window for editing.

The entry function can be generated as weak or external:

- When the task is generated as **weak**, the user can propose a definition different from the one generated by default.
- When the task is **extern**, it is up to the user to provide its function definition.

By default, the function definition is generated including user sections to allow customization.

- Queues

Under the **Queues** section, click the **Add** button to open the **New Queue** window where the queue **name**, **size** and **item size** can be configured (see [Figure 75](#)). The queue size corresponds to the maximum number of items that the queue can hold at a

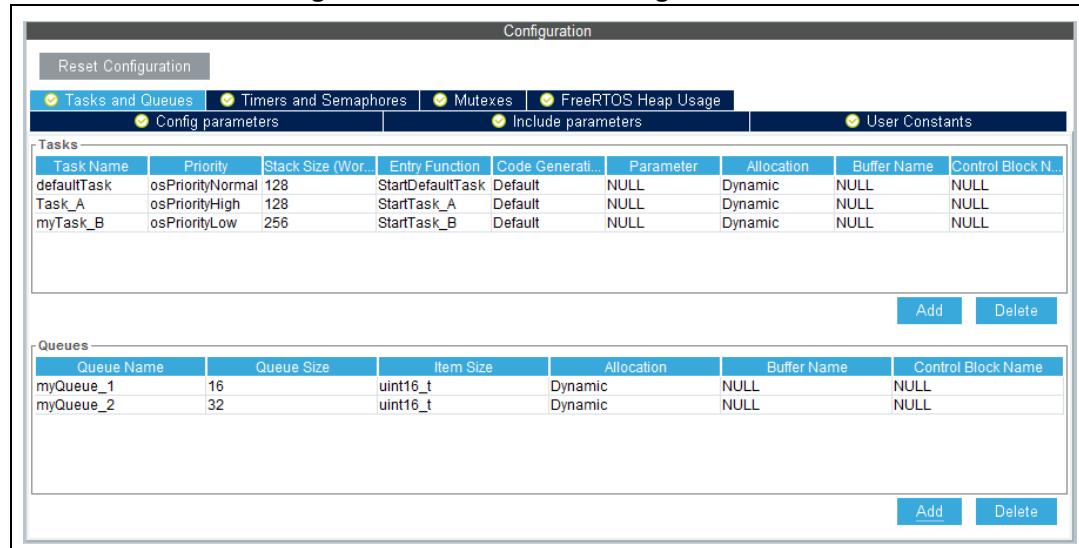
time, while the item size is the size of each data item stored in the queue. The item size can be expressed either in number of bytes or as a data type:

- 1 byte for uint8\_t, int8\_t, char and portCHAR types
- 2 bytes for uint16\_t, int16\_t, short and portSHORT types
- 4 bytes for uint32\_t, int32\_t, int, long and float
- 8 bytes for uint64\_t, int64\_t and double

By default, the FreeRTOS heap usage calculator uses four bytes when the item size cannot be automatically derived from user input.

These settings can be updated at any time: double-clicking a queue row opens again the new queue window for editing.

**Figure 75. FreeRTOS: creating a new task**



The following code snippet shows the generated code corresponding to [Figure 74](#).

```

/* Create the thread(s) */
/* definition and creation of defaultTask */
osThreadDef(defaultTask, StartDefaultTask, osPriorityNormal, 0, 128);
defaultTaskHandle = osThreadCreate(osThread(defaultTask), NULL);

/* definition and creation of Task_A */
osThreadDef(Task_A, StartTask_A, osPriorityHigh, 0, 128);
Task_AHandle = osThreadCreate(osThread(Task_A), NULL);

/* definition and creation of Task_B */
osThreadDef(Task_B, StartTask_B, osPriorityLow, 0, 256);
Task_BHandle = osThreadCreate(osThread(Task_B), NULL);

/* Create the queue(s) */
/* definition and creation of myQueue_1 */
osMessageQDef(myQueue_1, 16, 4);
myQueue_1Handle = osMessageCreate(osMessageQ(myQueue_1), NULL);

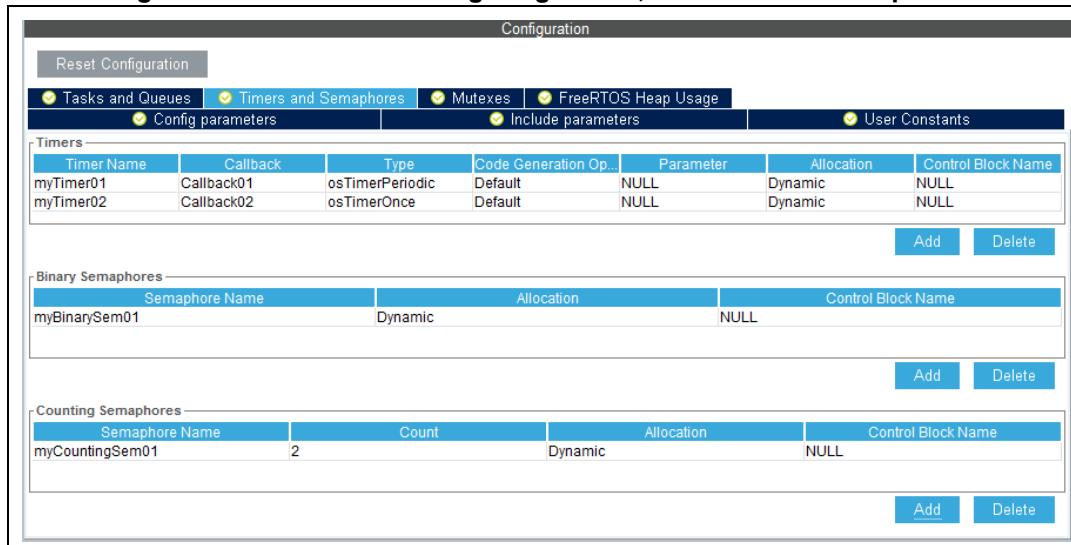
/* definition and creation of myQueue_2 */
osMessageQDef(myQueue_2, 32, 2);
myQueue_2Handle = osMessageCreate(osMessageQ(myQueue_2), NULL);

```

## Timers, Mutexes and Semaphores

FreeRTOS timers, mutexes and semaphores can be created via the FreeRTOS **Timers and Semaphores** tab. They first need to be enabled from the Config tab (see [Figure 76](#)).

**Figure 76. FreeRTOS - Configuring timers, mutexes and semaphores**



Under each object dedicated section, clicking the **Add** button to open the corresponding **New <object>** window where the object specific parameters can be specified. Object settings can be modified at any time: double-clicking the relevant row opens again the **New <object>** window for edition.

**Note:** *Expand the window if the newly created objects are not visible.*

- Timers

Prior to creating timers, their usage (USE\_TIMERS definition) must be enabled in the **software timer definitions section** of the **Configuration parameters** tab. In the same section, timer task priority, queue length and stack depth can be also configured. The timer can be created to be one-shot (run once) or auto-reload (periodic). The timer name and the corresponding callback function name must be specified. It is up to the user to fill the callback function code and to specify the timer period (time between the timer being started and its callback function being executed) when calling the CMSIS-RTOS osTimerStart function.

- Mutexes / Semaphores

Prior to creating mutexes, recursive mutexes and counting semaphores, their usage (USE\_MUTEXES, USE\_RECURSIVE\_MUTEXES, USE\_COUNTING\_SEMAPHORES definitions) must be enabled within the **Kernel settings** section of the **Configuration parameters** tab.

The following code snippet shows the generated code corresponding to [Figure 76](#).

```

/* Create the semaphore(s) */
/* definition and creation of myBinarySem01 */
osSemaphoreDef(myBinarySem01);
myBinarySem01Handle = osSemaphoreCreate(osSemaphore(myBinarySem01), 1);

/* definition and creation of myCountingSem01 */
osSemaphoreDef(myCountingSem01);
myCountingSem01Handle = osSemaphoreCreate(osSemaphore(myCountingSem01),
7);

/* Create the timer(s) */
/* definition and creation of myTimer01 */
osTimerDef(myTimer01, Callback01);
myTimer01Handle = osTimerCreate(osTimer(myTimer01), osTimerPeriodic,
NULL);

/* definition and creation of myTimer02 */
osTimerDef(myTimer02, Callback02);
myTimer02Handle = osTimerCreate(osTimer(myTimer02), osTimerOnce, NULL);

/* Create the mutex(es) */
/* definition and creation of myMutex01 */
osMutexDef(myMutex01);
myMutex01Handle = osMutexCreate(osMutex(myMutex01));

```

```

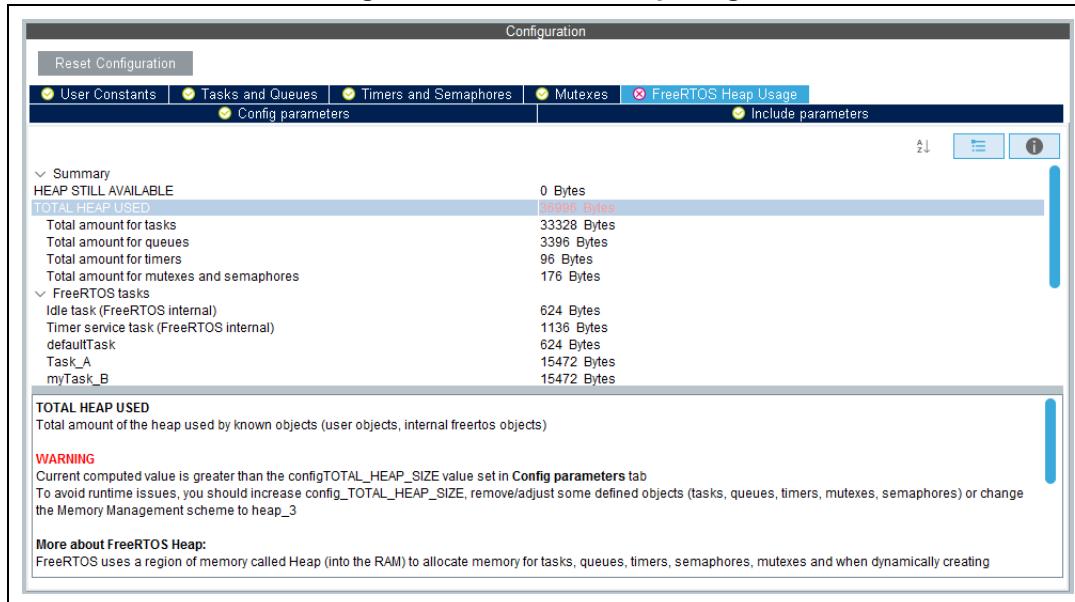
/* Create the recursive mutex(es) */
/* definition and creation of myRecursiveMutex01 */
osMutexDef(myRecursiveMutex01);
myRecursiveMutex01Handle =
osRecursiveMutexCreate(osMutex(myRecursiveMutex01));

```

### FreeRTOS heap usage

The **FreeRTOS Heap usage** tab displays the heap currently used and compares it to the TOTAL\_HEAP\_SIZE parameter set in the **Config Parameters** tab. When the total heap used crosses the TOTAL\_HEAP\_SIZE maximum threshold, it is shown in fuchsia and a cross of the same color appears on the tab (see [Figure 77](#)).

**Figure 77. FreeRTOS Heap usage**



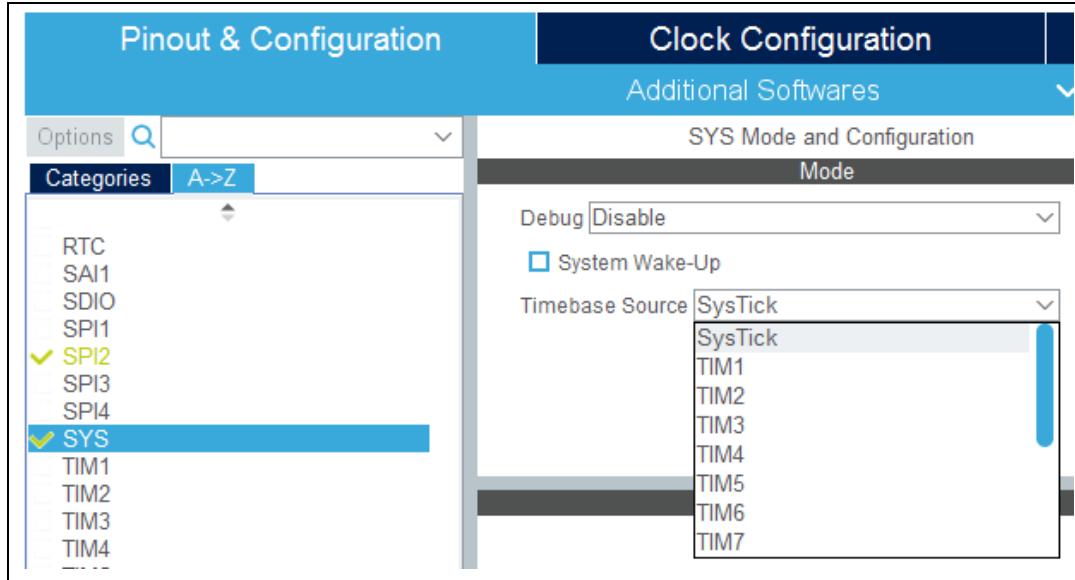
#### 4.4.16 Setting HAL timebase source

By default, the STM32Cube HAL is built around a unique timebase source, the Arm® Cortex® system timer (SysTick).

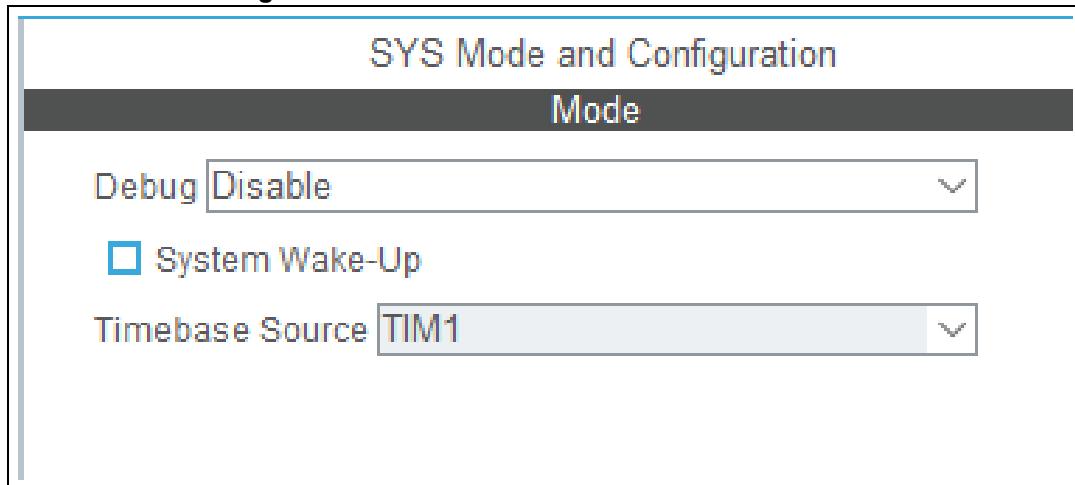
However, HAL-timebase related functions are defined as weak so that they can be overloaded to use another hardware timebase source. This is strongly recommended when the application uses an RTOS, since this middleware has full control on the SysTick configuration (tick and priority) and most RTOSs force the SysTick priority to be the lowest.

Using the SysTick remains acceptable if the application respects the HAL programming model, that is, does not perform any call to HAL timebase services within an Interrupt Service Request context (no dead lock issue).

To change the HAL timebase source, go to the SYS peripheral in the **Component list** panel and select a clock among the available sources: SysTick, TIM1, TIM2,... (see [Figure 78](#)).

**Figure 78. Selecting a HAL timebase source (STM32F407 example)**

When used as timebase source, a given peripheral is grayed and can no longer be selected (see [Figure 79](#)).

**Figure 79. TIM1 selected as HAL timebase source**

As illustrated in the following examples, the selection of the HAL timebase source and the use of FreeRTOS influence the generated code.

### Example of configuration using SysTick without FreeRTOS

As illustrated in [Figure 80](#), the SysTick priority is set to 0 (High) when using the SysTick without FreeRTOS.

**Figure 80. NVIC settings when using SysTick as HAL timebase, no FreeRTOS**

The screenshot shows the STM32CubeMX software interface for NVIC configuration. The title bar indicates 'NVIC' and 'Code generation'. The main window displays a table of NVIC Interrupt Table settings. The columns are: NVIC Interrupt Table, Enabled, Preemption Priority, and Sub Priority. The table lists 16 standard STM32 interrupts, all of which have their 'Enabled' checkboxes checked. The 'Preemption Priority' and 'Sub Priority' for all listed interrupts are set to 0. The 'Sort by Preemption Priority and Sub Priority' checkbox is unchecked. There is also a search bar and a checkbox for 'Show only enabled interrupts'.

NVIC Interrupt Table	Enabled	Preemption Priority	Sub Priority
Non maskable interrupt	✓	0	0
Hard fault interrupt	✓	0	0
Memory management fault	✓	0	0
Pre-fetch fault, memory access fault	✓	0	0
Undefined instruction or illegal state	✓	0	0
System service call via SWI instruction	✓	0	0
Debug monitor	✓	0	0
Pendable request for system service	✓	0	0
Time base: System tick timer	✓	0	0
PVD interrupt through EXTI line 16	□	0	0
Flash global interrupt	□	0	0
RCC global interrupt	□	0	0
SPI2 global interrupt	□	0	0
TIM6 global interrupt, DAC1 and DAC2 underrun error interrupts	□	0	0
FPU global interrupt	□	0	0

Interrupt priorities (in main.c) and handler code (in stm32f4xx\_it.c) are generated accordingly:

- main.c file
- ```
/* SysTick_IRQn interrupt configuration */
HAL_NVIC_SetPriority(SysTick_IRQn, 0, 0);
```
- stm32f4xx\_it.c file
- ```
/**
 * @brief This function handles System tick timer.
 */
void SysTick_Handler(void)
{
    /* USER CODE BEGIN SysTick_IRQn 0 */
    /* USER CODE END SysTick_IRQn 0 */
    HAL_IncTick();
    HAL_SYSTICK_IRQHandler();
    /* USER CODE BEGIN SysTick_IRQn 1 */

    /* USER CODE END SysTick_IRQn 1 */
}
```

### Example of configuration using SysTick and FreeRTOS

As illustrated in [Figure 81](#), the SysTick priority is set to 15 (Low) when using the SysTick with FreeRTOS.

**Figure 81. NVIC settings when using FreeRTOS and SysTick as HAL timebase**

The screenshot shows the NVIC configuration interface in STM32CubeMX. The 'NVIC' tab is selected. The table lists various interrupt sources with their enable status, preemption priority, and sub priority. The 'Time base: System tick timer' row is highlighted with a blue background, indicating it is the active HAL timebase. Its Preemption Priority is set to 15.

NVIC Interrupt Table	Enabled	Preemption Priority	Sub Priority
Non maskable interrupt	<input checked="" type="checkbox"/>	0	0
Hard fault interrupt	<input checked="" type="checkbox"/>	0	0
Memory management fault	<input checked="" type="checkbox"/>	0	0
Pre-fetch fault, memory access fault	<input checked="" type="checkbox"/>	0	0
Undefined instruction or illegal state	<input checked="" type="checkbox"/>	0	0
System service call via SWI instruction	<input checked="" type="checkbox"/>	0	0
Debug monitor	<input checked="" type="checkbox"/>	0	0
Pendable request for system service	<input checked="" type="checkbox"/>	0	0
Time base: System tick timer	<input checked="" type="checkbox"/>	15	0
PVD interrupt through EXTI line 16	<input type="checkbox"/>	0	0
Flash global interrupt	<input type="checkbox"/>	0	0
RCC global interrupt	<input type="checkbox"/>	0	0
SPI2 global interrupt	<input type="checkbox"/>	0	0
TIM6 global interrupt, DAC1 and DAC2 underrun error interrupts	<input type="checkbox"/>	0	0
FPU global interrupt	<input type="checkbox"/>	0	0

As shown in the code snippets below, the SysTick interrupt handler is updated to use CMSIS-os osSystickHandler function.

- main.c file

```
/* SysTick_IRQn interrupt configuration */
HAL_NVIC_SetPriority(SysTick_IRQn, 15, 0);
```

- stm32f4xx\_it.c file

```
/**
 * @brief This function handles System tick timer.
 */
void SysTick_Handler(void)
{
    /* USER CODE BEGIN SysTick_0 */

    /* USER CODE END SysTick_0 */
    HAL_IncTick();
    osSystickHandler();
    /* USER CODE BEGIN SysTick_1 */

    /* USER CODE END SysTick_1 */
}
```

### Example of configuration using TIM2 as HAL timebase source

When TIM2 is used as HAL timebase source, a new `stm32f4xx_hal_timebase_TIM.c` file is generated to overload the HAL timebase related functions, including the `HAL_InitTick` function that configures the TIM2 as the HAL time-base source.

The priority of TIM2 timebase interrupts is set to 0 (High). The SysTick priority is set to 15 (Low) if FreeRTOS is used, otherwise is set to 0 (High).

**Figure 82. NVIC settings when using FreeRTOS and TIM2 as HAL timebase**

The screenshot shows the NVIC settings window in STM32CubeMX. The 'NVIC' tab is selected. The table lists various interrupt sources with their enable status, preemption priority, and subpriority. The 'System tick timer' row is highlighted with a pink border and has a priority of 15. The 'Time base: TIM2 global interrupt' row is also highlighted with a pink border and has a priority of 0. Other rows like 'Non maskable interrupt', 'Hard fault interrupt', etc., have priorities of 0.

NVIC Interrupt Table	Enabled	Preemption Priority	Sub Priority
Non maskable interrupt	<input checked="" type="checkbox"/>	0	0
Hard fault interrupt	<input checked="" type="checkbox"/>	0	0
Memory management fault	<input checked="" type="checkbox"/>	0	0
Pre-fetch fault, memory access fault	<input checked="" type="checkbox"/>	0	0
Undefined instruction or illegal state	<input checked="" type="checkbox"/>	0	0
System service call via SWI instruction	<input checked="" type="checkbox"/>	0	0
Debug monitor	<input checked="" type="checkbox"/>	0	0
Pendable request for system service	<input checked="" type="checkbox"/>	0	0
System tick timer	<input checked="" type="checkbox"/>	15	0
PVD interrupt through EXTI line 16	<input type="checkbox"/>	0	0
Flash global interrupt	<input type="checkbox"/>	0	0
RCC global interrupt	<input type="checkbox"/>	0	0
Time base: TIM2 global interrupt	<input checked="" type="checkbox"/>	0	0
SPI2 global interrupt	<input type="checkbox"/>	0	0
TIM6 global interrupt, DAC1 and DAC2 underrun error interrupts	<input type="checkbox"/>	0	0
FPU global interrupt	<input type="checkbox"/>	0	0

The `stm32f4xx_it.c` file is generated accordingly:

- SysTick\_Handler calls osSystickHandler when FreeRTOS is used, otherwise it calls HAL\_SYSTICK\_IRQHandler.
- TIM2\_IRQHandler is generated to handle TIM2 global interrupt.

## 4.5

### Pinout & Configuration view for STM32MP1 Series

For the STM32MP1 Series the **Pinout & Configuration** view allows the user to:

- assign components to one or several run time contexts
- configure peripherals as boot devices
- select the peripherals to be managed by boot loaders
- assign GPIOs to one runtime (see [Figure 84](#)).

These possibilities are offered in two different panels (see [Figure 83](#))

1. from the component tree panel, that lists all supported peripherals and middleware (the “Show contexts” option must be enabled)
2. from each component mode panel, opened by clicking the component name.

Figure 83. STM32MP1 boot devices and runtime contexts

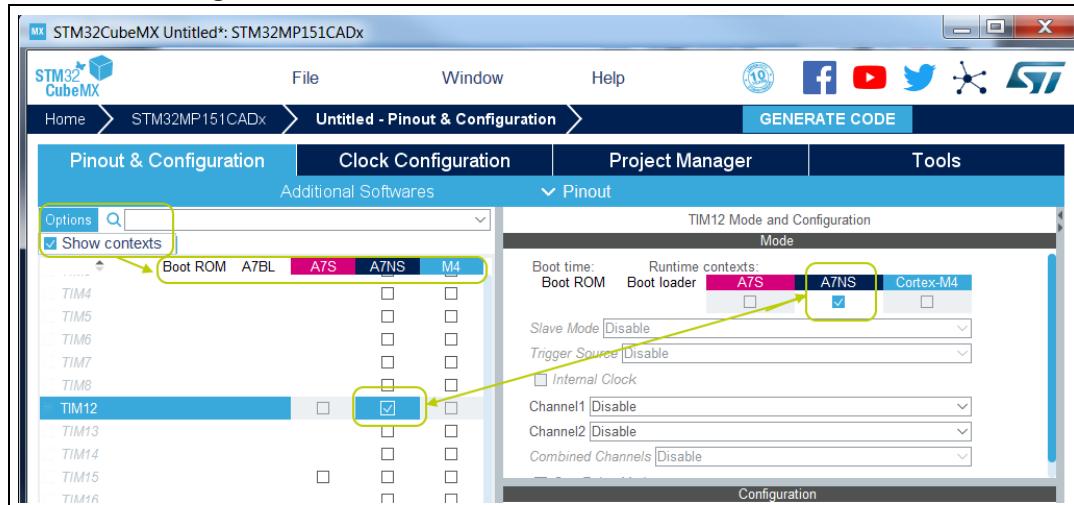
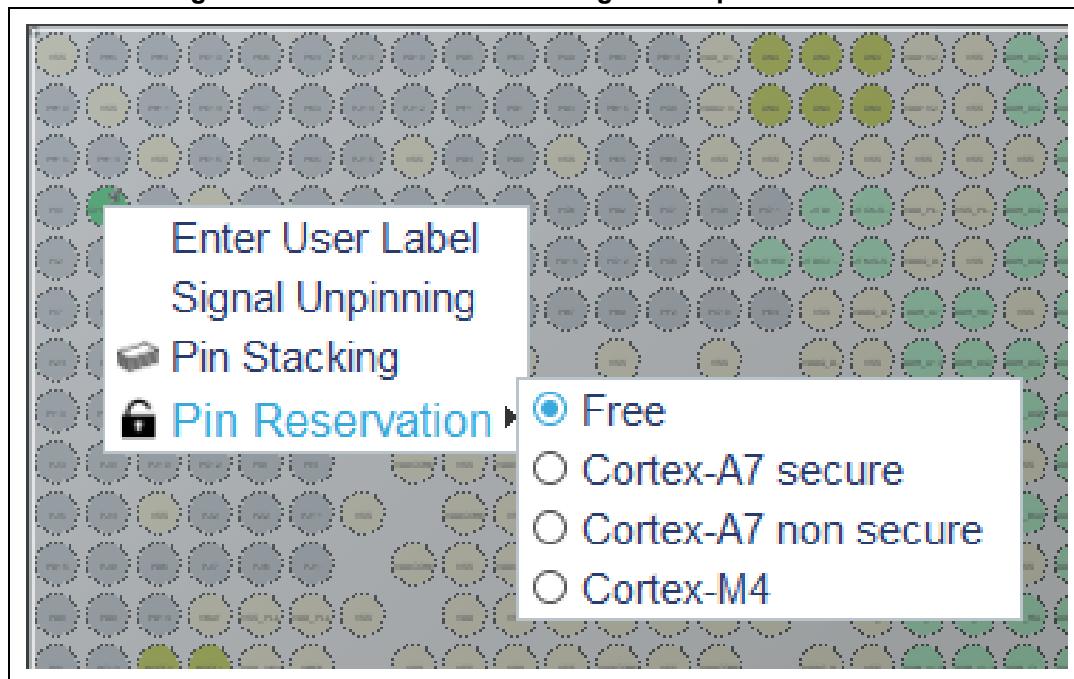


Figure 84. STM32MP1 Series: assignment options for GPIOs



#### 4.5.1 Run time configuration

The STM32MP1 devices are multi-core (Arm® Cortex®-A7 dual-core and Cortex-®M4) and multi-firmware, each firmware executing on one of the cores. The association between firmware and core defines a runtime context where the firmware executes its code.

Three runtime contexts are available:

1. Cortex-A7 Non Secure running the Linux kernel
2. Cortex-A7 Secure running the SP\_min
3. Cortex-M4 running the STM32Cube firmware.

Assigning a component to a runtime context means specifying which context(s) will control the component at runtime. Assignments to a Cortex-A7 context are reflected in the device tree code generation, while assignments to the Cortex-M4 context are reflected in STM32Cube based C code generation (refer to code generation sections for more details).

The component assignment to a context is done in the context dedicated column.

## 4.5.2 Boot stages configuration

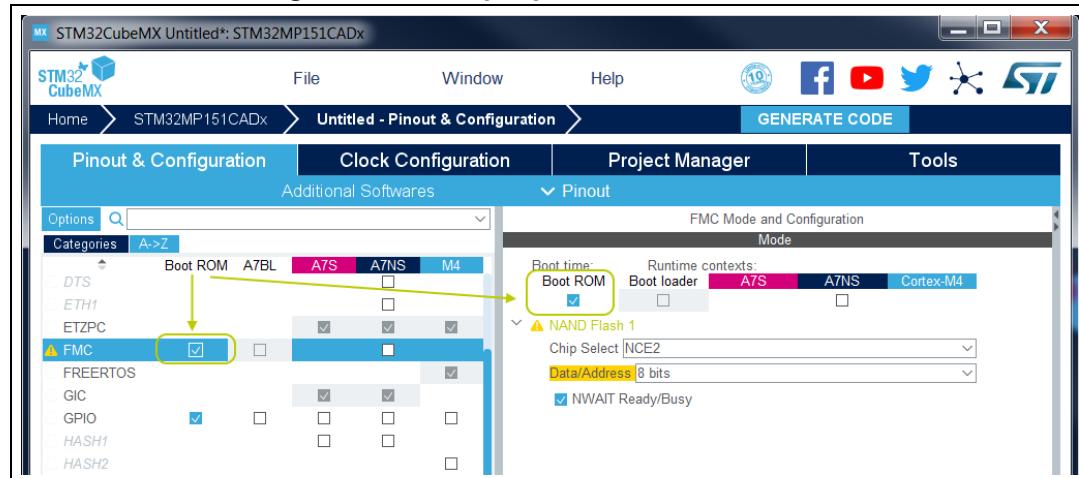
### Boot ROM peripherals selection

Several execution stages are needed by the microprocessor to be up and running.

The binary code embedded in the ROM is the first to be executed. It uses a default configuration to initialize the clock tree and all peripherals involved in the boot detection.

The peripherals managed by the boot ROM program can be selected as boot devices. This choice is done in the Boot ROM column (see [Figure 85](#)).

**Figure 85. Select peripherals as boot devices**



When a peripheral is set as boot device, it imposes a specific pinout: some signals have to be mapped exclusively on pins visible by the boot ROM and only these signals/pins are taken into account by the boot ROM program.

When a functional mode of a ROM-bootable peripheral is set, the pinout linked to this mode is the same of that for a runtime context except for the signals imposed on specific pins by the boot ROM code.

During the boot step (boot ROM code execution), the peripheral is running only with the sub-set of bootable signals and pins. After boot, during runtime, the peripheral runs with all signals necessary to the selected functional mode.

### Boot loader (A7BL) peripherals selection

When the board starts, the launching of each of the Cortex-A7 runtime contexts (Secure and Non Secure) on which a firmware executes (SP\_min for Cortex-A7 Secure, Linux kernel for Cortex-A7 Non Secure) preceded by an early boot execution stage, that is before U-Boot relocation in DDR.

The Boot loader (A7BL) column is used to define which devices can be managed during this Boot loader Stage.

This assignment are reflected in the different Device-Trees generated (refer to code generation sections for more details).

## 4.6 Pinout & Configuration view for STM32H7 dual-core product lines

Some STM32H7 product lines come with an Arm Cortex-M7 core, an Arm Cortex-M4 core and three power domains.

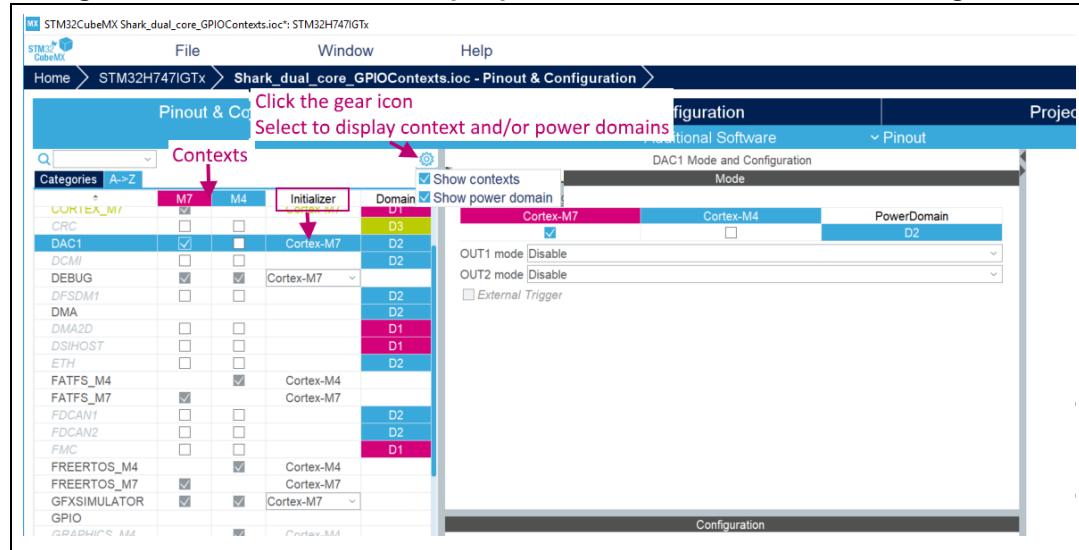
For such products, the **Pinout & Configuration** view allows the user to:

- For each peripheral and middleware: assign it to one core context or both, whenever possible. in case both contexts are selected, assign an “initializer” core to indicate on which core the peripheral or middleware initialization function shall be called.
- For each peripheral: view the power domain it belongs to.
- For GPIOs: assign it to a core or leave it free for other components that may require it. In this last case the GPIO initialization are performed on the same core as the component reserving it (code is generated accordingly).

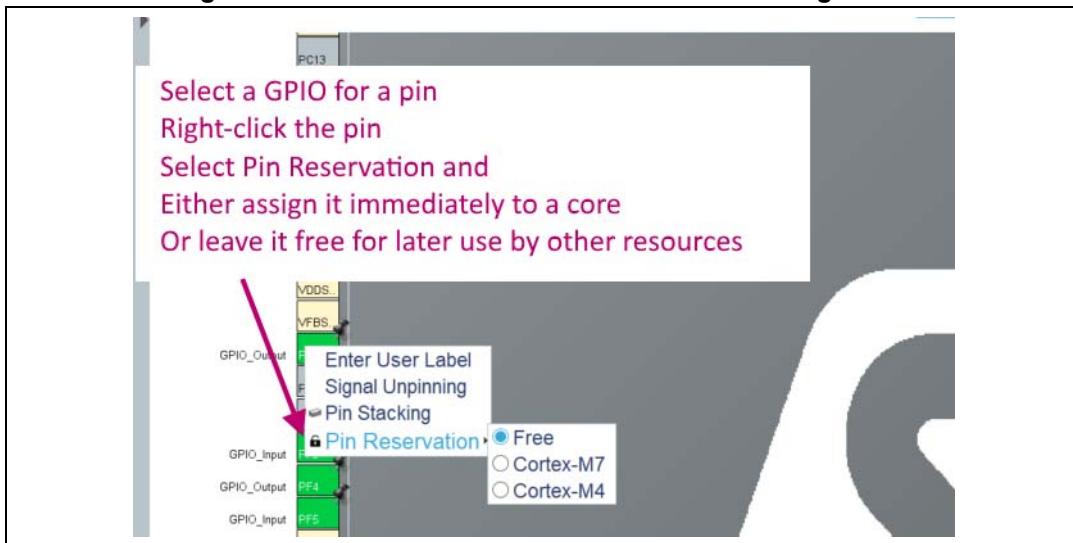
For peripherals and middleware, these possibilities are offered in two different panels

1. from the component tree panel, which lists all supported peripherals and middleware (clicking the gear icon enables the “Show contexts” option), see [Figure 86](#)
2. from each component mode panel, opened by clicking the component name.

**Figure 86. STM32H7 dual-core: peripheral and middleware context assignment**



For GPIOs (see [Figure 87](#)), assignment is done through the **Pinout** view directly or later and automatically through its selection in the platform settings panel of a middleware.

**Figure 87. STM32H7 dual-core: GPIOs context assignment**

## 4.7 Enabling security in Pinout & Configuration view (STM32L5 Series only)

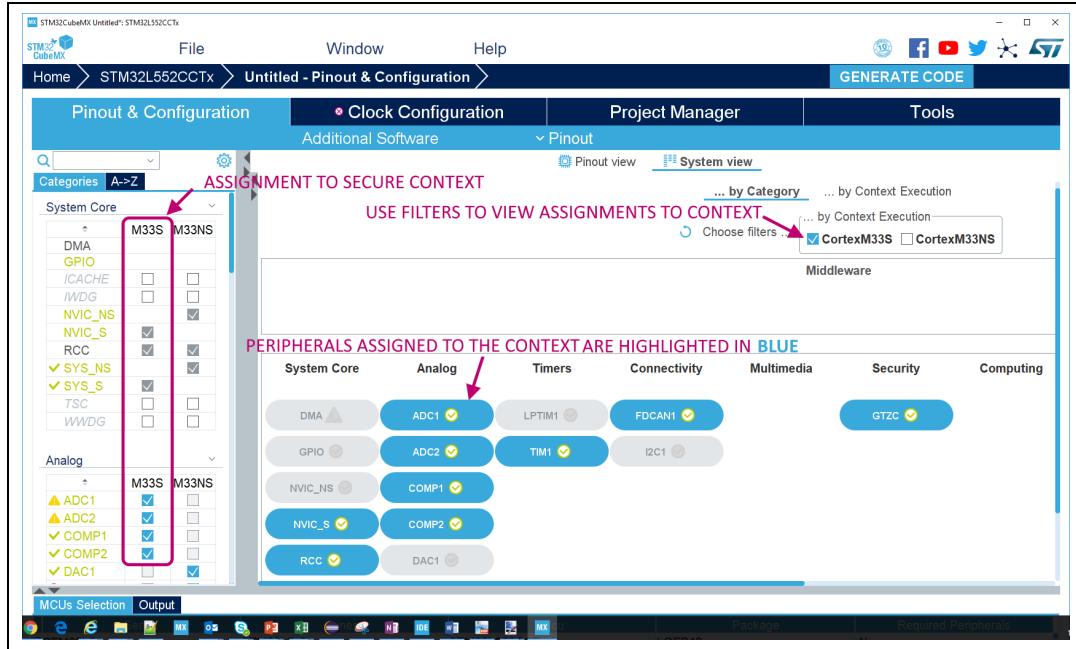
The STM32L5 MCU series harnesses the security features of the Arm Cortex-M33 processor and its TrustZone for Armv8-M combined with ST security implementation.

STM32L5 MCUs support

- two levels of privilege
  - unprivileged: software has limited access to system resources
  - privileged: software has full access to system resources, subject to security restrictions
- two security states, Secure and Non-secure: TrustZone security is activated when the TZEN option bit is set in the FLASH\_OPTR register. Security states are orthogonal to mode and privilege, therefore, each security state supports execution in both modes and both levels of privilege.

In STM32CubeMX the choice to activate TrustZone is made at project creation (see [Section 4.2: New Project window](#)). When TrustZone is enabled, STM32CubeMX Pinout & Configuration view is adjusted accordingly with a split between secure (M33S) and non-secure context (M33NS), and more security-related configuration options (see [Figure 88](#)).

Figure 88. Pinout &amp; Configuration view for Trustzone-enabled projects



#### 4.7.1 Privilege access for peripherals, GPIO EXTI and DMA requests

Independently of TrustZone, STM32CubeMX enables privilege access:

- for each peripheral: in the GTZC configuration panel (see [Section 4.7.5](#)), as shown in [Figure 89](#)
- for each GPIO EXTI: in the GPIO configuration panel, , as shown in [Figure 90](#)
- for each DMA channel: in the DMA configuration panel (see [Section 4.7.4](#)), as shown in [Figure 91](#).

**Note:**

*When TrustZone is active, either all or none of the RCC registers can be put in privilege mode. In STM32CubeMX, this is done by selecting “Privileged-only attribute” check box from RCC mode panel (see [Figure 92](#)). In privilege mode, all RCC registers configuration are reserved for the privilege application through the PWR\_CR\_PRIVEN bit, which is secured when Trustzone is activated.*

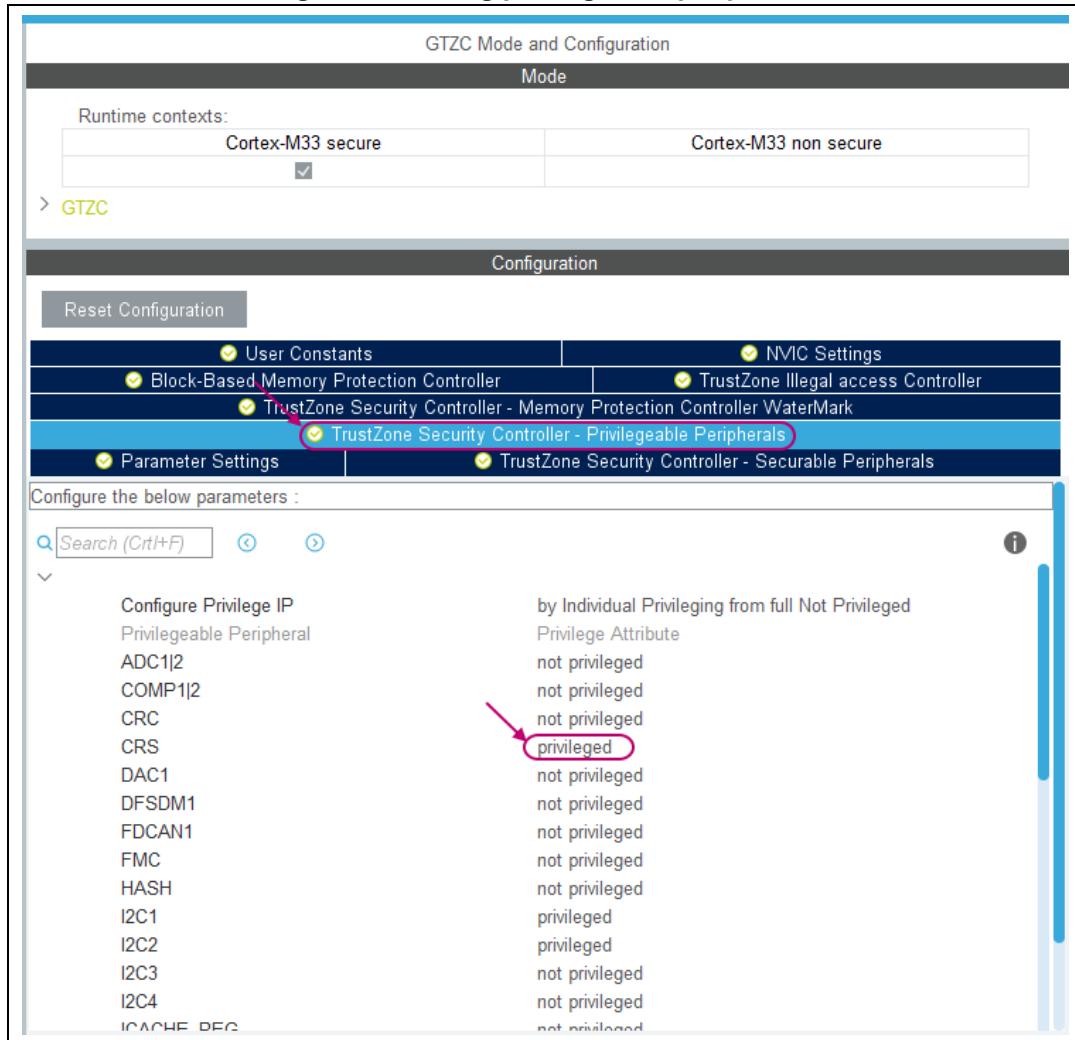
**Figure 89. Setting privileges for peripherals**

Figure 90. Setting privileges for GPIO EXTI

The screenshot shows the STM32CubeMX software interface for pin configuration. At the top, there's a toolbar with 'Configuration' and a dropdown for 'Group By Peripherals' (set to 'GPIO'). Below that are three checkboxes: 'GPIO' (selected), 'UART', and 'NVIC'. A search bar labeled 'Search (Ctrl+F)' is followed by a checkbox 'Show only Modified Pins'. The main area is a table of pins:

Pin N...	Signal o...	Pin Cont...	Pin Privilege access	GPIO o...	GPIO mode	GP...	Ma...	Fa...	Us...	Mo...
PA5	n/a	Free	n/a	n/a	Analog mode	No ...	n/a	n/a		<input checked="" type="checkbox"/>
PC13	n/a	Free	Privileged-only access	n/a	External Interrupt Mode ...	No ...	n/a	n/a		<input checked="" type="checkbox"/>
PC15-O...	n/a	Free	n/a	n/a	Input mode	No ...	n/a	n/a		<input checked="" type="checkbox"/>
PH1-OS...	n/a	Cortex-...	n/a	n/a	Input mode	No ...	n/a	n/a		<input checked="" type="checkbox"/>

Below the table, a panel titled 'PC13 Configuration : -' contains the following settings:

- Pin Context Assignment: Free
- Pin Privilege access: Privileged-only access (highlighted with a red box)
- GPIO mode: External Interrupt Mode with Rising edge trigger detection
- GPIO Pull-up/Pull-down: No pull-up and no pull-down
- User Label: (empty)

**Figure 91. Configuring security and privilege of DMA requests**

The screenshot shows the 'DMA Mode and Configuration' screen. At the top, there are two selected tabs: 'DMA1, DMA2' and 'MemToMem'. The 'Configuration' tab is active. Below it is a table with four rows:

DMA Request	Channel	Direction	Priority
MEMTOMEM	DMA1 Channel 1	Memory To Memory	Low
UART4_RX	DMA1 Channel 2	Peripheral To Memory	Low
UART4_TX	DMA1 Channel 3	Memory To Peripheral	Low

Below the table are 'Add' and 'Delete' buttons. Under 'DMA Request Settings', there is a table for 'Peripheral' and 'Memory' modes. A red arrow points to the 'DMA Request Security/Privilege' section, which contains four checkboxes:

- Enable Channel as Secured (checked)
- Enable Channel as Privileged (checked)
- Enable Source as Secured (checked)
- Enable Destination as Secured (checked)

**Figure 92. RCC privilege mode**

The screenshot shows the 'RCC Mode and Configuration' screen. At the top, there is a 'Mode' tab. Below it is a section titled 'Runtime contexts:' with two checkboxes:

Cortex-M33 secure	Cortex-M33 non secure
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Below this are several configuration options with dropdown menus:

- High Speed Clock (HSE) - Disable
- Low Speed Clock (LSE) - Disable
- Master Clock Output -
- LSCO Clock Output -
- SAI1 Extern Clock -
- SAI2 Extern Clock -
- CRS SYNC - Disable

#### 4.7.2 Secure/non-secure context assignment for GPIO/Peripherals/Middleware

STM32CubeMX allows the user

- To assign each peripheral and middleware to one of the contexts.
- To assign a GPIO input or output to one of the context or to leave it free for other components that may require it. In this last case the GPIO assignment is in the same context as the component reserving it. By default all IOs are secured.

The assignment is done in different panels:

- For peripherals and middleware only: from the component tree panel when “Show contexts” option is enabled (clicking the gear icon) or from the mode panel.
- For peripherals only: from the GTZC configuration panel (peripherals only).
- For GPIOs only: from the configuration panel or from the Pinout view, through a right-click on the GPIO pin and by selecting “Pin Reservation”.
- For DMA requests: from the DMA configuration panel.

*Note:* RCC resources can be secured through the Clock configuration view (see [Section 4.8.2](#)).

*Note:* For middleware requiring a peripheral the middleware can only be assigned to the context the peripheral is already assigned to.

#### 4.7.3 NVIC and context assignment for peripherals interrupts

When TrustZone is enabled, the interrupt controller is split into NVIC\_NS for the non-secure context and NVIC\_S for the secure context. Two SysTick instances are available as well, one for each context: they are visible respectively under SYS\_NS and SYS\_S.

By default, all interrupts are secured.

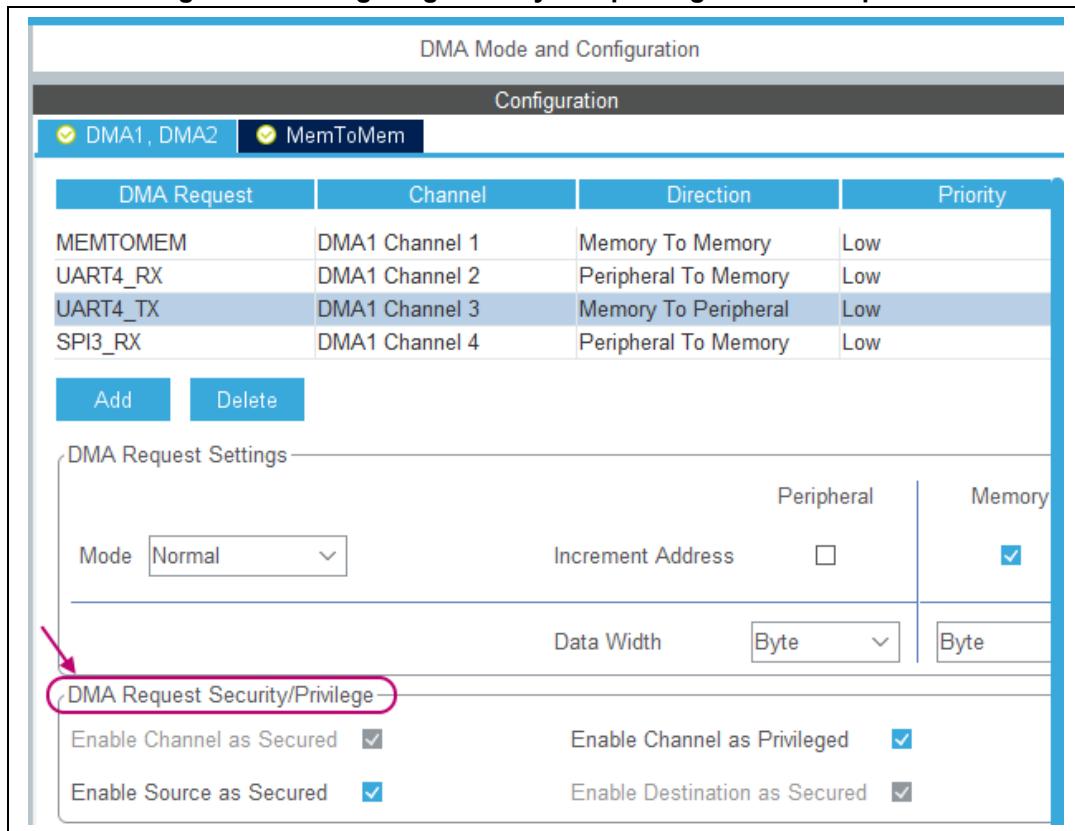
Peripherals interrupts are automatically assigned to the interrupt controller relevant to the context:

- For peripherals assigned to the non-secure context, interrupts are enabled on NVIC\_NS.
- For peripherals assigned to the secure context, interrupts are enabled on NVIC\_S.

#### 4.7.4 DMA (context assignment and privilege access settings)

STM32CubeMX allows the user to set as privileged the DMA channel and in some cases, to secure the DMA channel, source and destination see [Figure 93](#).

Figure 93. Configuring security and privilege of DMA requests



The DMA channel is set to non-privileged by default. The choice to set it as privileged is always available.

The choice to secure the DMA channel, source, and destination depends on the request characteristics.

There are four cases:

- The request is either a memory to memory transfer request or a DMA generator request: the channel is not secure by default but can be secured. The source and destination can be secured only when the channel is secure.
- The request is for a peripheral assigned to the non-secure context: channel, source and destination cannot be secured (checkboxes are disabled) and so they are forced to the non-secure context.
- The request is a peripheral to memory request for a peripheral assigned to the secure context: channel and source are automatically secured (checkboxes enabled, cannot be disabled), while there is a choice to secure or not the destination.
- The request is a memory to peripheral request for a peripheral assigned to the secure context: channel and destination are automatically secured (checkboxes enabled, cannot be disabled), while there is a choice to secure or not the source.

## 4.7.5 GTZC

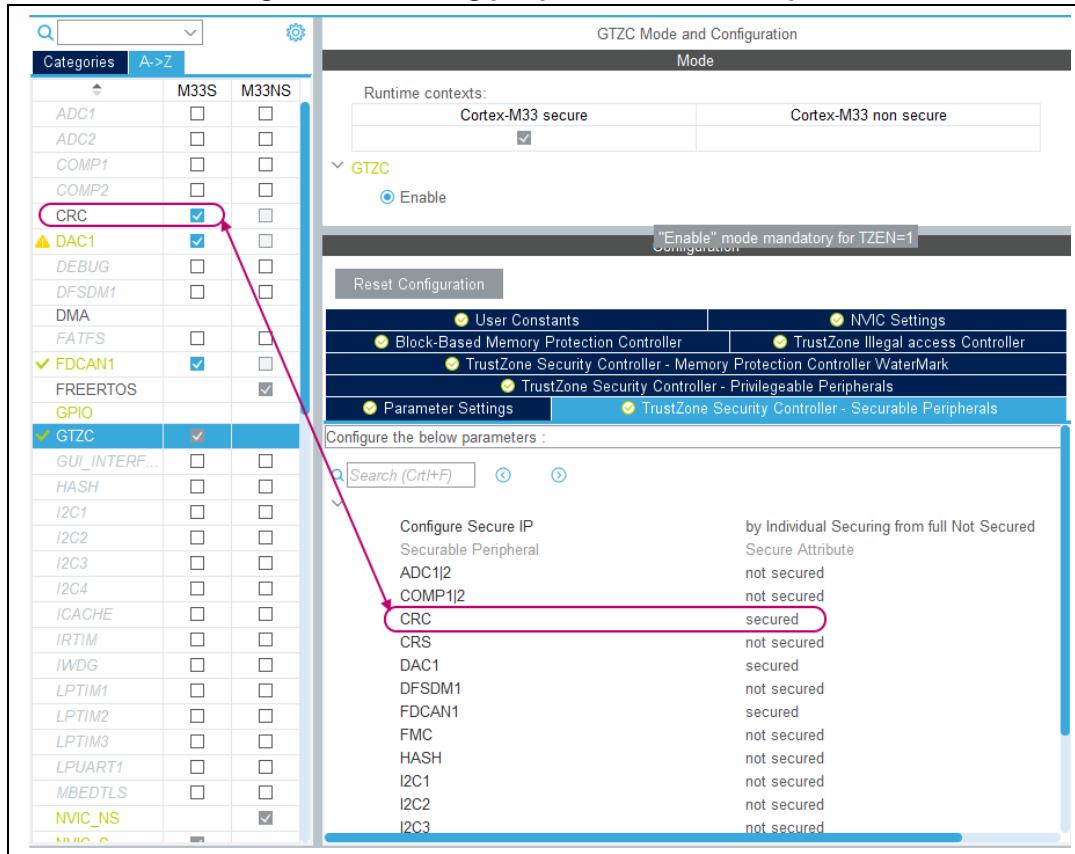
To configure TrustZone system security, STM32L5 Series come with a Global TrustZone security controller (GTZC). Refer to reference manual RM0438 for more details.

In STM32CubeMX, for projects with TrustZone activated, GTZC is enabled by default and cannot be disabled. For projects without Trustzone active, GTZC can be enabled and gives only the possibility to set privileges.

GTZC is made up of three blocks that can be configured through CubeMX using dedicated tabs in GTZC configuration panel:

- TZSC (TrustZone security controller)
  - Defines which peripherals are secured and/or privileged, and controls the non-secure area size for the watermark memory peripheral controller (MPCWM). The TZSC block informs some peripherals (such as RCC or GPIOs) about the secure status of each securable peripheral, by sharing with RCC and I/O logic.
  - The privileges are set in the TrustZone Security Controller – Privilegeable Peripherals tab.
  - The secure states are set in TrustZone Security Controller – Securable Peripherals tab (they match the assignment to context (M33S or M33NS) done on the Tree view or in the Mode panel).
  - The MPCWM configuration is done through the TrustZone Security Controller – Memory Protection Controller Watermark tab.
- MPCBB (block-based memory protection controller)
  - Controls secure states of all blocks (256-byte pages) of the associated SRAM. It is configured through the Block-based Memory Protection Controller tab.
- TZIC (TrustZone illegal access controller)
  - Gathers all illegal access events in the system and generates a secure interrupt towards NVIC. It is configured through the TrustZone Illegal Access Controller tab.

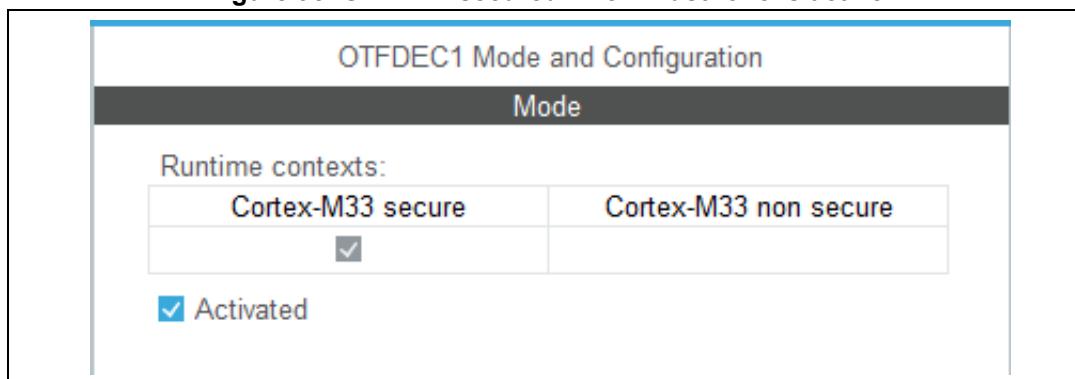
Figure 94. Securing peripherals from GTZC panel



#### 4.7.6 OTFDEC

On-the-fly decryption engine (OTFDEC) allows the user to decrypt on-the-fly AHB traffic based on the read request address information. When security is enabled in the product OTFDEC can be programmed only by a secure host.

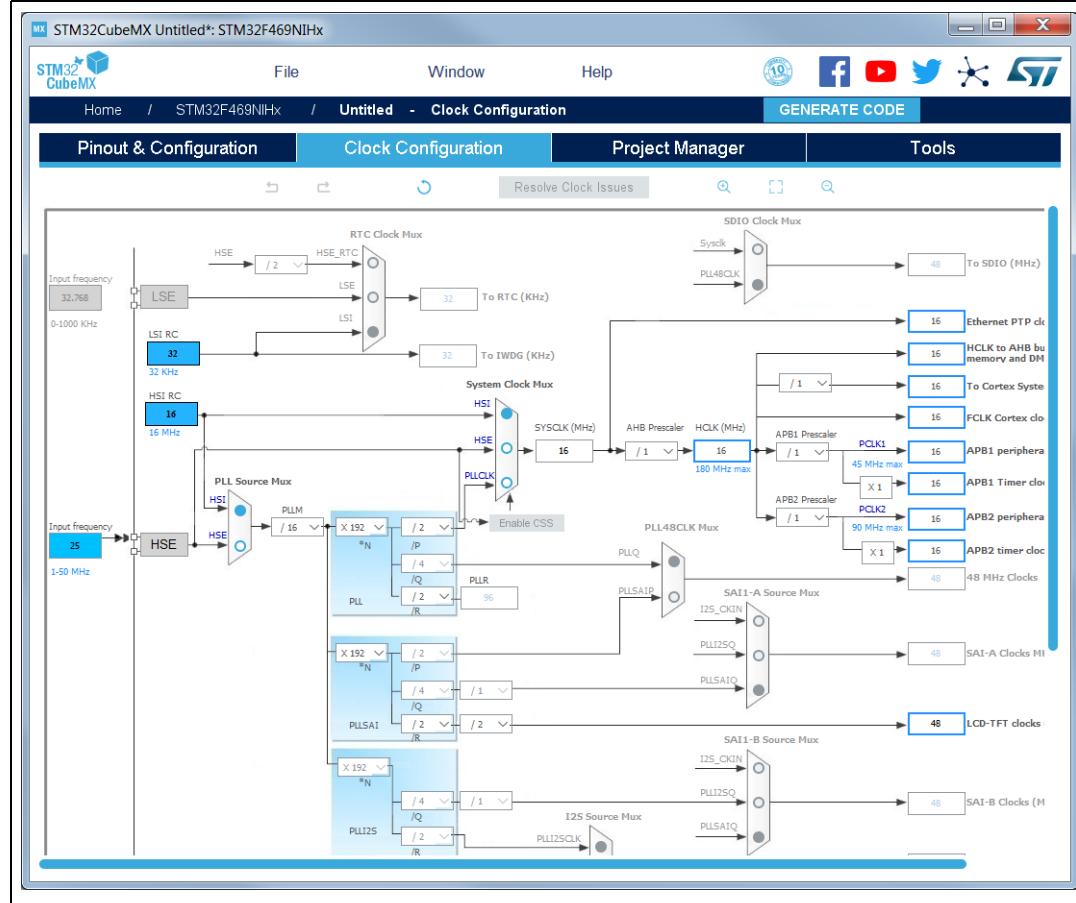
Figure 95. OTFDEC secured when TrustZone is active



## 4.8 Clock Configuration view

STM32CubeMX **Clock Configuration** window (see *Figure 96*) provides a schematic overview of the clock paths, clock sources, dividers, and multipliers. Drop-down menus and buttons can be used to modify the actual clock tree configuration, to meet the application requirements.

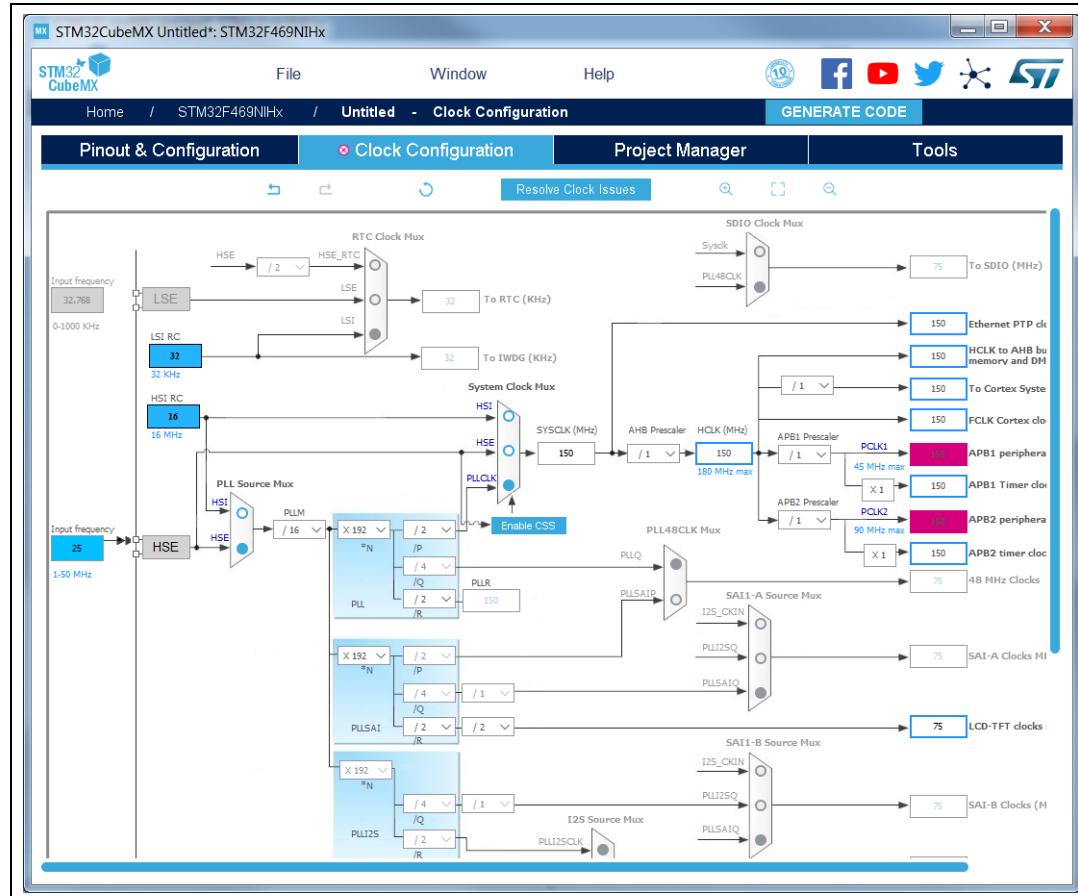
**Figure 96. STM32F469NIHx clock tree configuration view**



Actual clock speeds are displayed and active. The use clock signals are highlighted in blue.

Out-of-range configured values are highlighted as shown in [Figure 97](#) to flag potential issues. A solver feature is proposed to automatically resolve such configuration issues.

**Figure 97. Clock tree configuration view with errors**



Reverse path is supported: just enter the required clock speed in the blue field and STM32CubeMX attempts to reconfigure multipliers and dividers to provide the requested value. The resulting clock value can then be locked by right clicking the field to prevent modifications.

STM32CubeMX generates the corresponding initialization code:

- main.c with relevant HAL\_RCC structure initializations and function calls
- stm32xxxx\_hal\_conf.h for oscillator frequencies and V<sub>DD</sub> values.

## 4.8.1 Clock tree configuration functions

### External clock sources

When external clock sources are used, the user must previously enable them from the **Pinout** view available under the RCC peripheral.

## Peripheral clock configuration options

Other paths, corresponding to clock peripherals, are grayed out. To become active, the peripheral must be properly configured in the **Pinout** view (e.g. USB). This view allows the user to:

- **Enter a frequency value for the CPU Clock (HCLK), buses or peripheral clocks**  
STM32CubeMX tries to propose a clock tree configuration that reaches the desired frequency while adjusting prescalers and dividers and taking into account other peripheral constraints (such as USB clock minimum value). If no solution can be found, STM32CubeMX proposes to switch to a different clock source or can even conclude that no solution matches the desired frequency.
- **Lock the frequency fields for which the current value should be preserved**  
Right click a frequency field and select **Lock** to preserve the value currently assigned when STM32CubeMX searches for a new clock configuration solution.  
The user can unlock the locked frequency fields when the preservation is no longer necessary.
- **Select the clock source that will drive the system clock (SYSCLK)**
  - External oscillator clock (HSE) for a user defined frequency.
  - Internal oscillator clock (HSI) for the defined fixed frequency.
  - Main PLL clock
- **Select secondary sources (as available for the product)**
  - Low-speed internal (LSI) or external (LSE) clock
  - I2S input clock
  - Other sources
- **Select prescalers, dividers and multipliers values**
- **Enable the Clock Security system (CSS) on HSE when it is supported by the MCU**  
This feature is available only when the HSE clock is used as the system clock source directly or indirectly through the PLL. It allows detecting HSE failure and inform the software about it, thus allowing the MCU to perform rescue operations.
- **Enable the CSS on LSE when it is supported by the MCU**  
This feature is available only when the LSE and LSI are enabled and after the RTC or LCD clock sources have been selected to be either LSE or LSI.
- **Reset the Clock tree default settings by using the toolbar Reset button**  
This feature reloads STM32CubeMX default clock tree configuration.
- **Undo/Redo user configuration steps by using the toolbar Undo/Redo buttons**
- **Detect and resolve configuration issues**  
Erroneous clock tree configurations are detected prior to code generation. Errors are highlighted in fuchsia and the **Clock Configuration** view is marked with a fuchsia cross (see [Figure 97](#)).  
Issues can be resolved manually or automatically by clicking the **Resolve Clock Issue** button that is enabled only if issues have been detected.  
The underlying resolution process follows a specific sequence:
  - a) Setting HSE frequency to its maximum value (optional).
  - b) Setting HCLK frequency then peripheral frequencies to a maximum or minimum value (optional).
  - c) Changing multiplexers inputs (optional).

- d) Finally, iterating through multiplier/dividers values to fix the issue. The clock tree is cleared from fuchsia highlights if a solution is found, otherwise an error message is displayed.

**Note:** *To be available from the clock tree, external clocks, I2S input clock, and master clocks must be enabled in RCC configuration in the **Pinout** view. This information is also available as tooltips.*

The tool automatically performs the following operations:

- Adjust bus frequencies, timers, peripherals and master output clocks according to user selection of clock sources, clock frequencies and prescalers/multipliers/dividers values.
- Check the validity of user settings.
- Highlight invalid settings in fuchsia and provide tooltips to guide the user to achieve a valid configuration.

The **Clock Configuration** view is adjusted according to the RCC settings (configured in RCC **Pinout & Configuration** views) and vice versa:

- If in RCC **Pinout** view, the external and output clocks are enabled, they become configurable in the **Clock Configuration** view.
- If in RCC Configuration view, the Timer prescaler is enabled, the choice of Timer clocks multipliers is adjusted.

Conversely, the clock tree configuration may affect some RCC parameters in the configuration view:

- Flash latency: number of wait states automatically derived from  $V_{DD}$  voltage, HCLK frequency, and power over-drive state.
- Power regulator voltage scale: automatically derived from HCLK frequency.
- Power over-drive is enabled automatically according to HCLK frequency. When the power drive is enabled, the maximum possible frequency values for AHB and APB domains are increased. They are displayed in the **Clock Configuration** view.

The default optimal system settings that is used at startup are defined in the `system_stm32f4xx.c` file. This file is copied by STM32CubeMX from the STM32CubeF4 MCU package. The switch to user defined clock settings is done afterwards in the main function.

*Figure 96* gives an example of Clock tree configuration for an STM32F429x MCU and *Table 9* describes the widgets that can be used to configure each clock.

**Table 9. Clock configuration view widgets**

Format	Configuration status of the Peripheral Instance
	Active clock sources
	Unavailable settings are blurred or grayed out (clock sources, dividers,...)
	Gray drop down lists for prescalers, dividers, multipliers selection.
	Multiplier selection
	User defined frequency values
	Automatically derived frequency values
	User-modifiable frequency field
	Right click blue border rectangles to lock/unlock a frequency field. Lock to preserve the frequency value during clock tree configuration updates.

#### 4.8.2 Securing clock resources (STM32L5 Series only)

When the TrustZone security is activated, the RCC is able, through the security configuration register, to prevent non-secure access to system clock resources.

Accordingly, STM32CubeMX allows the user to configure as secure:

- system clock sources with a fixed frequency: HSI, LSI, and RC48
- system clock sources with a configurable frequency: HSE (+CSS), MSI and LSE (+CSS)
- two multiplexers: CLK48 clock multiplexer, System Clock (+MCO source) multiplexer
- other system configurations: PLLSYS, PLLSAI1, PLLSAI2 phase-locked loops and AHB/APB1/APB2 bus pre-scalers

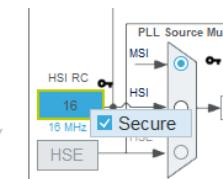
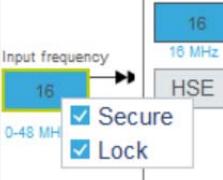
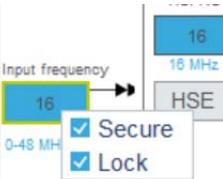
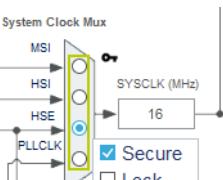
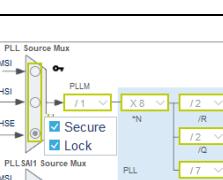
In the Clock Configuration view, these securable resources are highlighted with a key icon. Security is enabled using the Secure checkbox accessed through a right-click on the resource. Once the resource is secure, it is highlighted with a green square.

Configurable resources can be locked to prevent further configuration changes: this is done by selecting the Lock checkbox accessed through a right-click on the resource.

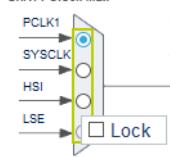
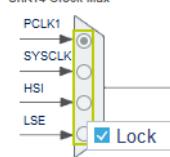
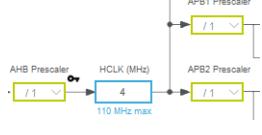
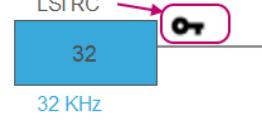
There is also a shortcut button to lock/unlock in one click all resources that are both securable and configurable.

When a peripheral is configured as secure, its related clock, reset, clock source and clock enable are also secure. In STM32CubeMX the peripheral is configured as secure in the Pinout & Configuration view and its clock source is automatically highlighted as secure using a green square in the Clock configuration view.

**Table 10. Clock Configuration security settings**

View	Description
	Example of non-configurable system clock resource that is secured.
	Example of the system clock HSE clock source that is secured and remains open for editing: the frequency value can be changed.
	Example of the system clock HSE clock source that is secured and has been locked for editing: the frequency value cannot be modified.
	Example of the System clock multiplexer that is secured and unlocked: the clock source can be changed.
	Example of the main PLL multiplexer that is secured and locked. The clock source is HSE and cannot be changed. PLLxxM, PLLxxN, PLLxxP, PLLxxQ and PLLxxR are secured and locked for editing as well.

**Table 10. Clock Configuration security settings (continued)**

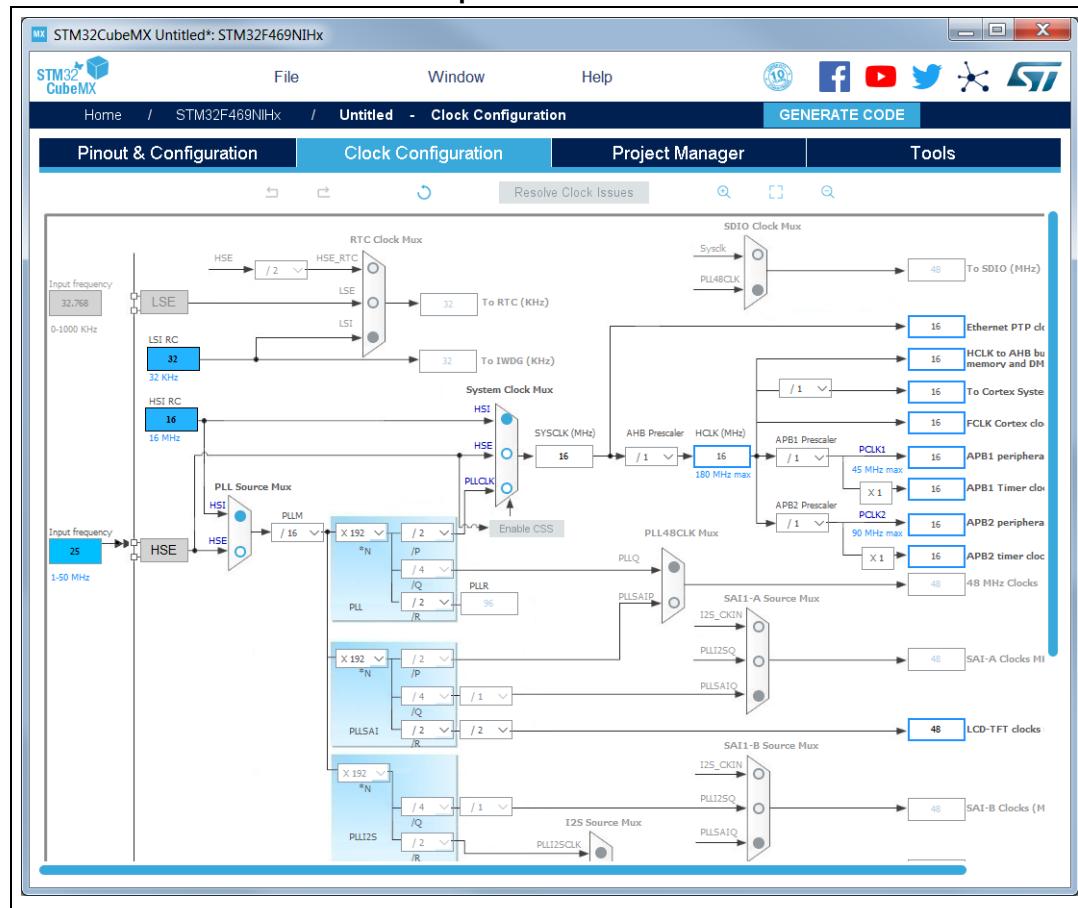
View	Description
	Example of the UART4 clock source multiplexer: the clock source is secured because the UART4 peripheral is configured as secure in the Pinout & Configuration view. It is set to PCLK1 and can be changed as the Lock checkbox is unchecked.
	Example of the UART4 clock source multiplexer: the clock source is secured because the UART4 peripheral is configured as secure in the Pinout & Configuration view. It is set to PCLK1 and can no longer be changed as Lock is on.
	Example of securing and locking the access to AHB prescaler. APB1 and APB2 prescalers are locked as well.
	Example of LSI highlighted as a securable resource using the key icon.
	Lock/Unlock All button (only active for securable resources).

### 4.8.3 Recommendations

The **Clock Configuration** view is not the only entry for clock configuration, RCC and RTC peripherals can also be configured.

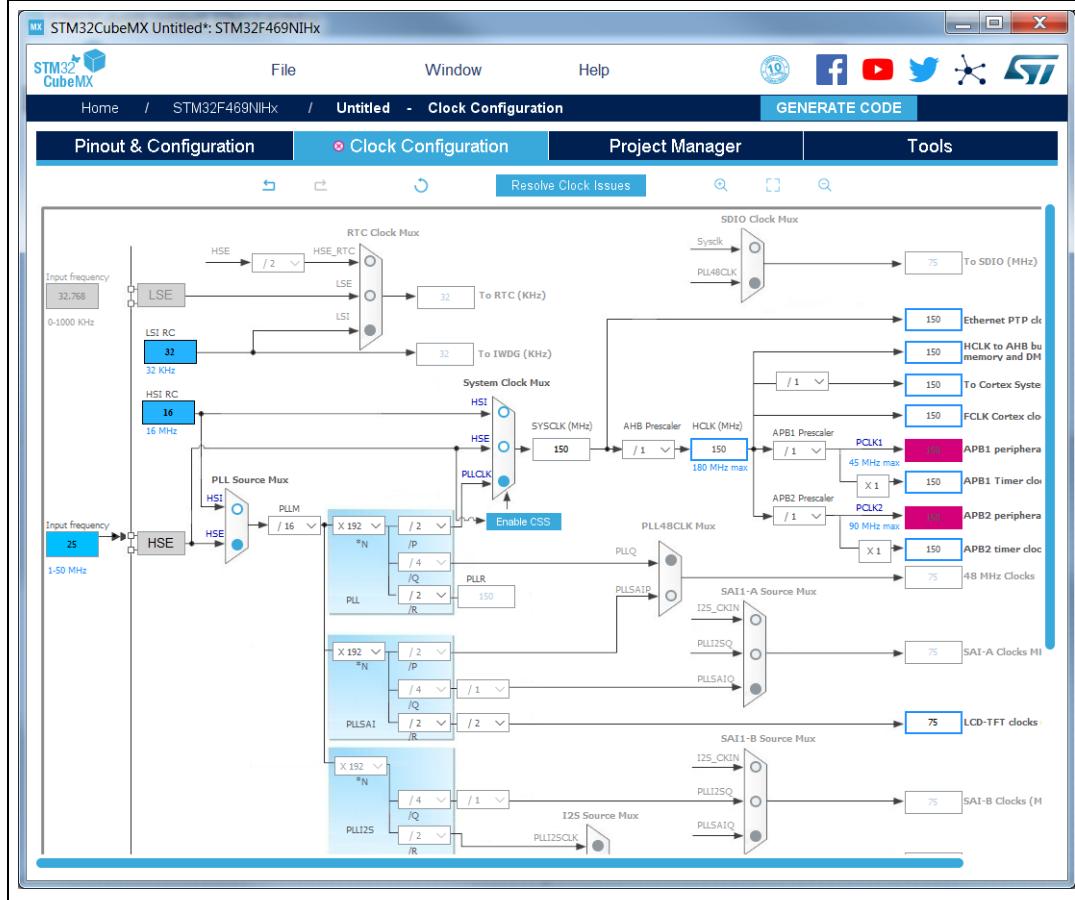
1. From the **Pinout & Configuration** view, go to the RCC mode panel to enable the clocks as needed: external clocks, master output clocks and Audio I2S input clock when available. Then go to the RCC configuration panel, and adjust the default settings if needed. Changes are reflected in the **Clock Configuration** view. The defined settings may change the settings in the RCC configuration as well (see [Figure 98](#)).

**Figure 98. Clock tree configuration: enabling RTC, RCC clock source and outputs from Pinout view**



2. Go to the **RCC configuration** in the **Pinout & Configuration** view. The settings defined there for advanced configurations are reflected in the **Clock configuration** view. The defined settings may change the settings in the RCC configuration.

**Figure 99. Clock tree configuration: RCC peripheral advanced parameters**



#### 4.8.4 STM32F43x/42x power-over-drive feature

STM32F42x/43x MCUs implement a power over-drive feature that allows them to work at the maximum AHB/APB bus frequencies (e.g., 180 MHz for HCLK) when a sufficient  $V_{DD}$  supply voltage is applied (e.g.  $V_{DD} > 2.1$  V).

*Table 11* lists the different parameters linked to the power over-drive feature and their availability in STM32CubeMX user interface.

**Table 11. Voltage scaling versus power over-drive and HCLK frequency**

Parameter	STM32CubeMX panel	Value
V <sub>DD</sub> voltage	Configuration (RCC)	User-defined within a predefined range. Impacts power over-drive.
Power regulator voltage scaling		Automatically derived from HCLK frequency and power over-drive (see <a href="#">Table 12</a> ).
Power over-drive		This value is conditioned by HCLK and V <sub>DD</sub> values (see <a href="#">Table 12</a> ). It can be enabled only if V <sub>DD</sub> ≥ 2.2 V. When V <sub>DD</sub> ≥ 2.2 V it is either automatically derived from HCLK or it can be configured by the user if multiple choices are possible (e.g. HCLK = 130 MHz)
HCLK/AHB clock maximum frequency value	Clock Configuration	Displayed in blue to indicate the maximum possible value. For example: maximum value is 168 MHz for HCLK when power over-drive cannot be activated (when V <sub>DD</sub> ≤ 2.1 V), otherwise it is 180 MHz.
APB1/APB2 clock maximum frequency value		Displayed in blue to indicate maximum possible value.

[Table 12](#) gives the relations between power-over drive mode and HCLK frequency.

**Table 12. Relations between power over-drive and HCLK frequency**

HCLK frequency range: V <sub>DD</sub> > 2.1 V required to enable power over-drive (POD)	Corresponding voltage scaling and power over-drive (POD)
≤120 MHz	Scale 3 POD is disabled
120 to 144 MHz	Scale 2 POD can be either disabled or enabled
144 to 168 MHz	Scale 1 when POD is disabled Scale 2 when POD is enabled
168 to 180 MHz	POD must be enabled Scale 1 (otherwise frequency range not supported)

#### 4.8.5 Clock tree glossary

**Table 13. Glossary**

Acronym	Definition
HSI	High speed Internal oscillator: enabled after reset, lower accuracy than HSE
HSE	High speed external oscillator: requires an external clock circuit
PLL	Phase locked loop: used to multiply above clock sources
LSI	Low speed Internal clock: low power clocks usually used for watchdog timers

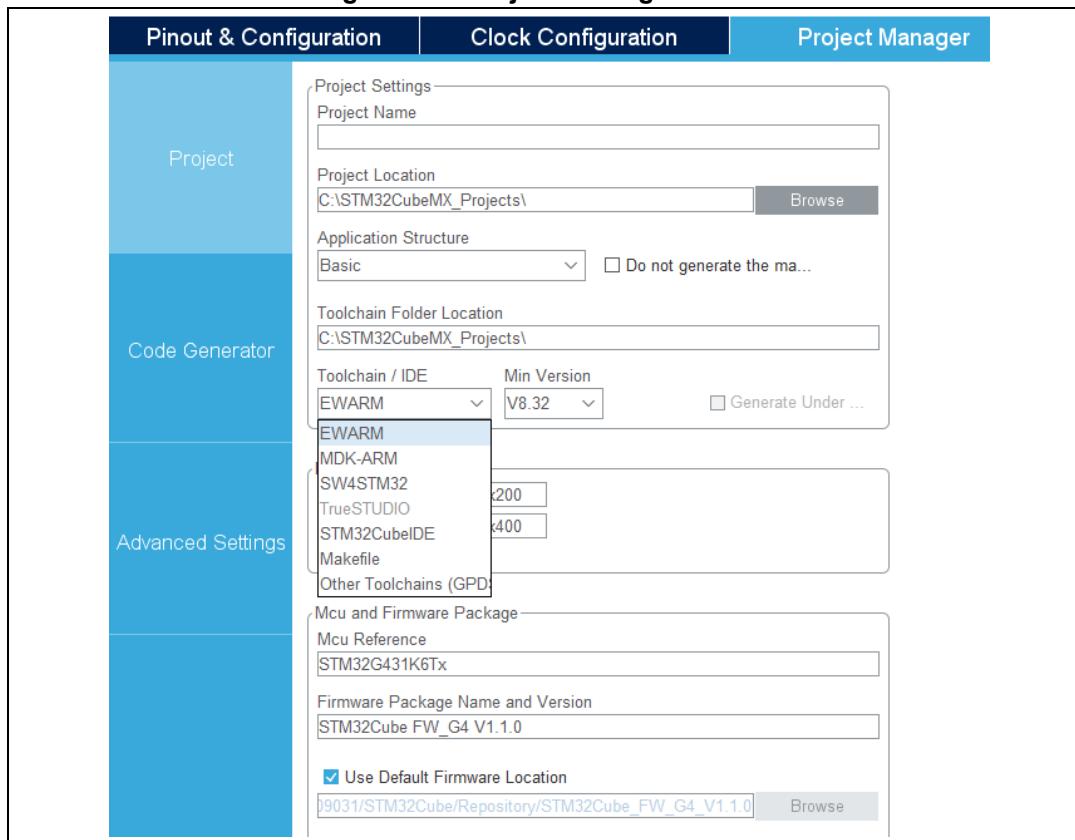
**Table 13. Glossary (continued)**

Acronym	Definition
LSE	Low speed external clock: powered by an external clock
SYSCLK	System clock
HCLK	Internal AHB clock frequency
FCLK	Cortex free running clock
AHB	Advanced high performance bus
APB1	Low speed advanced peripheral bus
APB2	High speed advanced peripheral bus

## 4.9 Project Manager view

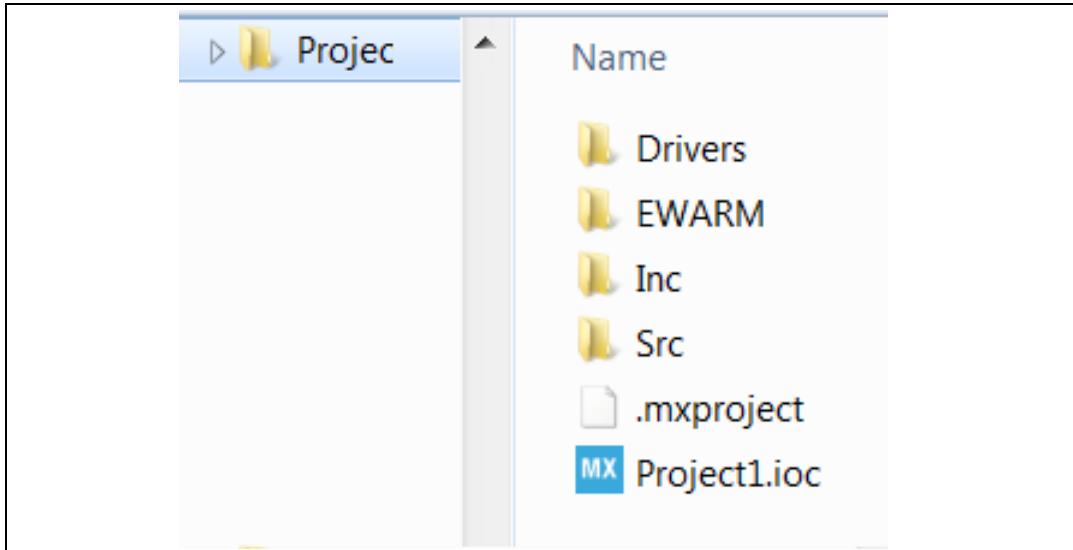
This view (see [Figure 100](#)) comes with three tabs:

- General project setting: to specify the project name, location, toolchain, and firmware version.
- Code generation: to set code generation options such as the location of peripheral initialization code, library copy/link options, and to select templates for customized code.
- Advanced settings: dedicated to ordering STM32CubeMX initialization function calls.

**Figure 100. Project Settings window**

The code is generated in the project folder tree shown in [Figure 101](#).

**Figure 101. Project folder**



**Note:** Some project settings options become read-only once the project is saved. To modify these options, the project must be saved as a new project using the **File> Save Project as** menu.

#### 4.9.1 Project tab

The **Project** tab of the **Project Settings** window allows configuring the following options (see [Figure 100](#)):

- Project settings:
  - Project name: name used to create the project folder and the .ioc file name at a given project location
  - Project location: directory where the project folder is stored.
  - Application structure: select between Basic and Advanced options.
    - Basic structure: recommended for projects using one or no middleware. This structure consists in placing the IDE configuration folder at the same level as the sources, organized in sources and includes subfolders (see [Figure 102](#))
    - Advanced structure: recommended when several middleware components are used in the project. It makes the integration of middleware applications easier (see [Figure 103](#))
  - Toolchain folder location: by default, it is located in the project folder at the same level as the .ioc file.
  - Toolchain/IDE: selected toolchain
  - For the STM32MP1 Series only, OpenSTLinux settings: location of generated device tree and manifest version and contents for current project (see [Figure 104](#)). These information enable the synchronization of the right SW components versions with STM32CubeMP1 for Cortex® M and Linux, tf-a, u-boot for Cortex® A. It is important to take them into account especially to ensure one Cube firmware version is aligned with SW components for Cortex® A around OpenAMP / RPM link and resource management API.

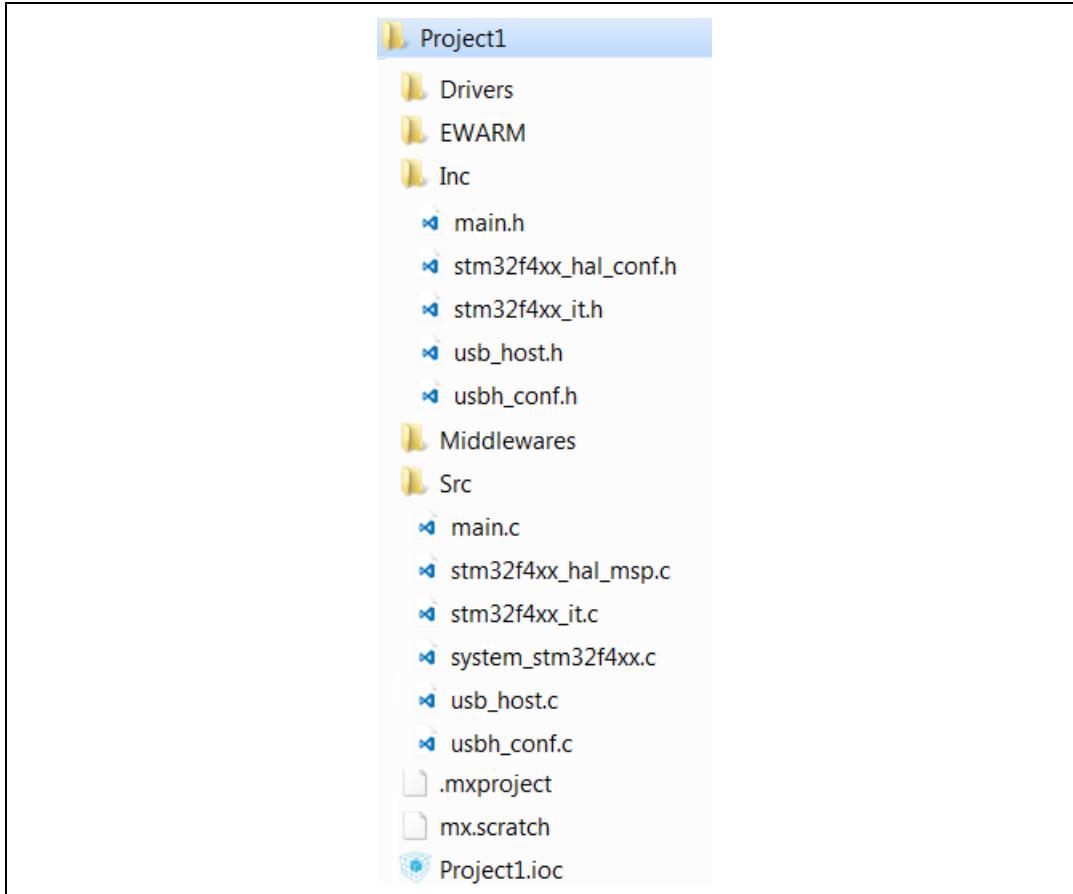
Selecting *Makefile* under Toolchain/IDE leads to the generation of a generic gcc-based makefile.

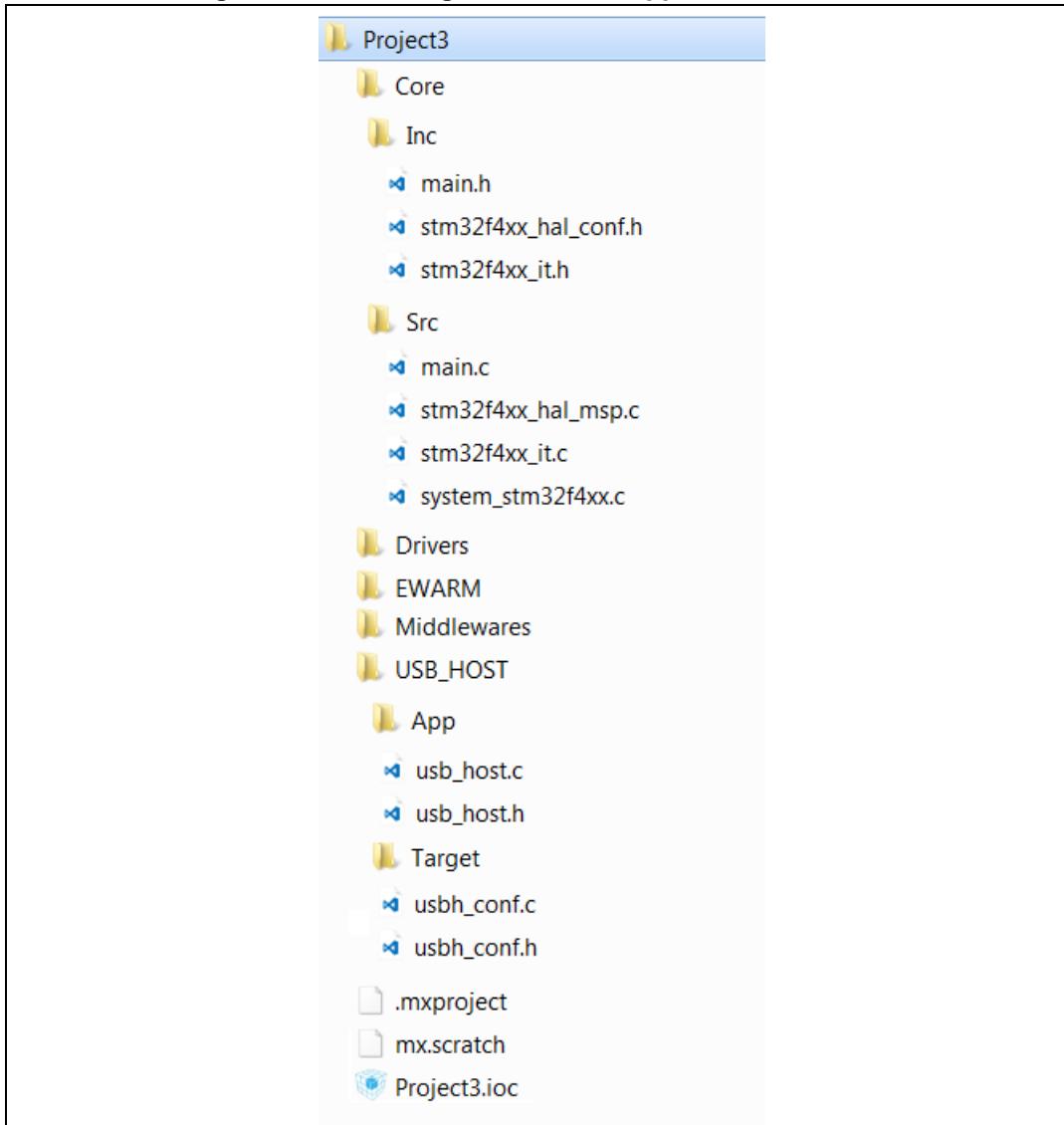
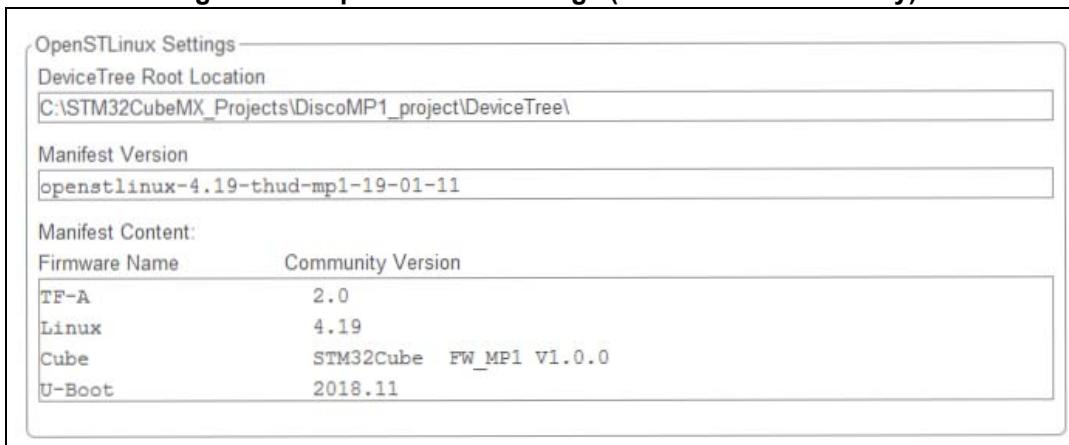
Selecting *Other Toolchains (GPDSC)* generates a gpdsc file. The gpdsc file provides a generic description of the project, including the list and paths of drivers and other files (such as startup files) that are required for building the project. It is thus possible to extend STM32CubeMX project generation to any toolchain supporting gpdsc, as the toolchain is able to load a STM32CubeMX generated C project by processing the gpdsc file information. To standardize the description of embedded projects, the gpdsc solution is based on CMSIS-Pack.

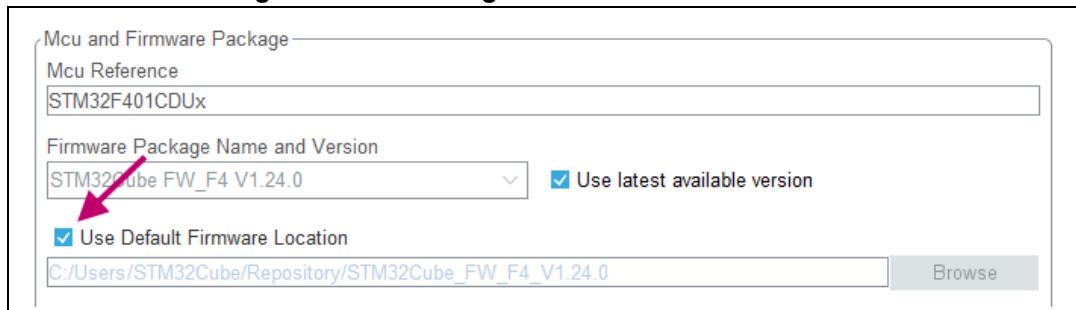
- Additional project settings for SW4STM32 and Atollic® TrueSTUDIO® toolchain:  
Select the optional **Generate under root** checkbox to generate the toolchain project files in STM32CubeMX user project root folder or deselect it to generate them under a dedicated toolchain folder.  
STM32CubeMX project generation under the root folder allows to benefit from the following Eclipse features when using Eclipse-based IDEs such as SW4STM32 and TrueStudio®:
  - Optional copy of the project into the Eclipse workspace when importing a project.
  - Use of source control systems such as GIT or SVN from the Eclipse workspace.Choosing to copy the project into workspace prevents any further synchronization between changes done in Eclipse and changes done in STM32CubeMX, as there will be two different copies of the project.
- Linker settings: value of minimum heap and stack sizes to be allocated for the application. The default values proposed are 0x200 and 0x400 for heap and stack sizes, respectively. These values may need to be increased when the application uses middleware stacks.
- Firmware package selection when more than one version is available (this is the case when successive versions implement the same API and support the same MCUs). By default, the latest available version is used.
- Firmware location selection option

The default location is the location specified under the **Help > updater settings** menu.

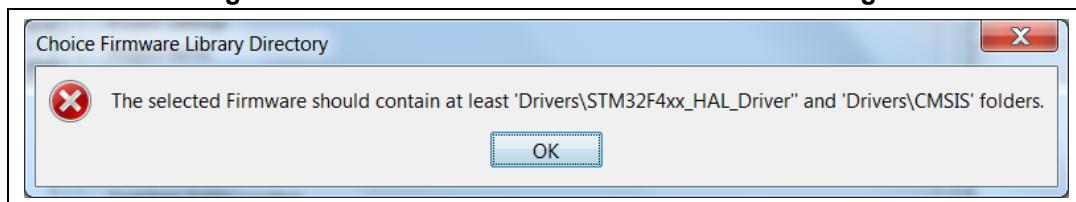
Deselecting the **Use Default Firmware Location** checkbox allows the user to specify a different path for the firmware that will be used for the project (see [Figure 105](#)).

**Figure 102. Selecting a basic application structure**

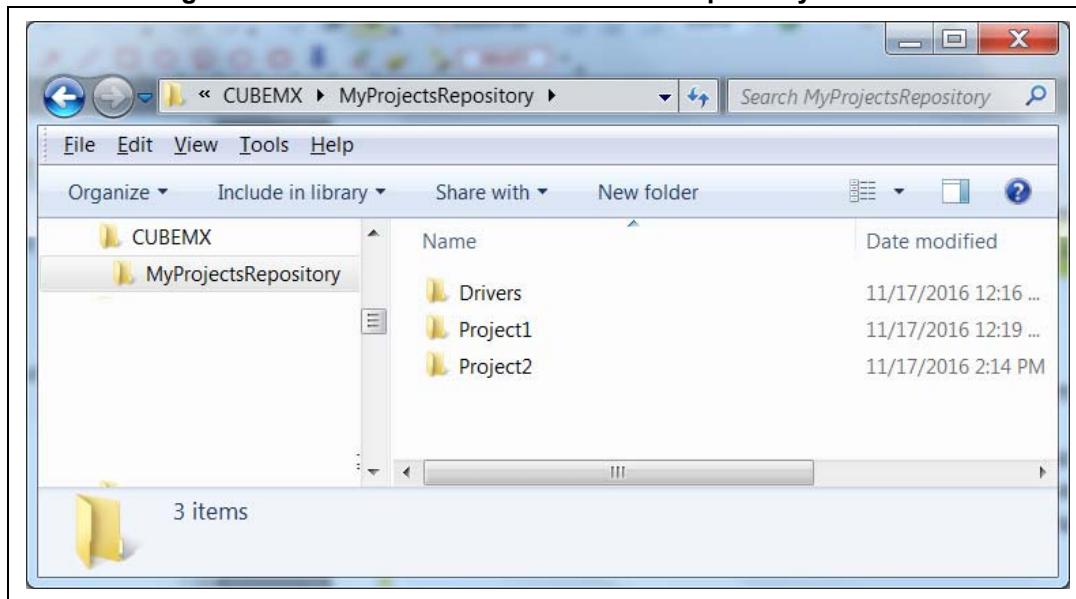
**Figure 103. Selecting an advanced application structure****Figure 104. OpenSTLinux settings (STM32MP1 Series only)**

**Figure 105. Selecting a different firmware location**

The new location must contain at least a *Drivers* directory containing the HAL and CMSIS drivers from the relevant STM32Cube MCU package. An error message pops up if the folders cannot be found (see [Figure 106](#)).

**Figure 106. Firmware location selection error message**

To reuse the same *Drivers* folder across all projects that use the same firmware location, select the **Add the library files as reference** from the **Code generator** tab allows (see [Figure 107](#)).

**Figure 107. Recommended new firmware repository structure**

**Caution:** STM32CubeMX manages firmware updates solely for this default location. Choosing another location prevents the user from benefiting from automatic updates. The user must manually copy new driver versions to its project folder.

## 4.9.2 Code Generator tab

The **Code Generator** tab allows specifying the following code generation options (see [Figure 108](#)):

- STM32Cube Firmware Library Package option
- Generated files options
- HAL settings options
- Custom code template options

### STM32Cube Firmware Library Package option

The following actions are possible:

- Copy all used libraries into the project folder  
STM32CubeMX copies to the user project folder the drivers libraries (HAL, CMSIS) and the middleware libraries relevant to the user configuration (e.g. FatFs, USB).
- Copy only the necessary library files:  
STM32CubeMX copies to the user project folder only the library files relevant to the user configuration (e.g., SDIO HAL driver from the HAL library).
- Add the required library as referenced in the toolchain project configuration file  
By default, the required library files are copied to the user project. Select this option for the configuration file to point to files in STM32CubeMX repository instead: the user project folder will not hold a copy of the library files but only a reference to the files in STM32CubeMX repository.

### Generated files options

This area allows the user to define the following options:

- Generate peripheral initialization as a pair of .c/.h files or keep all peripheral initializations in the main.c file.
- Backup previously generated files in a backup directory  
The .bak extension is added to previously generated .c/.h files.  
Keep user code when regenerating the C code.  
This option applies only to user sections within STM32CubeMX generated files. It does not apply to the user files that might have been added manually or generated via ffl templates.
- Delete previously generated files when these files are no longer needed by the current configuration. For example, uart.c/.h file are deleted if the UART peripheral, that was enabled in previous code generation, is now disabled in current configuration.

### HAL settings options

This area allows selection one HAL settings options among the following:

- Set all free pins as analog to optimize power consumption
- Enable/disable Use the *Full Assert* function: the Define statement in the stm32xx\_hal\_conf.h configuration file is commented or uncommented, respectively.

### Custom code template options

To generate custom code, click the **Settings** button under **Template Settings**, to open the Template Settings window (see [Figure 109](#)).

The user is then prompted to choose a source directory to select the code templates from, and a destination directory where the corresponding code will be generated.

The default source directory points to the extra\_template directory, within STM32CubeMX installation folder, which is meant for storing all user defined templates. The default destination folder is located in the user project folder.

STM32CubeMX then uses the selected templates to generate user custom code (see [Section 6.3: Custom code generation](#)).

[Figure 110](#) shows the result of the template configuration shown on [Figure 109](#): a sample.h file is generated according to sample\_h.ftl template definition.

**Figure 108. Project Settings code generator**

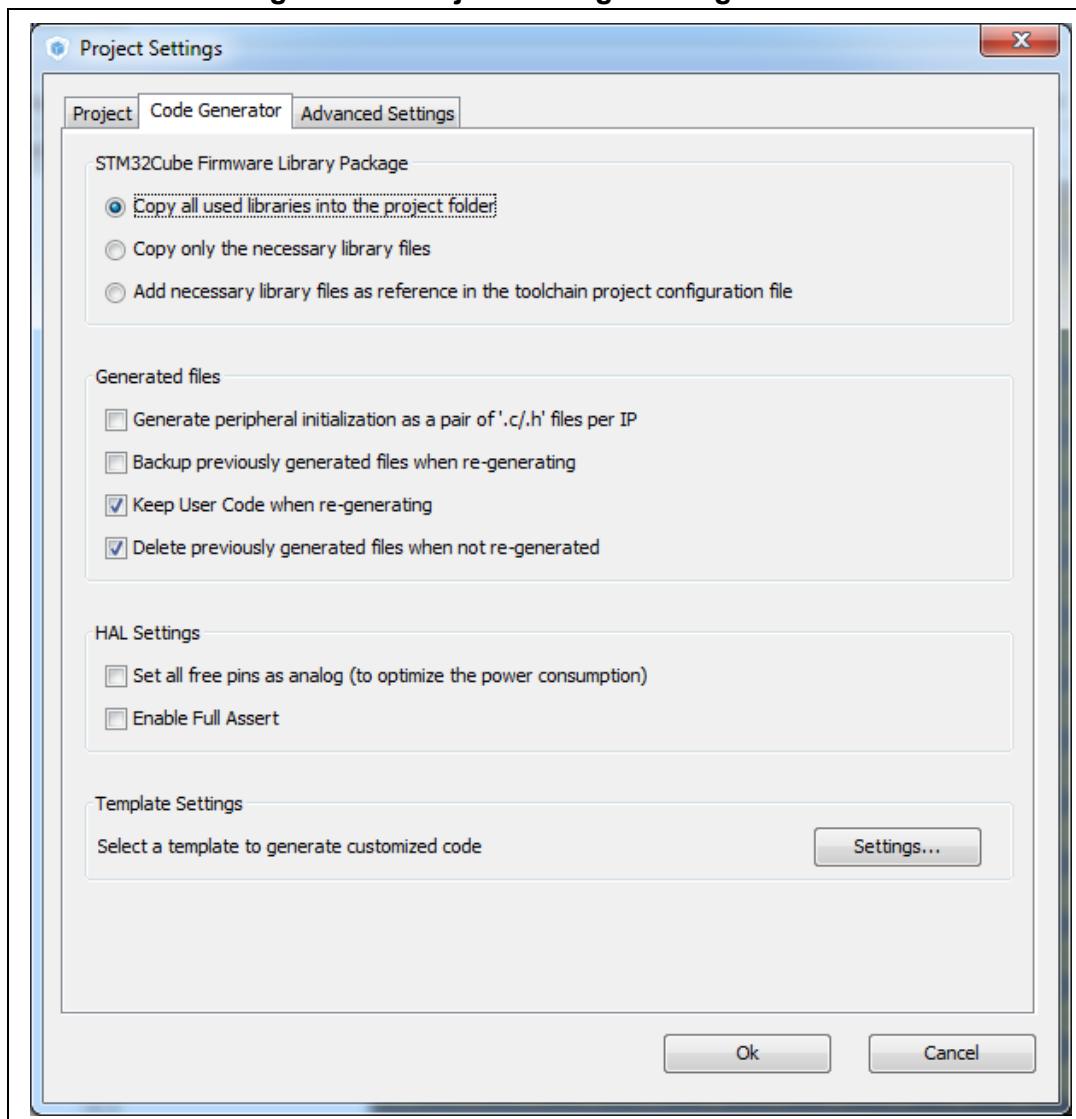


Figure 109. Template Settings window

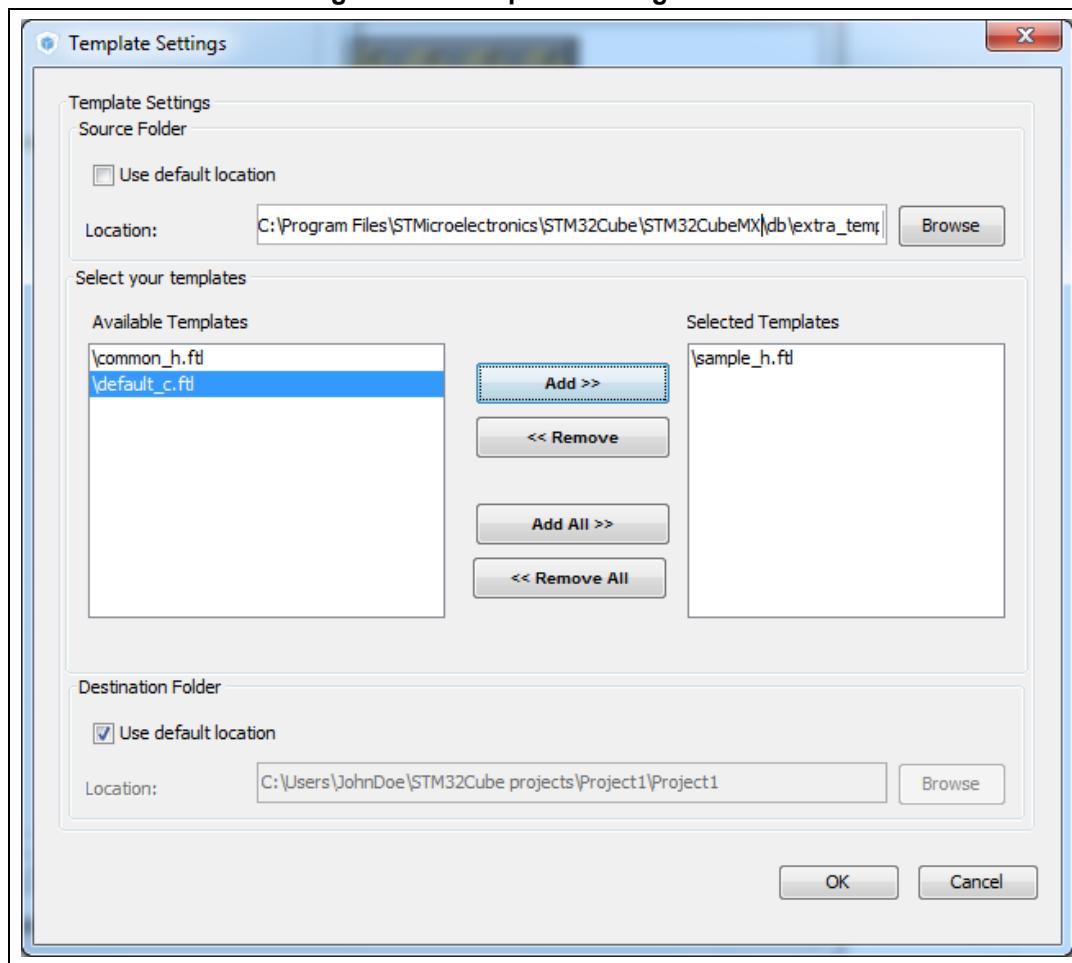
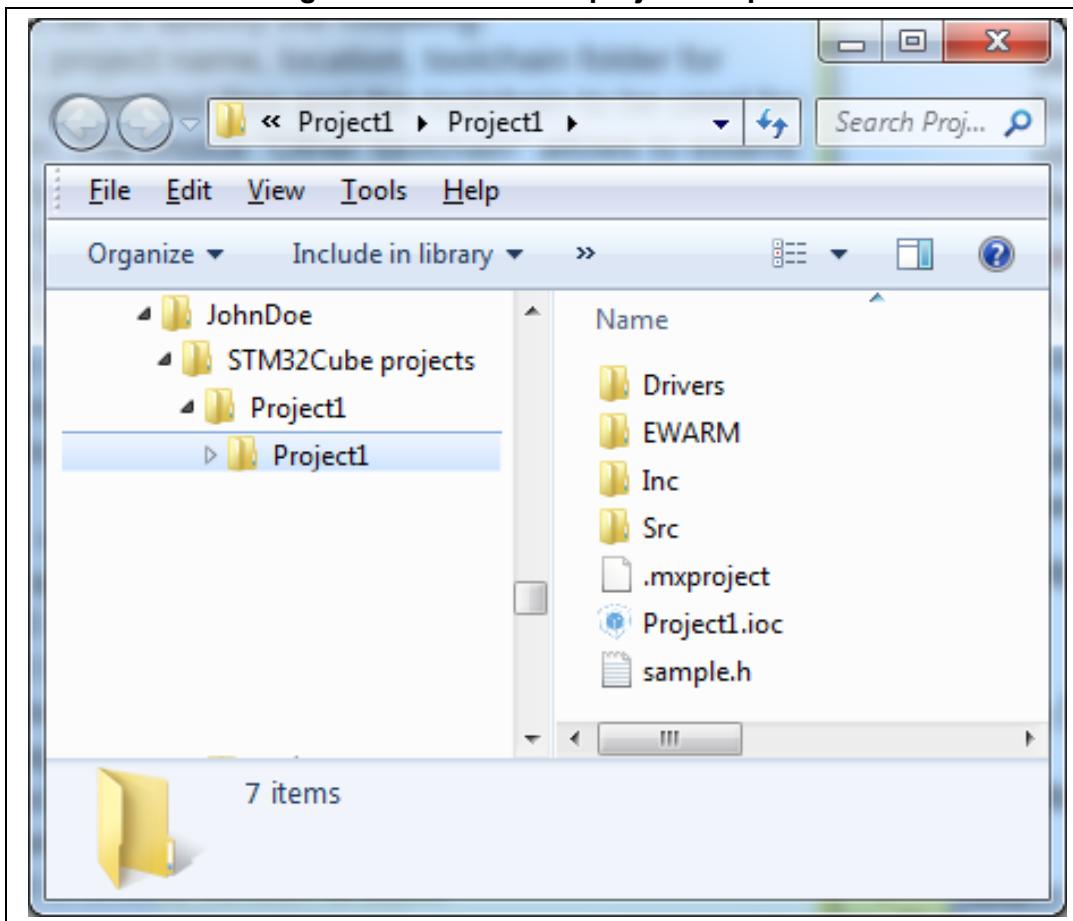


Figure 110. Generated project template



#### 4.9.3 Advanced Settings tab

This tab comes with three panels (see [Figure 111](#))

- The **Driver selector** panel, to select the driver (HAL or LL) to be used when generating the initialization code of a peripheral instance.
- The **Generated Function Calls** panel, to choose whether the function calls must be generated or not, generated as static or not and in which order.
- The **Register callback** panel, to select the peripherals for which the register callback define must be generated as part of the `stm32xxxx_hal_conf.h` file.

As an example, when ADC is enabled in the register callback panel, STM32CubeMX generates

```
#define USE_HAL_ADC_REGISTER_CALLBACKS 1U
```

#### Choosing not to generate code for some peripherals or middlewares

By default, STM32CubeMX generates initialization code. This automatic generation can be disabled per peripheral or middleware in the Generate code column.

## Ordering initialization function calls

By default, the generated code calls the peripheral/middleware initialization functions in the order in which peripherals and middleware have been enabled in STM32CubeMX. The user can then choose to re-order them by modifying the Rank number using the up and down arrow buttons.

The reset button allows the user to switch back to alphabetical order.

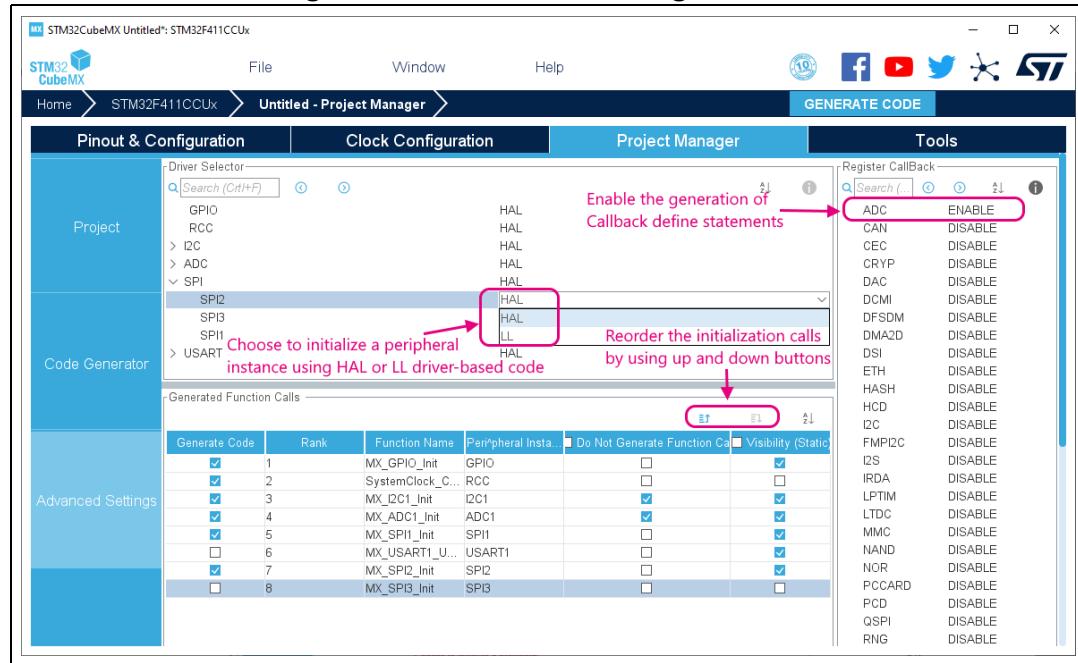
## Disabling calls to initialization functions

If the “**Not to be generated**” checkbox is checked, STM32CubeMX does not generate the call to the corresponding peripheral initialization function. It is up to the user code to do it.

## Choosing between HAL and LL based code generation for a given peripheral instance

Starting from STM32CubeMX 4.17 and STM32L4 Series, STM32CubeMX offers the possibility for some peripherals to generate initialization code based on Low Layer (LL) drivers instead of HAL drivers: the user can choose between LL and HAL driver in the **Driver Selector** section. The code is generated accordingly (see [Section 6.2: STM32Cube code generation using Low Layer drivers](#)).

**Figure 111. Advanced Settings window**



Unselecting the **Visibility (Static)** option, as shown for MX\_I2C1\_Init function in [Figure 111](#), allows the generation of the function definition without the static keyword and hence extends its visibility outside the current file (see [Figure 112](#)).

**Figure 112. Generated init functions without C language “static” keyword**

```
/* Private function prototypes -----
void SystemClock_Config(void);
static void MX_GPIO_Init(void);
static void MX_LPTIM1_Init(void);
static void MX_LPTIM2_Init(void);
void MX_I2C1_Init(void); // Function definition without static keyword
static void MX_I2C2_Init(void);
static void MX_SPI1_Init(void);
static void MX_SPI2_Init(void);
static void MX_USART1_UART_Init(void);
static void MX_USART2_Init(void);
```

**Caution:** For the STM32MP1 Series only

By default the SystemClock\_Config function is called in STM32Cube Cube firmware main() function since the 'Not generate Function call' box in Project Manager/Advanced Settings panel is not activated by default (see [Figure 111](#)).

This configuration is valid for running STM32Cube firmware in engineering mode (Cortex-M4 stand-alone mode).

This configuration is not valid for running STM32Cube firmware in production mode: the 'Not generate Function call' box must be checked under Project Manager/Advanced Settings panel so that there is no call to *SystemClock\_Config()* in the *main()* function.

## 4.10 Import Project window

The **Import Project** menu eases the porting of a previously-saved configuration to another MCU. By default the following settings are imported:

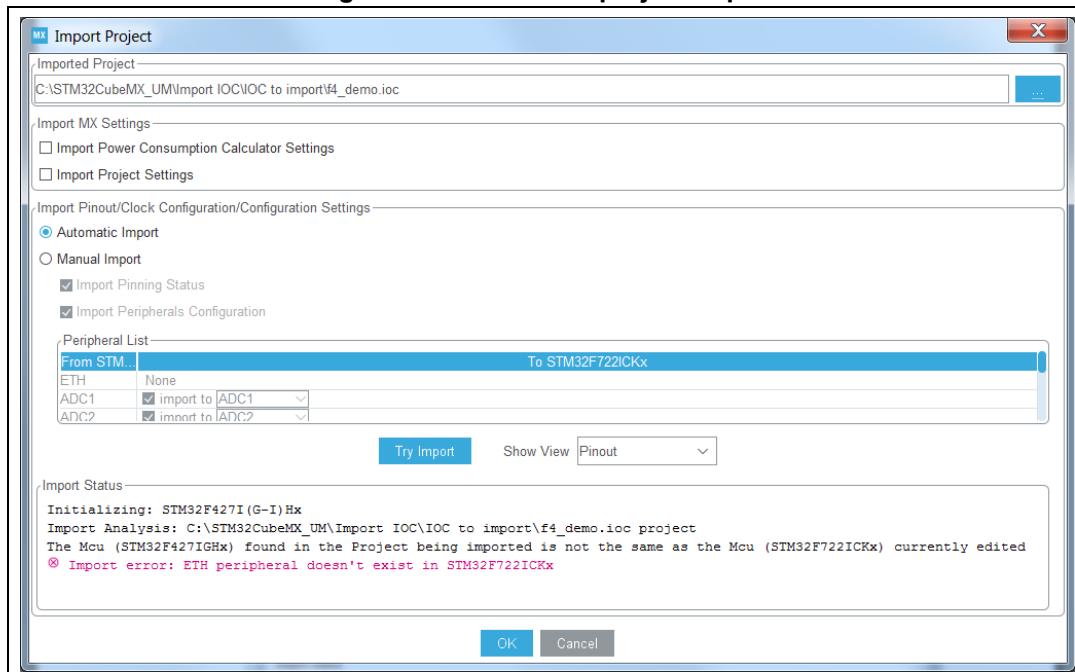
- **Pinout** tab: MCU pins and corresponding peripheral modes. The import fails if the same peripheral instances are not available in the target MCU.
- **Clock configuration** tab: clock tree parameters.
- **Configuration** tab: peripherals and middleware libraries initialization parameters.
- **Project settings**: choice of toolchain and code generation options.

To import a project, proceed as follows:

1. Select the **Import project** icon  that appears under the **File** menu after starting a New Project and once an MCU has been selected.  
The menu remains active as long as no user configuration settings are defined for the new project, that is just after the MCU selection. It is disabled as soon as a user action is performed on the project configuration.
2. Select **File > Import Project** for the dedicated Import project window to open. This window allows to specify the following options:
  - The STM32CubeMX configuration file (.ioc) pathname of the project to import on top of current empty project.

- Whether to import the configuration defined in the **Power Consumption Calculator** tab or not.
  - Whether to import the project settings defined through the **Project > Settings** menu: IDE selection, code generation options and advanced settings.
  - Whether to import the project settings defined through the **Project > Settings** menu: IDE selection and code generation options.
  - Whether to attempt to import the whole configuration (automatic import) or only a subset (manual import).
- a) Automatic project import (see [Figure 113](#))

**Figure 113. Automatic project import**

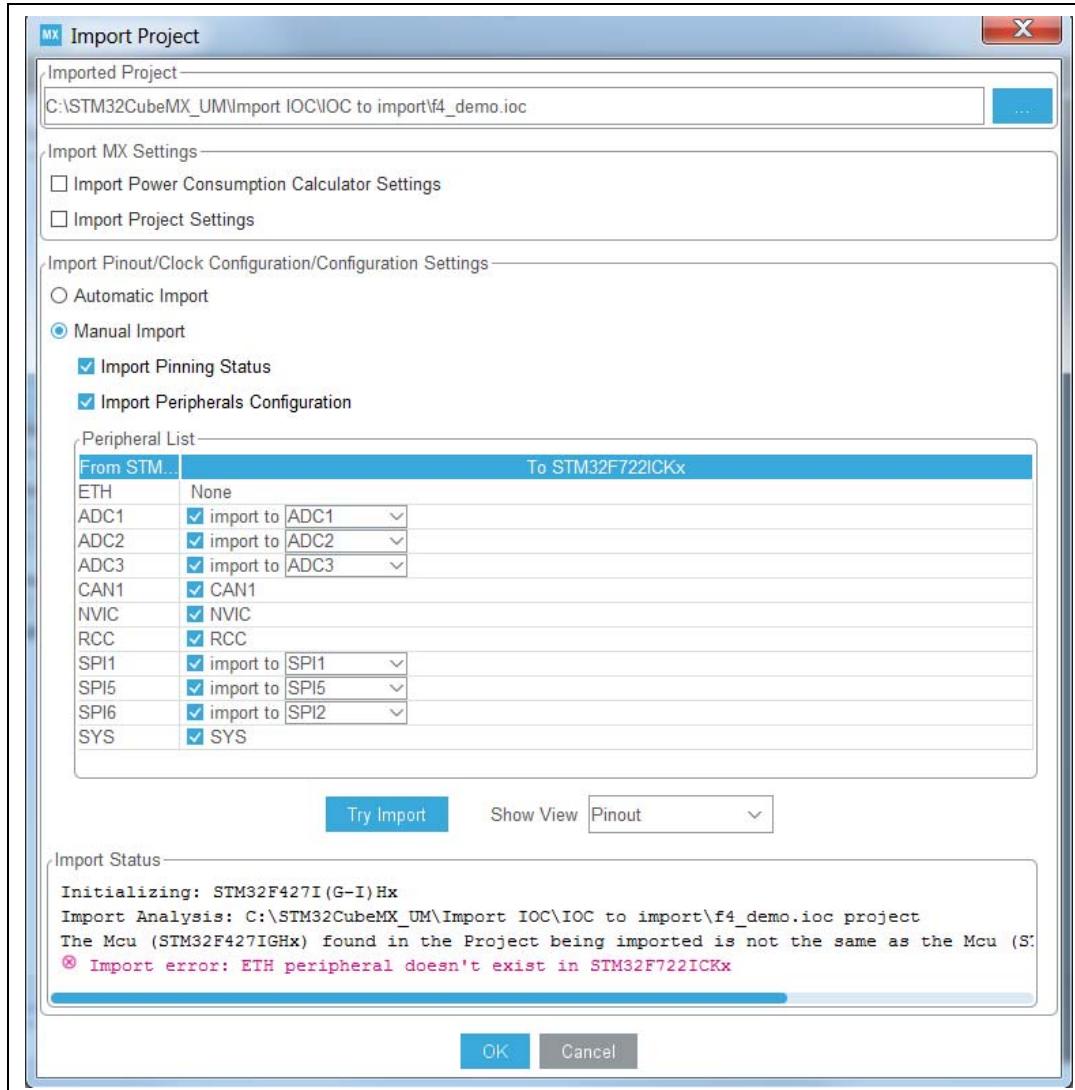


b) Manual project import

In this case, checkboxes allow the user to manually select the set of peripherals (see [Figure 114](#)).

Select the **Try Import** option to attempt importing.

**Figure 114. Manual project import**



The Peripheral List indicates:

- The peripheral instances configured in the project to be imported
- The peripheral instances, if any exists for the MCU currently selected, to which the configuration has to be imported. If several peripheral instances are candidate for the import, the user needs to choose one.

Conflicts can occur when importing a smaller package with less pins or a lower-end MCU with less peripheral options.

Click the **Try Import** button to check for such conflicts: the Import Status window and the Peripheral list get refreshed to indicate errors (see [Figure 115](#)), warnings and whether the import has been successful or not:

- Warning icons indicate that the user has selected a peripheral instance more than once and that one of the import requests will not be performed.
- A cross sign indicates that there is a pinout conflict and that the configuration can not be imported as such.

The manual import can be used to refine import choices and resolve the issues raised by the import trial. [Figure 116](#) gives an example of successful import trial, that has been obtained by deselecting the import request for some peripherals.

The **Show View** function allows switching between the different configuration tabs (pinout, clock tree, peripheral configuration) for checking influence of the "Try Import" action before actual deployment on current project (see [Figure 116](#)).

Figure 115. Import Project menu - Try import with errors

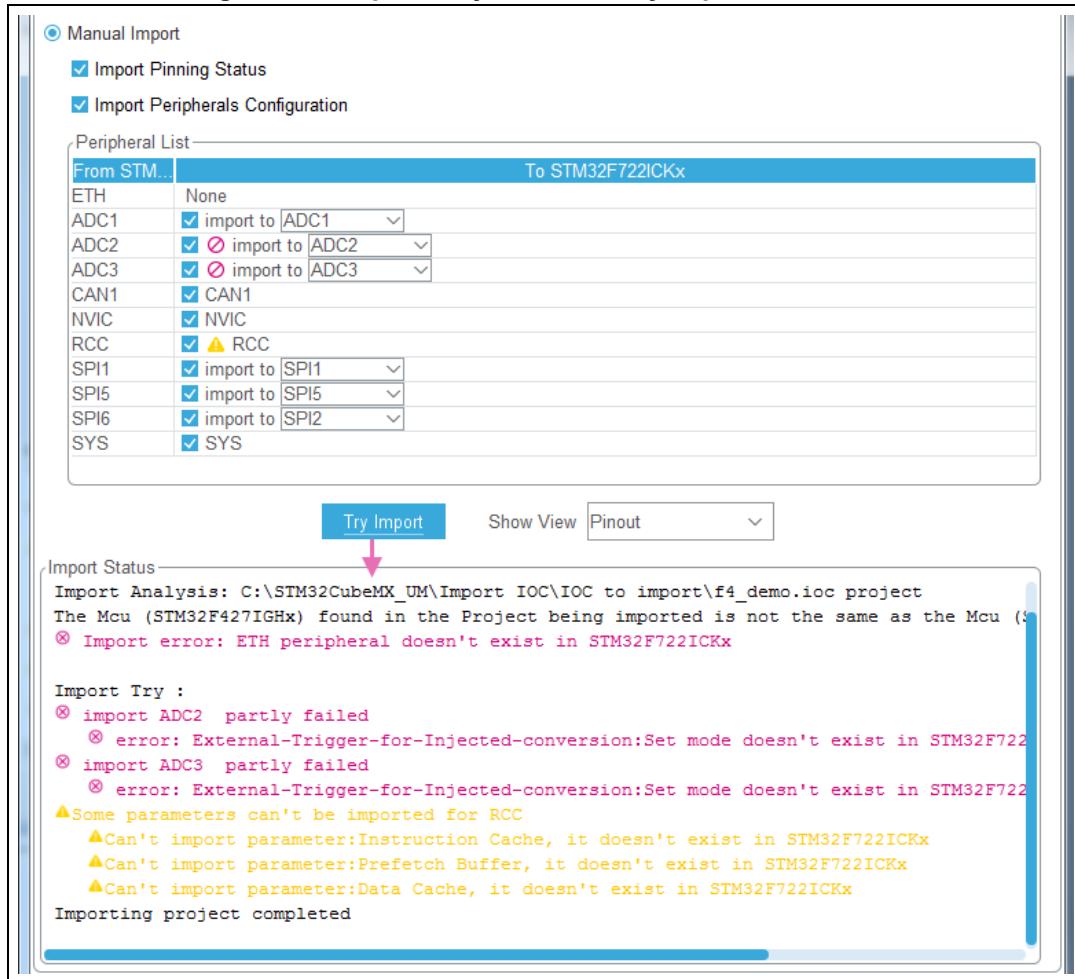
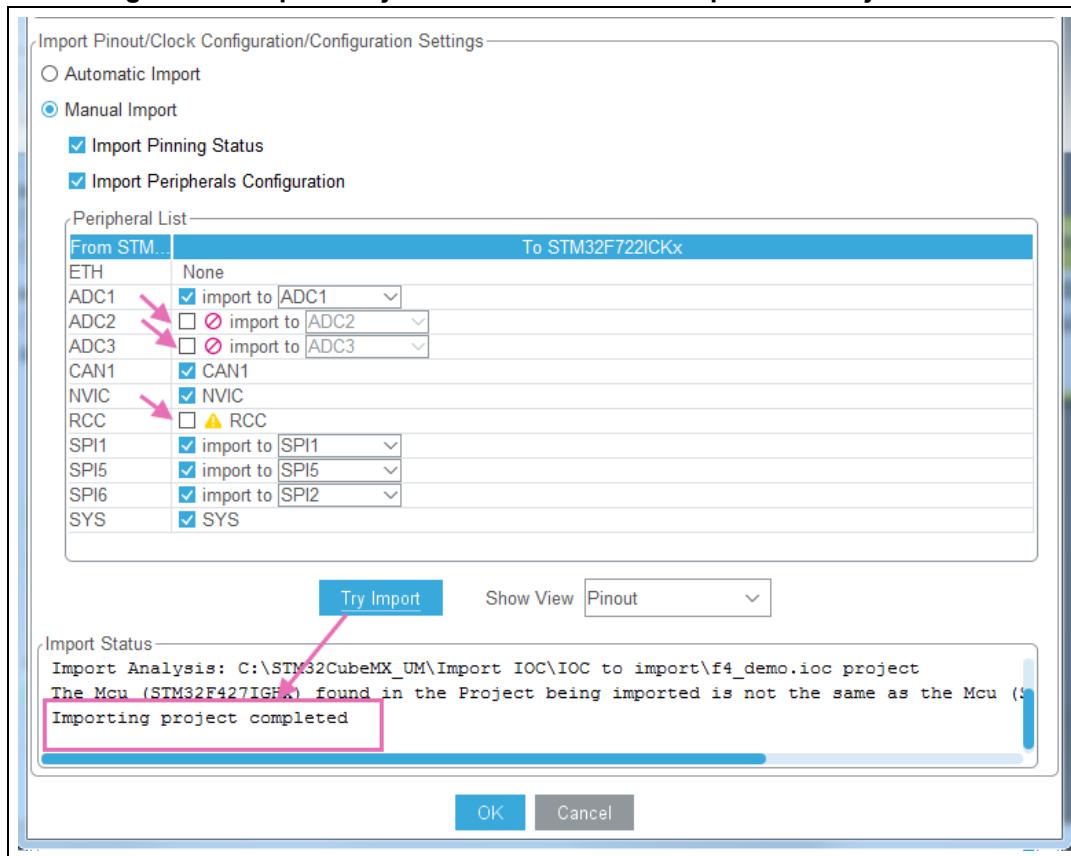


Figure 116. Import Project menu - Successful import after adjustments



- Choose **OK** to import with the current status or **Cancel** to go back to the empty project without importing.

Upon import, the Import icon gets grayed since the MCU is now configured and it is no more possible to import a non-empty configuration.

## 4.11 Set unused / Reset used GPIOs windows

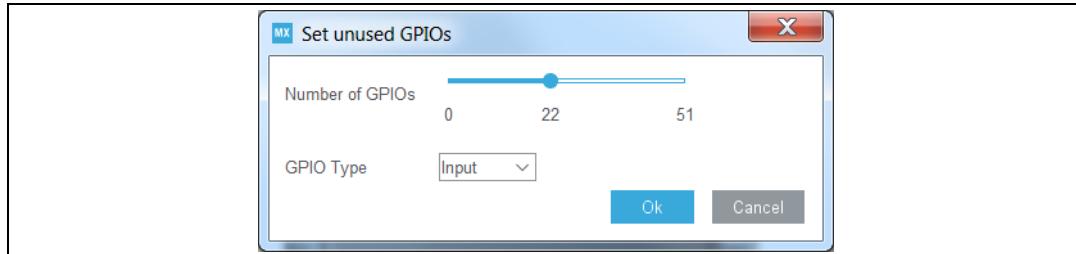
These windows are used to configure several pins at the same time in the same GPIO mode.

To open them:

- Select **Pinout > Set unused GPIOs** from the STM32CubeMX menu bar.

**Note:** *The user selects the number of GPIOs and lets STM32CubeMX choose the actual pins to be configured or reset, among the available ones.*

**Figure 117. Set unused pins window**



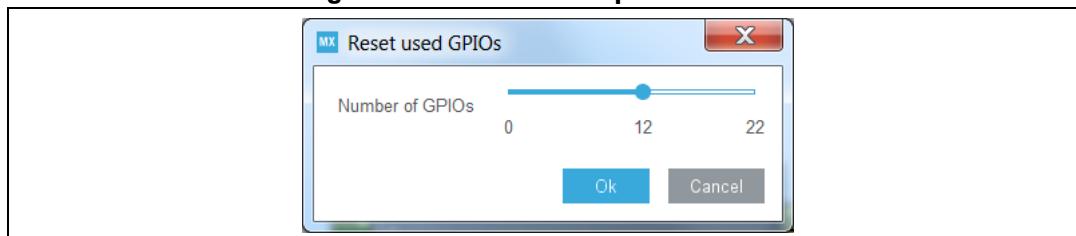
- Select **Pinout > Reset used GPIOs** from the STM32CubeMX menu bar.

Depending whether the Keep Current Signals Placement option is checked or not on the toolbar, STM32CubeMX conflict solver will be able to move or not the GPIO signals to other unused GPIOs:

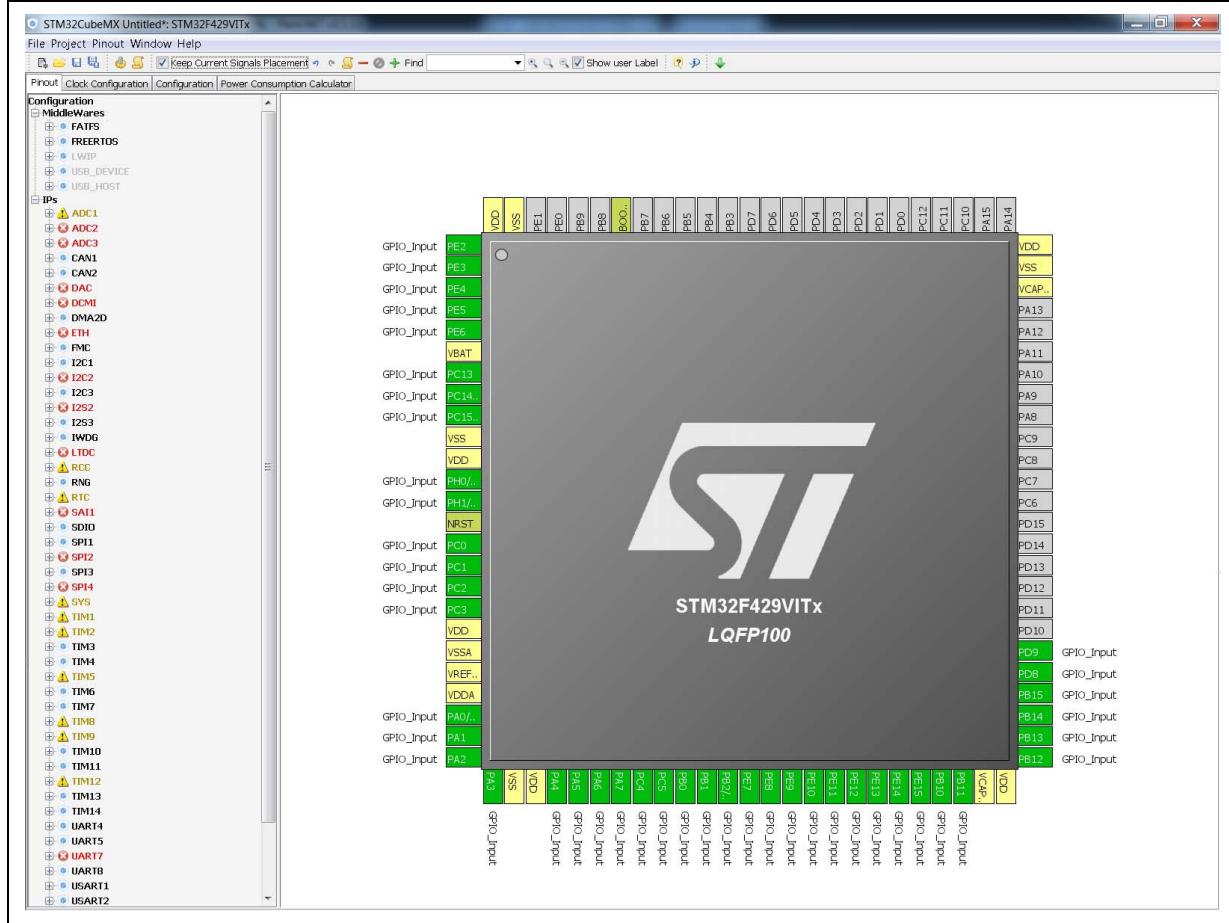
- When Keep Current Signals Placement is off (unchecked), STM32CubeMX conflict solver can move the GPIO signals to unused pins in order to fit in another peripheral mode.
- When Keep Current Signals Placement is on (checked), GPIO signals is not moved and the number of possible peripheral modes is limited.

Refer to [Figure 119](#) and [Figure 120](#) and check the limitation(s) in available peripheral modes.

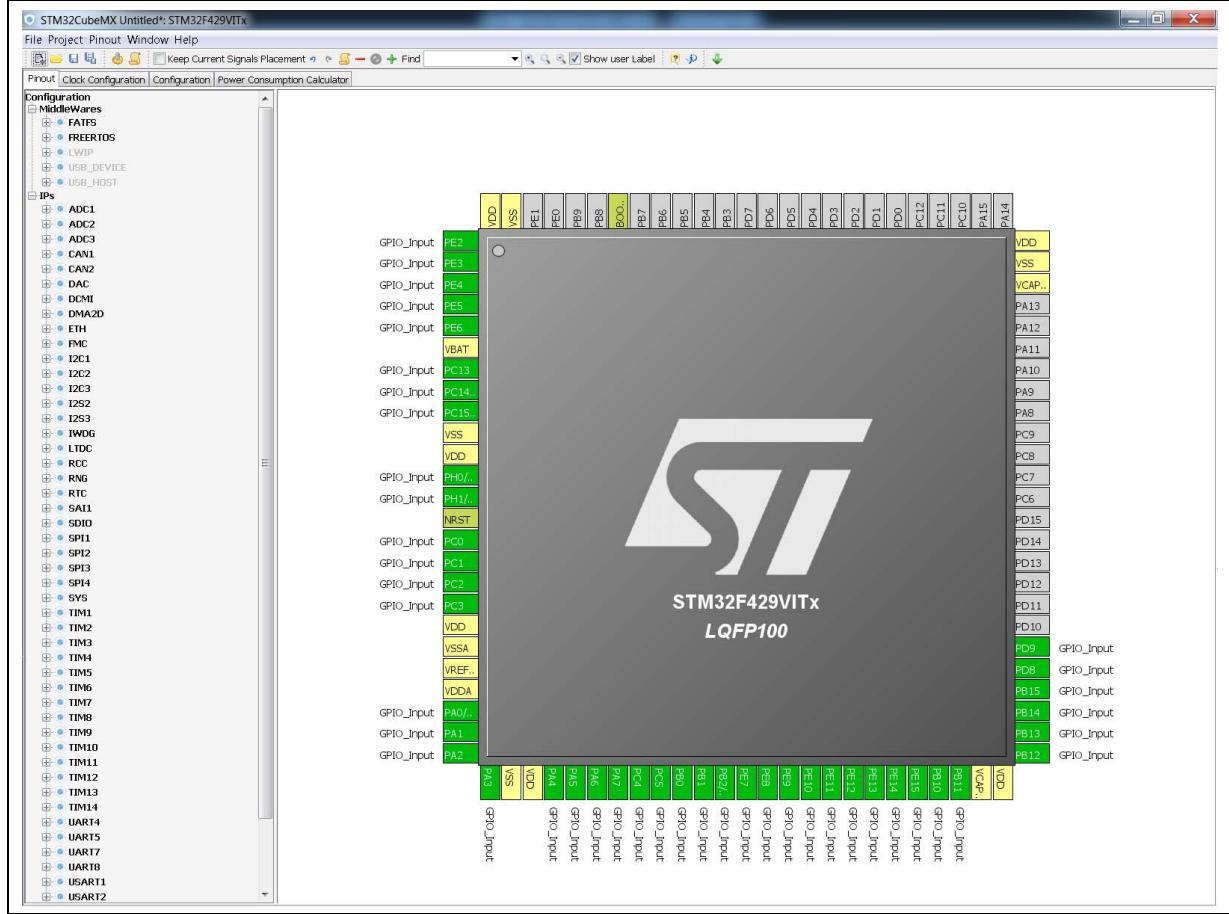
**Figure 118. Reset used pins window**



**Figure 119. Set unused GPIO pins with Keep Current Signals Placement checked**



**Figure 120. Set unused GPIO pins with Keep Current Signals Placement unchecked**



## 4.12 Update Manager windows

Three windows can be accessed through the **Help** menu available from STM32CubeMX menu bar:

1. Select **Help > Check for updates** to open the **Check Update Manager** window and find out about the latest software versions available for download.
  2. Select **Help > Manage embedded software packages** to open the **Embedded Software Package Manager** window and find out about the embedded software packages available for download. It also allows checking for package updates and removing previously installed software packages.
  3. Select **Help > Updater settings** to open the **Updater settings** window and configure update mechanism settings (proxy settings, manual versus automatic updates, repository folder where embedded software packages are stored).

Refer to [Section 3.4: Getting updates using STM32CubeMX](#) for a detailed description of these windows.

## 4.13 Additional software component selection window

The Additional Software Component selection window can be opened by clicking **Additional Software** from the **Pinout & Configuration** tab, at any time when working on the project. It allows the user to select additional software components for the current project. This feature is currently not supported for multi-core products.

It comes as four panels, as shown in *Figure 121*:

- **Filters** panel

Can be hidden using the “Show/hide filters” button. It is located on the left side of the window and provides a set of criteria to filter the pack component list.

- **Packs** panel

It is the main panel, as it displays the list of software components per pack that can be selected for the project.

- **Component dependencies** panel

Can be hidden using the “Show/hide dependencies” button. It displays dependencies, if any, for the component selected in the packs panel. It proposes solutions when any is found.

Dependencies that are not solved are highlighted with fuchsia icons.

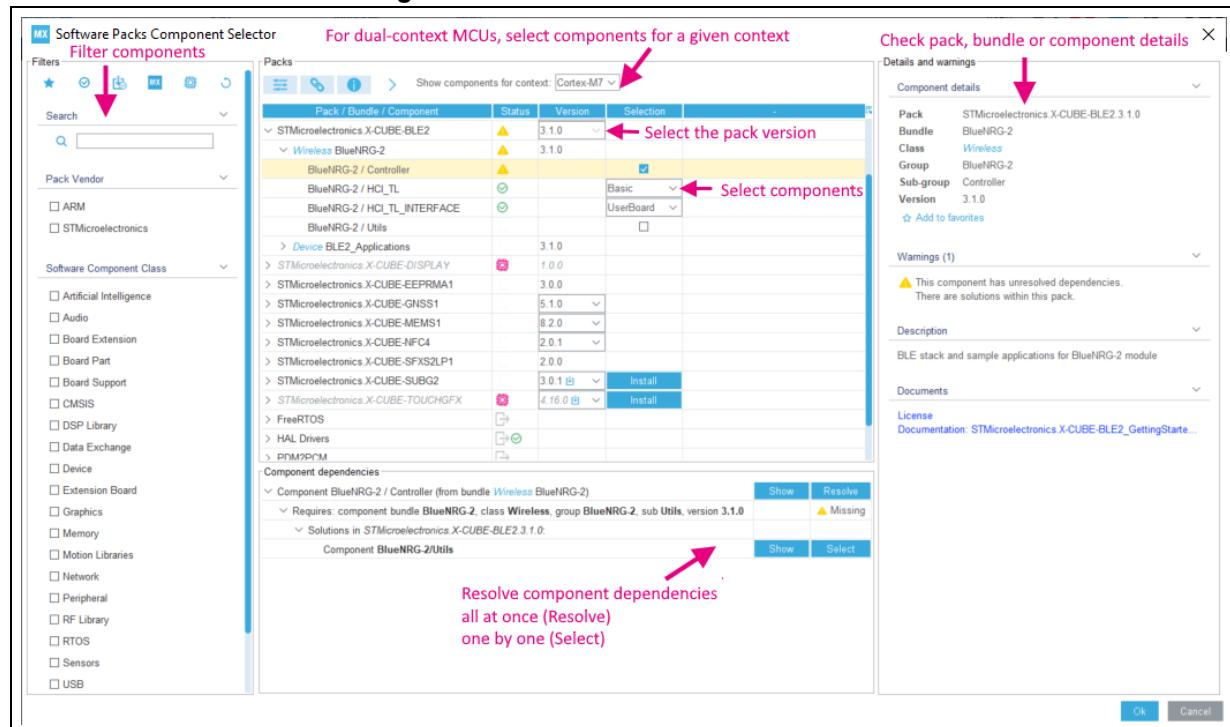
Once the dependency is solved (by selecting a component among the solution candidates) it is highlighted with green icons.

- **Details and warnings** panel

Can be hidden using the “Show/hide details” button. It is located on the right hand side. It provide informations for the element selected in the Pack panel.

This element can be a pack, a bundle or a component. It offers the possibility to install a version of the pack available but not yet installed, and allows the user to migrate the current project to a newer version of the pack, raising incompatibilities that cannot be automatically resolved.

Figure 121. Additional Software window



See [Section 10: Support of additional software components using CMSIS-Pack standard](#) for more details on how to handle additional software components through STM32CubeMX CMSIS-Pack integration.

#### 4.13.1 Introduction on software components

Arm® Keil™ CMSIS-Pack standard defines the pack (\*.pdsc) format for software components to be distributed as Software Packs. A Software pack is a zip file containing a \*.pdsc description file.

STM32CubeMX parses the pack .pdsc file to extract the list of software components. This list is presented in the Packs panel.

Arm® Keil™ CMSIS-Pack standard defines a software component as a list of files. The component or each of the corresponding individual files can optionally refer to a condition that must resolve to true, otherwise the component or file is not applicable in the given context. These conditions are listed in the **Component dependencies** panel.

There are no component names. Instead, each component is uniquely identified for a given vendor pack by the combination of class name, group name and a version. Additional categories, such as sub-group and variant can be assigned. These details are listed in the **Details & Warnings** panel.

#### 4.13.2 Filter panel

Click on  to open the Filter panel

To filter the software component list, choose pack vendor names and software component classes or enter a text string in the search field.

The resulting software component table is collapsed. Click the left arrow to expand it and display all the components that match the filtering criteria.

**Table 14. Additional software window - Filter icons**

Icon	Description
	Show only favorite packs. A pack is set as favorite in the <b>Details and Warnings</b> panel by clicking  <b>Add to favorites</b>
	Show only selected components. Components are selected in the Packs panel through checkboxes or variant selection when several implementation choices are available for the same component.
	Show only installed packs. Enables to show or hide not yet installed packs. Not yet installed packs are distinguished with the icon 
	Show only packs compatible with this version of STM32CubeMX. Packs not compatible with this version are distinguished with the icon 
	Show only packs compatible with the MCU used for the current project.
	Reset all filters

#### 4.13.3 Packs panel

By default, the Packs panel shows a collapsed view: all known packs are displayed with their name and for one given version (latest version is the default). Icons are used only to highlight the status of a pack version or of a component (see Table Packs panel icons).

**Details and warnings** and **Component dependencies** panels are used to provide detailed information.

The default view can be expanded by clicking the left arrows, revealing the next level, which can be a Bundle or a top component. The lowest level is the component level.

From this panel, clicking an icon highlighting a limitation or an action opens the relevant secondary panel (Details & Warnings or Component Dependency resolution).

**Note:** Some packs may have conditions on Arm® cores or STM32 Series or STM32 MCUs and they are visible only when the selected MCU meets the criteria. For example, a pack stating the “<accept Dcore="Cortex-M4"/>” condition will show but will be grayed out for MCUs not coming with an Arm® Cortex®-M4 core.

**Note:** A pack may promote an API and be shown under the “exposed APIs” entry. Clicking the API name allows to display additional information in the Details & warnings panel. Selecting the component implementing the API selects the API itself. STM32CubeMX generates the project with both the API .h definition file and the API implementation .c file.

**Note:** Some components, highlighted in gray in the component panel, are shown as read-only. They are software components (HAL peripheral drivers or middleware offers) coming with STM32Cube MCU embedded software package and are natively available in STM32CubeMX.

**Table 15. Additional Software window – Packs panel columns**

Column name	Description
Pack/Bundle/Component	At pack level, shows the <name of the Software pack> At bundle level, shows the <Name of the Class>_<Bundle name, if any> At component level, shows the <Group name>/<Subgroup name, if any>. Class names are standardized by the Arm CMSIS standard <sup>(1)</sup>
Version	Shows the version that has been selected from a list of one or more available versions of a pack. Bundle and components can either inherit the version of the pack or have their own specific version. The version is shown in the <b>Details and Warnings</b> panel.
Selection	Selects a component through a checkbox when only one implementation is available or from a list if variants exist.

1. The Arm® Keil™ CMSIS-Pack website, <http://www.keil.com>, lists the following classes:  
 Data Exchange: Software components for data exchange  
 File System: File drive support and file system  
 Graphics: Graphic libraries for user interfaces  
 Network: Network stack using Internet protocols  
 RTOS: Real-time operating systems  
 Safety: Components for testing application software against safety standards  
 Security: Encryption for secure communication or storage  
 USB: Universal serial bus stack  
 Wireless: Communication stacks such as Bluetooth®, WiFi®, and ZigBee®.

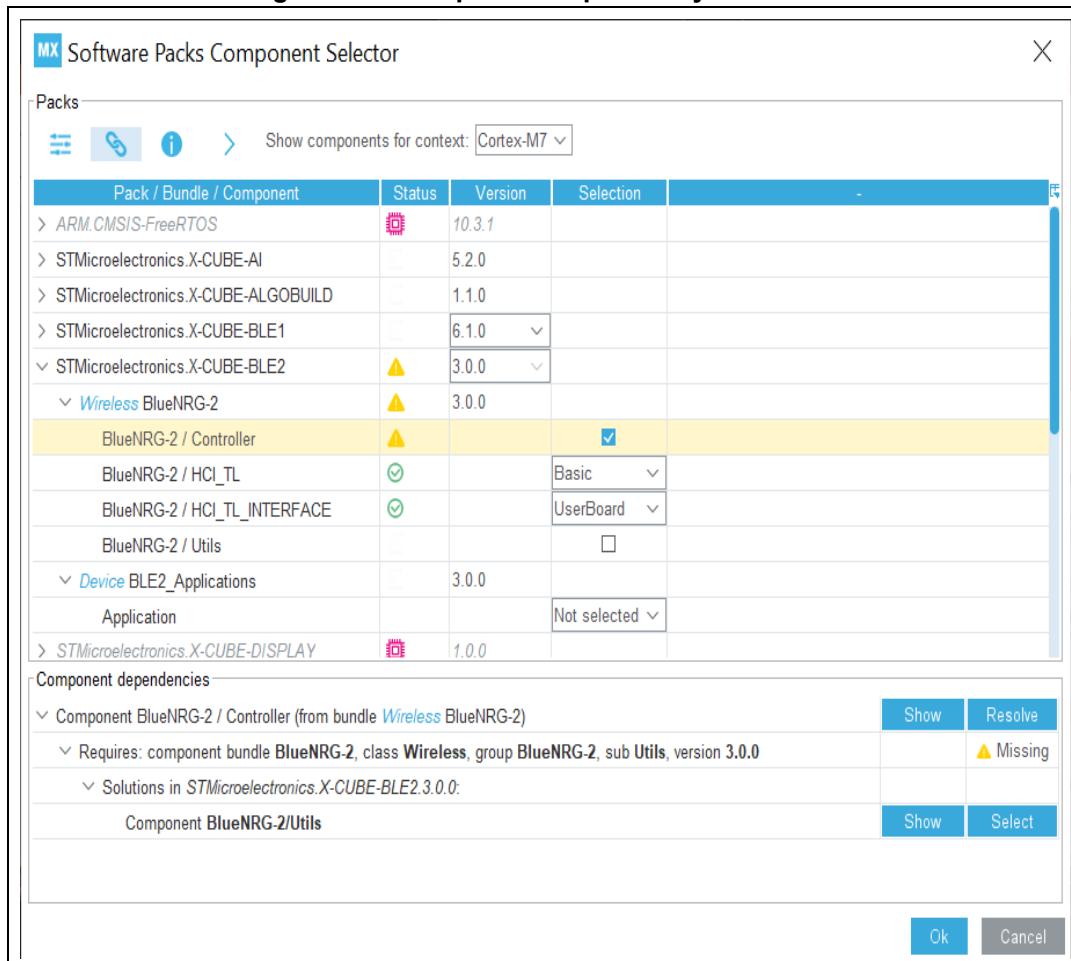
**Table 16. Additional Software window – Packs panel icons**

Icon	Description
	The pack has been added to the user favorite list of packs. Use the <b>Details and Warnings</b> panel to add/remove packs from list of favorites.
	The pack version is not compatible with this STM32CubeMX version. Solution: select a compatible version.
	The pack version is not yet installed. Solution: go to the <b>Details and Warnings</b> panel to download the pack version to use it for a project.
	The component is not available for selection. Solution: download the pack this component belongs to.
	A component is selected and at least one condition remains to be solved. Select the line of the component with such icon to refresh the <b>Component dependencies</b> panel with the list of dependencies, status and solutions if any found.
	At least one component is selected and all conditions, if any, are met.
	Other pack versions are available to switch to. Solution: use the <b>Details and Warnings</b> panel to proceed with a change.

#### 4.13.4 Component dependencies panel

The conditions are dependency rules applying to a given software component. When a component is selected, it shows with a green icon if there is no dependency to resolve, with a warning icon otherwise. Click  to open the dependency panel (see [Figure 122](#)).

**Figure 122. Component dependency resolution**



The panel is refreshed when selecting a component, providing details on the dependencies to solve and the available solutions, if found (see [Table 17](#)):

- click the Show button to show the component solving the dependency
- click the Select button to select the component solving the dependency
- when available, click Resolve button to automatically resolve the dependencies.

**Table 17. Component dependencies panel contextual help**

Contextual help	Description
<i>This component has no dependency.</i>	No dependency to solve.
<ul style="list-style-type: none"> <li>✖ Requires: Class CMSIS, Group CORE</li> <li>✖ No solution found</li> </ul>	Dependency to solve but no solution found.
<ul style="list-style-type: none"> <li>✖ Requires: Class Data Exchange, Group Interface</li> <li>✖ Solutions in pack STMicroelectronics.X-CUBE-GNSS1.3.0.0:           <ul style="list-style-type: none"> <li>?</li> <li>Component Interface / Variant Basic</li> <li>?</li> <li>Component Interface / Variant Template</li> </ul> </li> </ul>	Dependency to solve and at least one solution found. Click a solution proposal to be automatically re-directed to the component selection line in the packs panel.
<ul style="list-style-type: none"> <li>✖ Requires: Class Data Exchange, Group LibNMEA</li> <li>✖ Solutions in pack STMicroelectronics.X-CUBE-GNSS1.3.0.0:           <ul style="list-style-type: none"> <li>?</li> <li>Component LibNMEA</li> </ul> </li> </ul>	Dependency exists and has been solved (a component solving the condition has been selected).

#### 4.13.5 Details and Warnings panel

Click on  to show the panel (see [Figure 123](#)).

This panel is refreshed upon selecting a line from the **Packs** panel.

The following actions are possible from this panel:

- Add/Remove the pack from the list of favorite packs
- Install the pack
- Access the pack documentation through links
- Migrate the project to a new pack version.

To migrate a project to a new software pack version:

1. open the project
2. migrate to the new pack version
3. generate the code.

Known issue: performing step **2** after step **3** (migrating after code generation) leads to errors (wrong file path generation and project compilation failure). To fix such issue, the project must be saved as a new project and the code must be generated again. Actions are possible in this panel, namely adding/removing the pack to/from the list of favorite packs, installing a pack, accessing pack documentation through links.

**Figure 123. Details and Warnings panel**

The screenshot shows the 'Details and warnings' panel for the X-CUBE-MEMS1 pack. It includes sections for Pack details, Warnings, Description, and Documents.

**Pack details**

- Name: X-CUBE-MEMS1
- Vendor: STMicroelectronics
- Version: 6.2.0

[★ Add to favorites](#)

**Warnings (1)**

- This version of the pack is not compatible with the current version of STM32CubeMX.  
It is compatible with STM32CubeMX from 5.2.0 up to 5.2.1.

**Description**

Drivers and sample applications for MEMS components

**Documents**

[License](#)  
[Documentation](#)

#### 4.13.6 Updating the tree view for additional software components

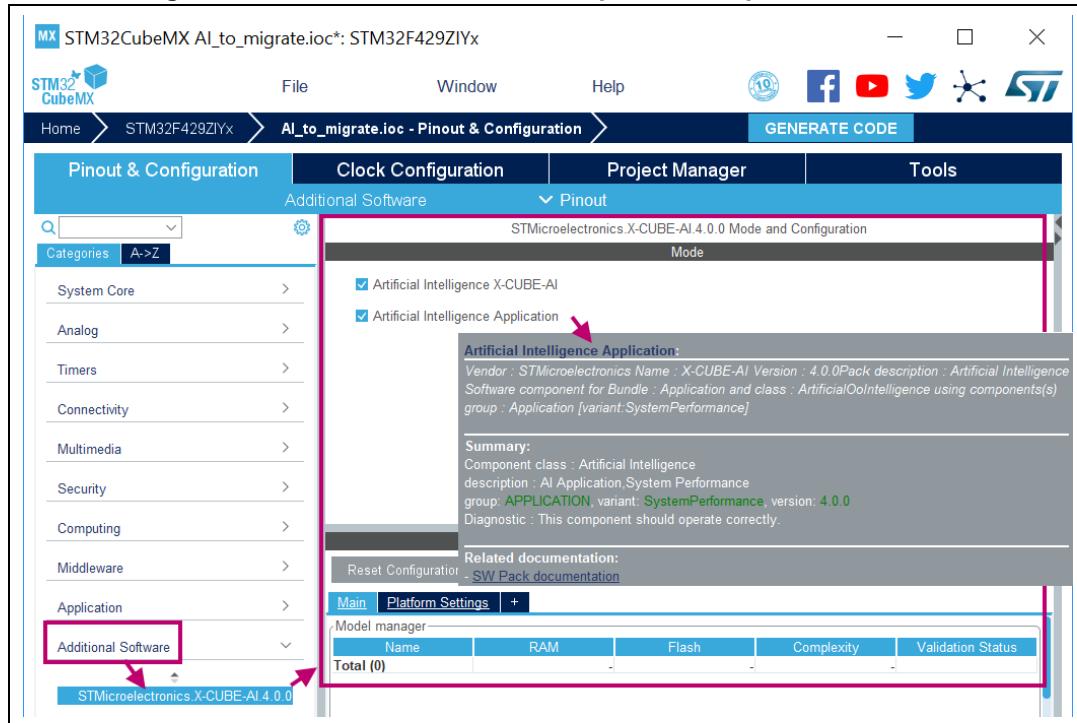
Once the selection of the software components required for the application is complete (see [Figure 124](#)), click **OK** to refresh STM32CubeMX window: the selected component appears in the tree view under Additional Software (see [Figure 125](#)).

**Figure 124. Selection of additional software components**

Packs		
Pack / Bundle / Component	Version	Selection
STMicroelectronics.X-CUBE-AI	4.0.0	
Artificial_Intelligence_Application		
Application		SystemPerformance
Artificial_Intelligence_X-CUBE-AI		
Core		<input checked="" type="checkbox"/>
STMicroelectronics.X-CUBE-BLE1	4.4.0	
STMicroelectronics.X-CUBE-GNSS1	3.0.0	
STMicroelectronics.X-CUBE-MEMS1	6.2.0 	
STMicroelectronics.X-CUBE-NFC4	1.4.0  	

The current selection of additional software components appears in the tree view (see [Figure 125](#)). The software components must be enabled in the Mode panel and may be configured further if any parameter is proposed in the configuration panel. Hovering the mouse over the component name reveals contextual help with links to documentation.

Figure 125. Additional software components - Updated tree view



## 4.14 About window

This window displays STM32CubeMX version information.

To open it, select **Help > About** from the STM32CubeMX menu bar.

**Figure 126. About window**



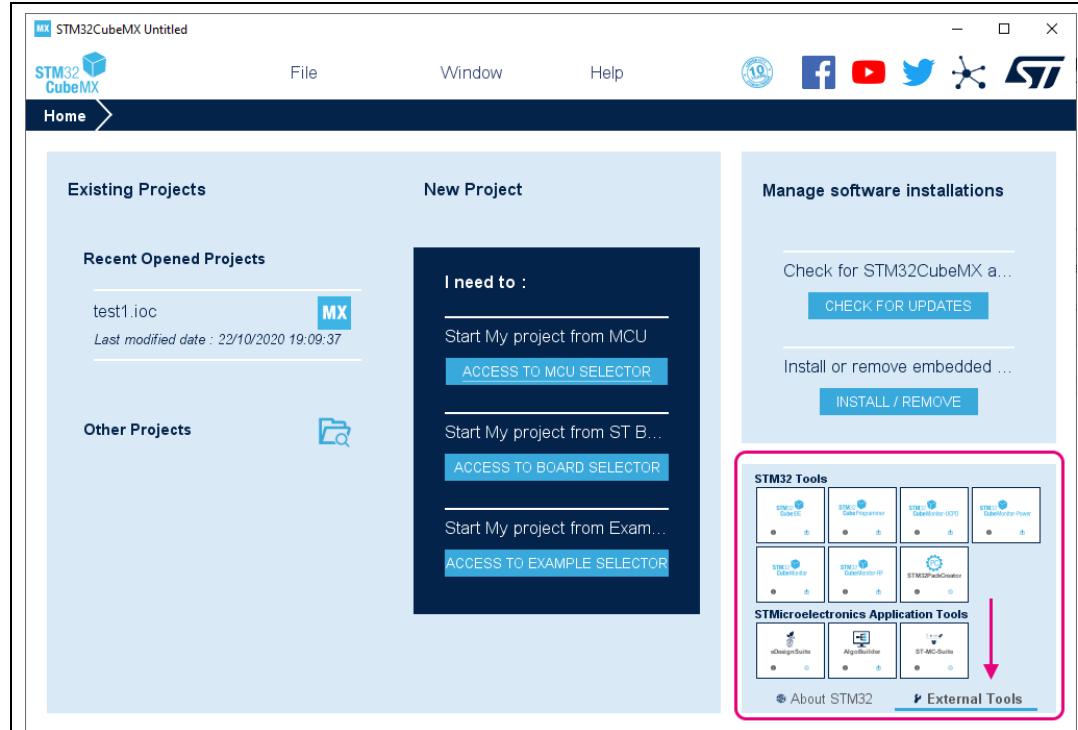
## 5 STM32CubeMX tools

### 5.1 External Tools

This panel is accessible from the home page. It provides an overview of the tools relevant for the STM32 product portfolio (see [Figure 127](#)):

- click  to open the tool information note
- click  to open the tool webpage on [www.st.com](http://www.st.com)
- click  to launch the tool.

**Figure 127. ST Tools**



## 5.2 Power Consumption Calculator view

For an ever-growing number of embedded systems applications power consumption is a major concern. To help minimizing it, STM32CubeMX offers the **Power Consumption Calculator** tab (see [Figure 128](#)), which, given a microcontroller, a battery model and a user-defined power sequence, provides the following results:

- Average current consumption

Power consumption values can either be taken from the datasheet or interpolated from a user specified bus or core frequency.

- Battery life

- Average DMIPs

DMIPs values are directly taken from the MCU datasheet and are neither interpolated nor extrapolated.

- Maximum ambient temperature ( $T_{AMAX}$ )

According to the chip internal power consumption, the package type and a maximum junction temperature of 105 °C, the tool computes the maximum ambient temperature to ensure good operating conditions.

Current  $T_{AMAX}$  implementation does not account for I/O consumption. For an accurate estimate, I/O consumption must be specified using the Additional Consumption field. The formula for I/O dynamic current consumption is specified in the microcontroller datasheet.

The **Power Consumption Calculator** view allows developers to visualize an estimate of the embedded application consumption and lower it further at each power sequence step:

- make use of low power modes when available
- adjust clock sources and frequencies based on the step requirements
- enable only the peripherals necessary for each phase.

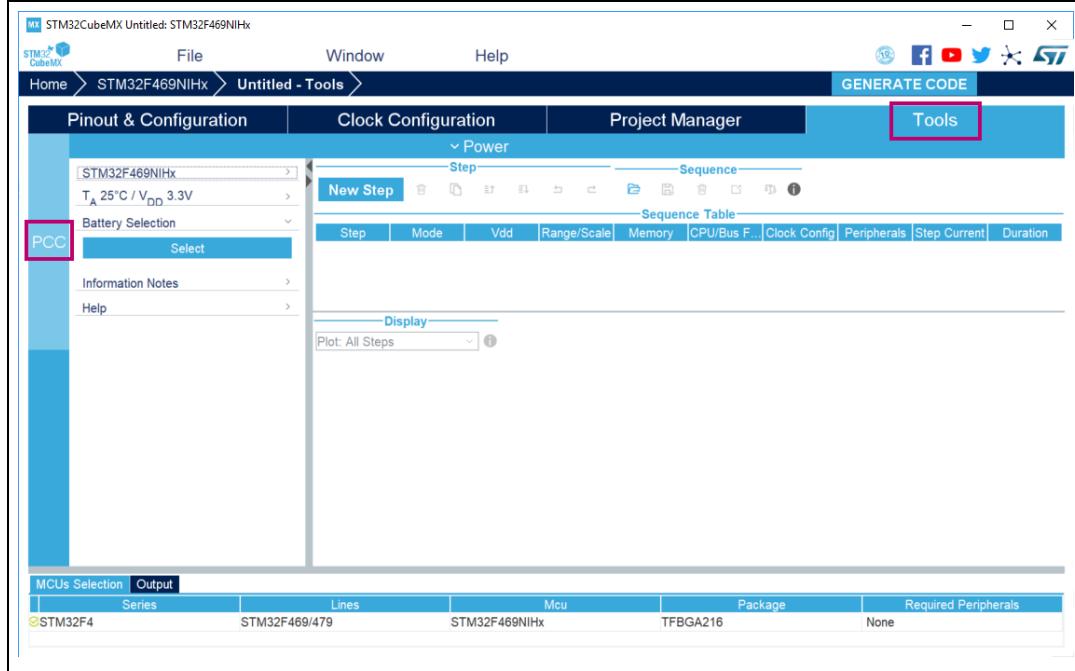
For each step the user can choose  $V_{BUS}$  as possible power source instead of the battery, impact battery life. If power consumption measurements are available at different voltage levels, STM32CubeMX also proposes a choice of voltage values (see [Figure 131](#)).

An additional option, the transition checker, is available for STM32L0, STM32L1, STM32L4, STM32L4+, STM32G0, STM32G4, STM32H7 and STM32WB Series. When enabled, the transition checker detects invalid transitions within the currently configured sequence. It ensures that only possible transitions are proposed to the user when a new step is added.

## 5.2.1 Building a power consumption sequence

The default starting view is shown in *Figure 128*.

**Figure 128. Power Consumption Calculator default view**



### Selecting a V<sub>DD</sub> value

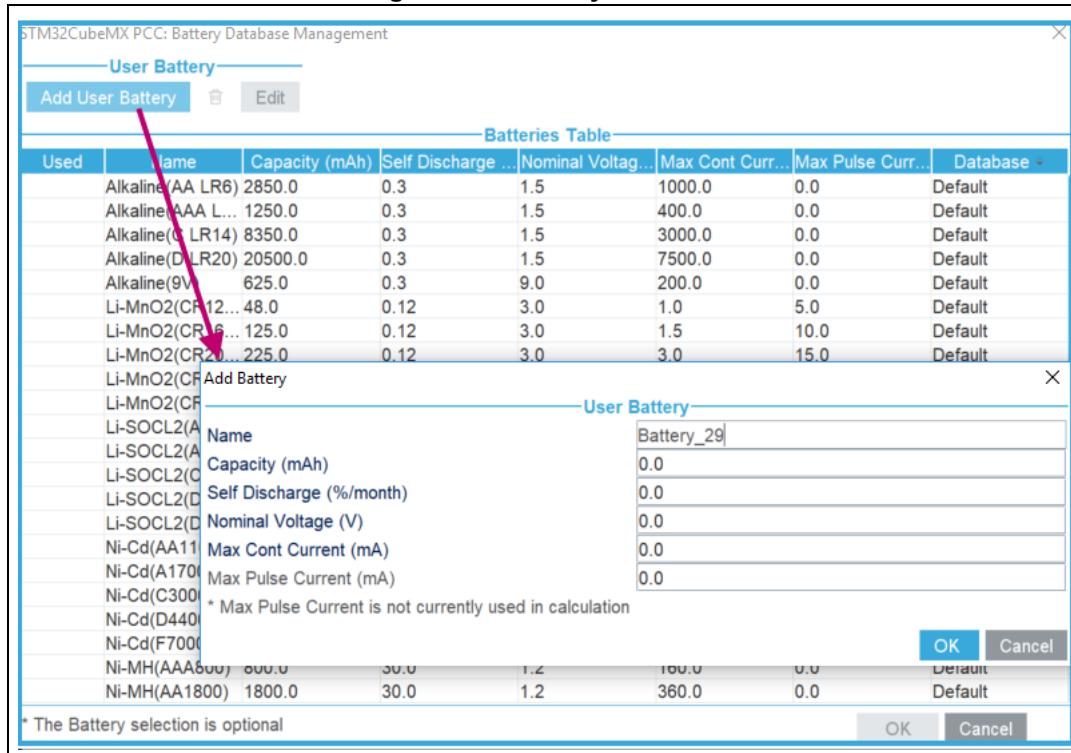
From this view and when multiple choices are available, the user must select a V<sub>DD</sub> value.

### Selecting a battery model (optional)

Optionally, the user can select a battery model. This can also be done once the power consumption sequence is configured.

The user can select a predefined battery or choose to specify a new battery that best matches its application (see [Figure 129](#)).

**Figure 129. Battery selection**



### Power sequence default view

The user can now proceed and build a power sequence.

### Managing sequence steps

Steps can be reorganized within a sequence (**Add** new, **Delete** a step, **Duplicate** a step, **move Up** or **Down** in the sequence) using the set of Step buttons (see [Figure 130](#)).

The user can undo or redo the last configuration actions by clicking the **Undo** button in the Power Consumption Calculator view or the Undo icon from the main toolbar

**Figure 130. Step management functions**

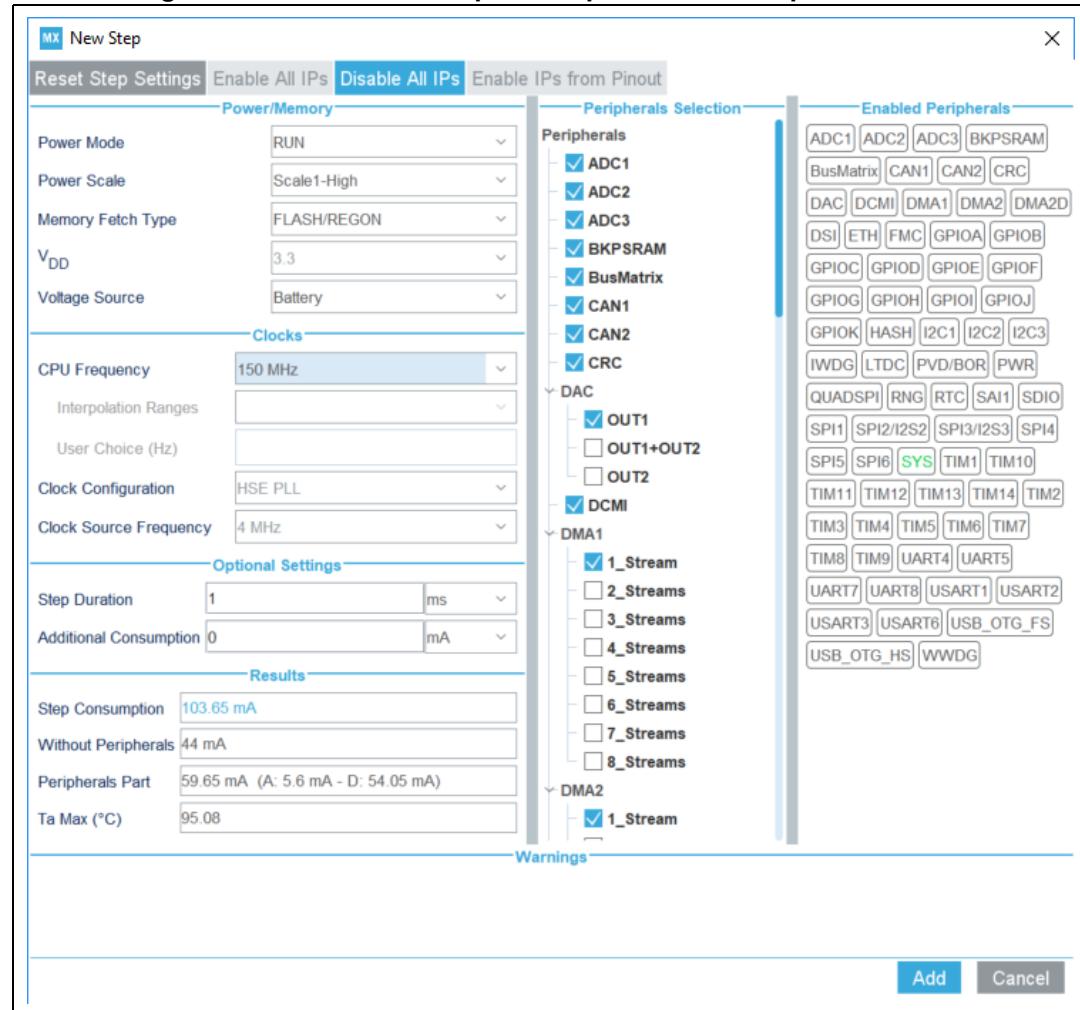


## Adding a step

There are two ways to add a new step:

- Click **Add** in the Power Consumption panel. The **New Step** window opens with empty step settings.
- Or, select a step from the sequence table and click **Duplicate**. A **New Step** window opens duplicating the step settings (see [Figure 131](#)).

**Figure 131. Power consumption sequence: New Step default view**



Once a step is configured, resulting current consumption and  $T_{AMAX}$  values are provided in the window.

## Editing a step

To edit a step, double-click it in the sequence table, this opens the **Edit Step** window.

## Moving a step

By default, a new step is added at the end of a sequence. Click the step in the sequence table to select it and use the **Up** and **Down** buttons to move it elsewhere in the sequence.

## Deleting a step

Select the step to be deleted and click the **Delete** button.

## Using the transition checker

Not all transitions between power modes are possible. The Power Consumption Calculator power menu proposes a transition checker to detect invalid transitions or restrict the sequence configuration to only valid transitions.

Enabling the transition checker option prior to sequence configuration ensures that the user will be able to select only valid transition steps.

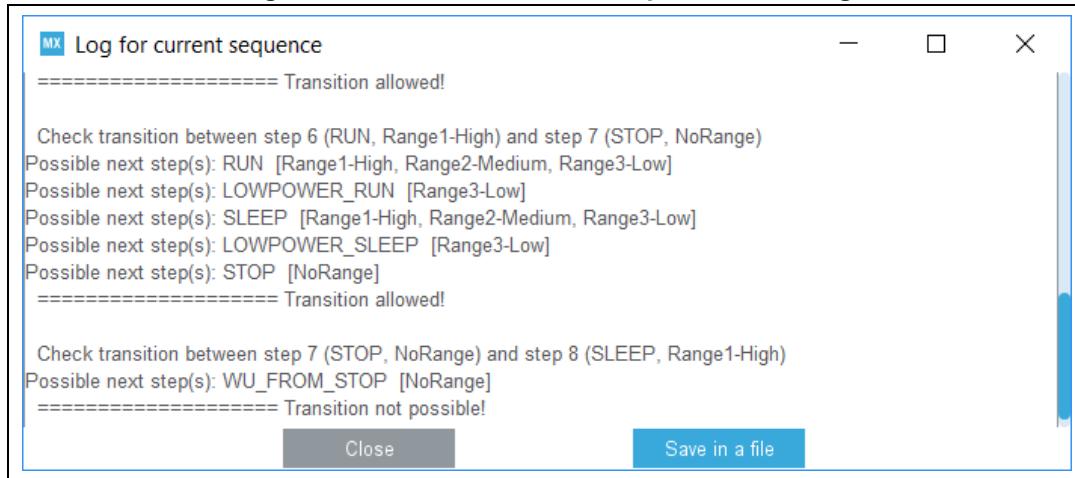
Enabling the transition checker option on an already configured sequence will highlight the sequence with a green frame if all transitions are valid (see [Figure 132](#)), or in fuchsia if at least one transition is invalid (fuchsia frame with description of invalid step highlighted in fuchsia, see [Figure 133](#)). In the latter case, the user can click the **Show log** button to find out how to solve the transition issue (see [Figure 134](#)).

**Figure 132. Enabling the transition checker option on an already configured sequence - All transitions valid**

Sequence Table									
Step	Mode	Vdd	Range/Scale	Memory	CPU/Bus Freq	Clock Config	Peripherals	Step Current	Duration
1	RUN	3.0	Range3-Low	FLASH	1000000 Hz	MSI		166.9 µA	1 ms
2	RUN	3.0	Range2-Medi...	FLASH	8 MHz	HSEBYP		1.3 mA	1 ms
3	RUN	3.0	Range1-High	FLASH	8 MHz	HSEBYP	COMP1 COM...	1.55 mA	1 ms
4	SLEEP	3.0	Range1-High	FLASH	8 MHz	HSEBYP		380 µA	1 ms
5	RUN	3.0	Range3-Low	FLASH	4.2 MHz	MSI	COMP1 COM...	623.66 µA	1 ms
6	RUN	3.0	Range1-High	FLASH	8 MHz	HSEBYP		1.55 mA	1 ms
7	STOP	3.0	NoRange	n/a	0 Hz	ALL CLOCKS...		410 nA	1 ms

**Figure 133. Enabling the transition checker option on an already configured sequence - At least one transition invalid**

Sequence Table									
Step	Mode	Vdd	Range/Scale	Memory	CPU/Bus Freq	Clock Config	Peripherals	Step Current	Duration
1	RUN	3.0	Range3-Low	FLASH	1000000 Hz	MSI		166.9 µA	1 ms
2	RUN	3.0	Range2-Medi...	FLASH	8 MHz	HSEBYP		1.3 mA	1 ms
3	RUN	3.0	Range1-High	FLASH	8 MHz	HSEBYP	COMP1 COM...	1.55 mA	1 ms
4	SLEEP	3.0	Range1-High	FLASH	8 MHz	HSEBYP		380 µA	1 ms
5	RUN	3.0	Range3-Low	FLASH	4.2 MHz	MSI	COMP1 COM...	623.66 µA	1 ms
6	RUN	3.0	Range1-High	FLASH	8 MHz	HSEBYP		1.55 mA	1 ms
7	STOP	3.0	NoRange	n/a	0 Hz	ALL CLOCKS...		410 nA	1 ms
8	SLEEP	3.0	Range1-High	FLASH	8 MHz	HSEBYP		380 µA	1 ms

**Figure 134. Transition checker option - Show log**

## 5.2.2 Configuring a step in the power sequence

The step configuration is performed from the **Edit Step** and **New Step** windows. The graphical interface guides the user by forcing a predefined order for setting parameters.

Their naming may differ according to the selected MCU Series. For details on each parameter, refer to glossary in [Section 5.2.4](#) and to [Appendix D: STM32 microcontrollers power consumption parameters](#), or to the electrical characteristics section of the datasheet.

The parameters are set automatically by the tool when there is only one possible value (in this case, the parameter cannot be modified and is grayed out). The tool proposes only the configuration choices relevant to the selected MCU.

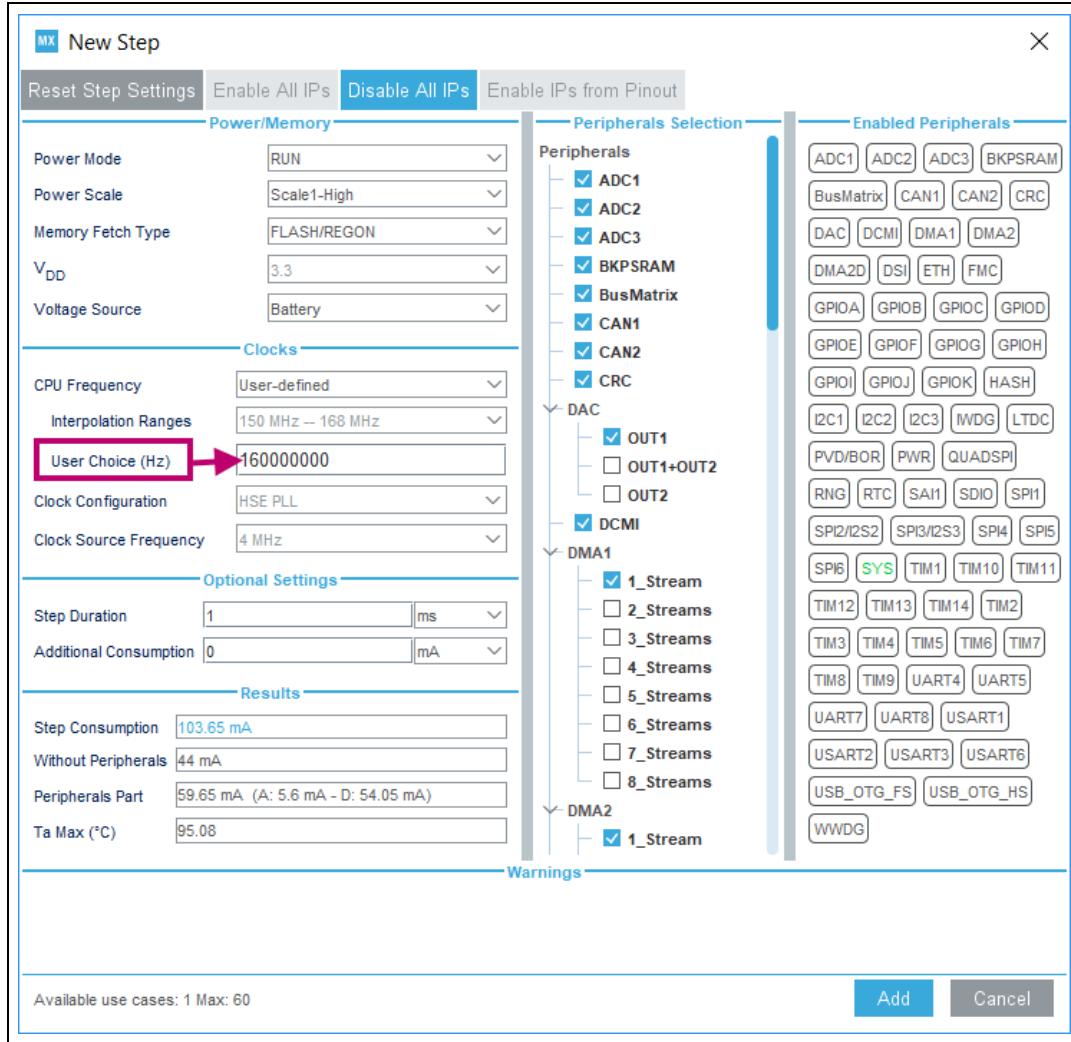
To configure a new step:

1. Click **Add** or **Duplicate** to open the **New step** window or double-click a step from the sequence table to open the **Edit step** window.
2. Within the open step window, select in the following order:
  - **The Power Mode**  
Changing the Power Mode resets the whole step configuration.
  - **The Peripherals**  
Peripherals can be selected/deselected at any time after the Power Mode is configured.
  - **The Power scale**  
The power scale corresponds to the power consumption range (STM32L1) or the power scale (STM32F4).  
Changing the Power Mode or the Power Consumption Range discards all subsequent configurations.
  - **The Memory Fetch Type**
  - The  $V_{DD}$  value if multiple choices available
  - The voltage source (battery or VBUS)
  - **A Clock Configuration**  
Changing the Clock Configuration resets the frequency choices further down.
  - When multiple choices are available, the **CPU Frequency** (STM32F4) and the **AHB Bus Frequency/CPU Frequency**(STM32L1) or, for active modes, a user specified frequency. In this case, the consumption value will be interpolated (see [Using interpolation](#)).
3. Optionally set
  - **A step duration** (1 ms is the default value)
  - An **additional consumption** value (expressed in mA) to reflect, for example, external components used by the application (external regulator, external pull-up, LEDs or other displays). This value added to the microcontroller power consumption will impact the step overall power consumption.
4. Once the configuration is complete, the **Add** button becomes active. Click it to create the step and add it to the sequence table.

## Using interpolation

For steps configured for active modes (Run, Sleep), frequency interpolation is supported by selecting CPU frequency as User Defined and entering a frequency in Hz (see [Figure 135](#)).

**Figure 135. Interpolated power consumption**

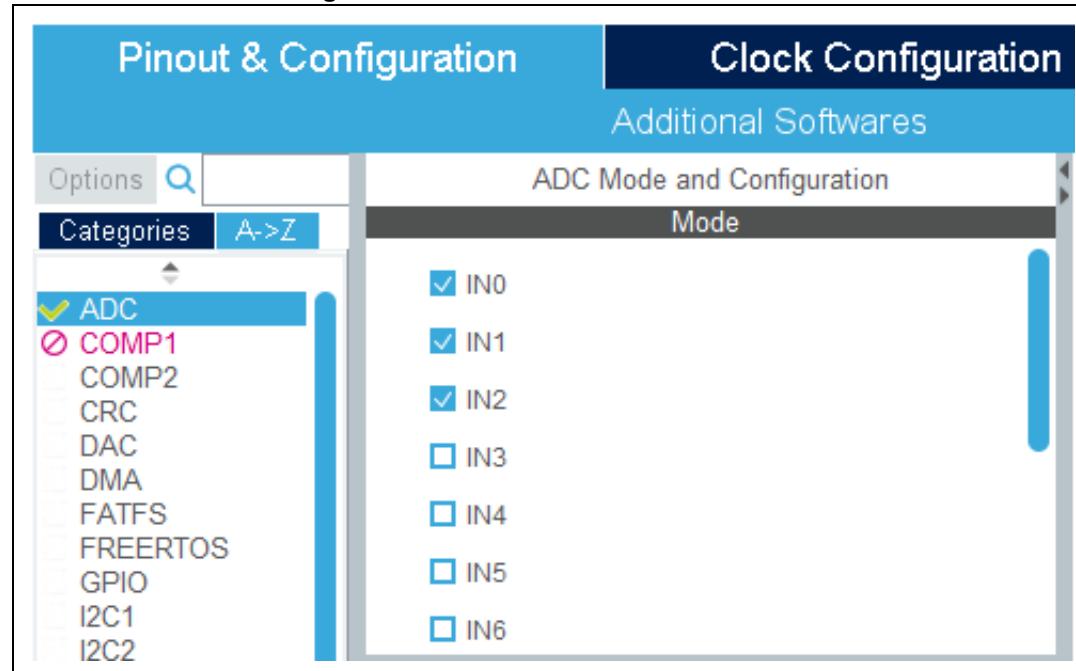


## Importing pinout

*Figure 136* illustrates the example of the ADC configuration in the **Pinout** view: clicking **Enable IPs from Pinout** in the Power Consumption Calculator view selects the ADC peripheral and GPIO A (*Figure 137*).

The **Enable IPs from Pinout** button allows the user to automatically select the peripherals that have been configured in the **Pinout** view.

Figure 136. ADC selected in Pinout view

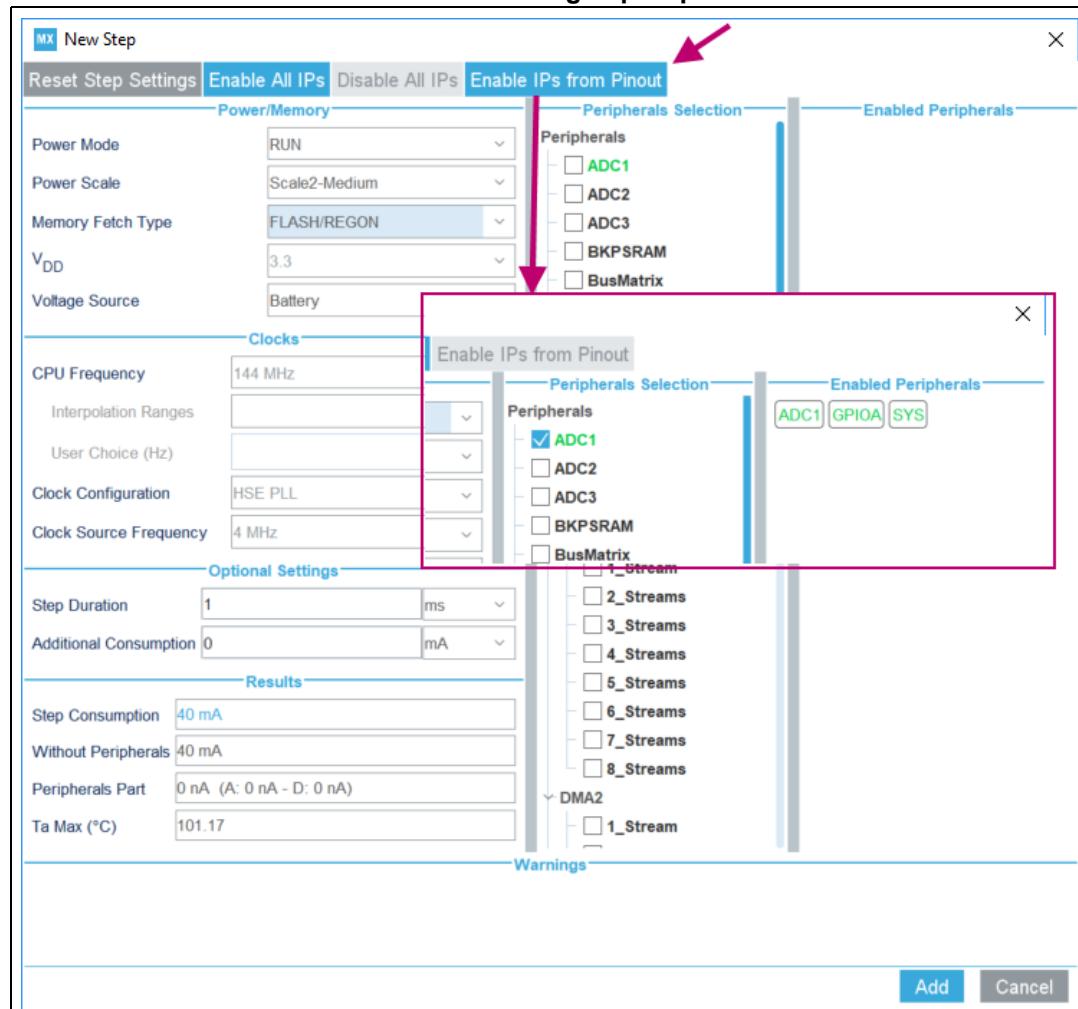


### Selecting/deselecting all peripherals

Clicking **Enable All IPs** allows the user to select all peripherals at once.

Clicking **Disable All IPs** removes them as contributors to the consumption.

**Figure 137. Power Consumption Calculator Step configuration window:  
ADC enabled using import pinout**



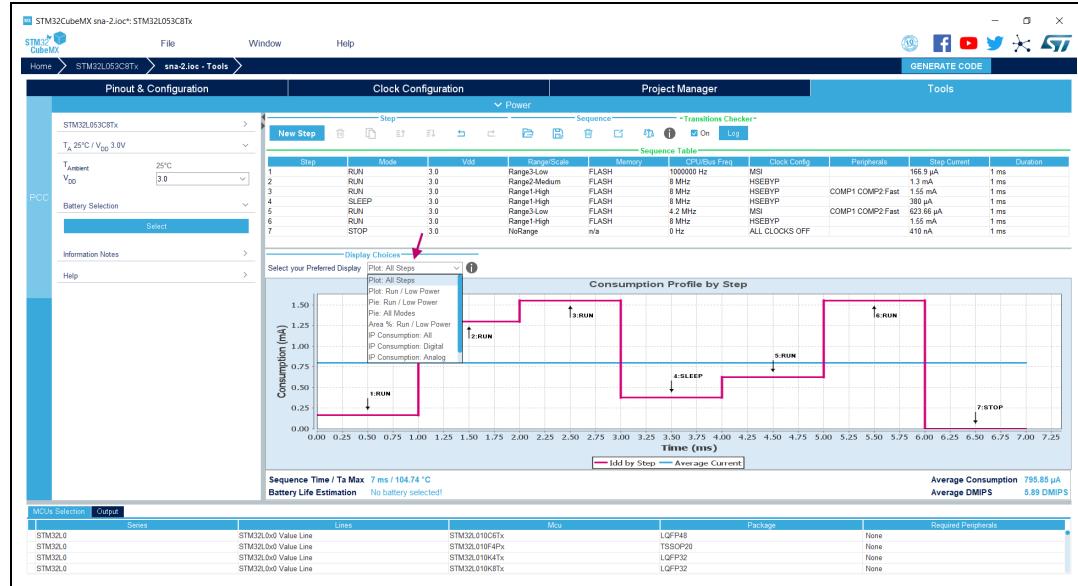
### 5.2.3

### Managing user-defined power sequence and reviewing results

The configuration of a power sequence leads to an update of the Power Consumption Calculator view (see [Figure 138](#)):

- The sequence table shows all steps and step parameters values. A category column indicates whether the consumption values are taken from the datasheet or are interpolated.
- The sequence chart area shows different views of the power sequence according to a display type (e.g. plot all steps, plot low power versus run modes)
- The results summary provides the total sequence time, the maximum ambient temperature ( $T_{AMAX}$ ), plus an estimate of the average power consumption, DMIPS, and battery lifetime provided a valid battery configuration has been selected.

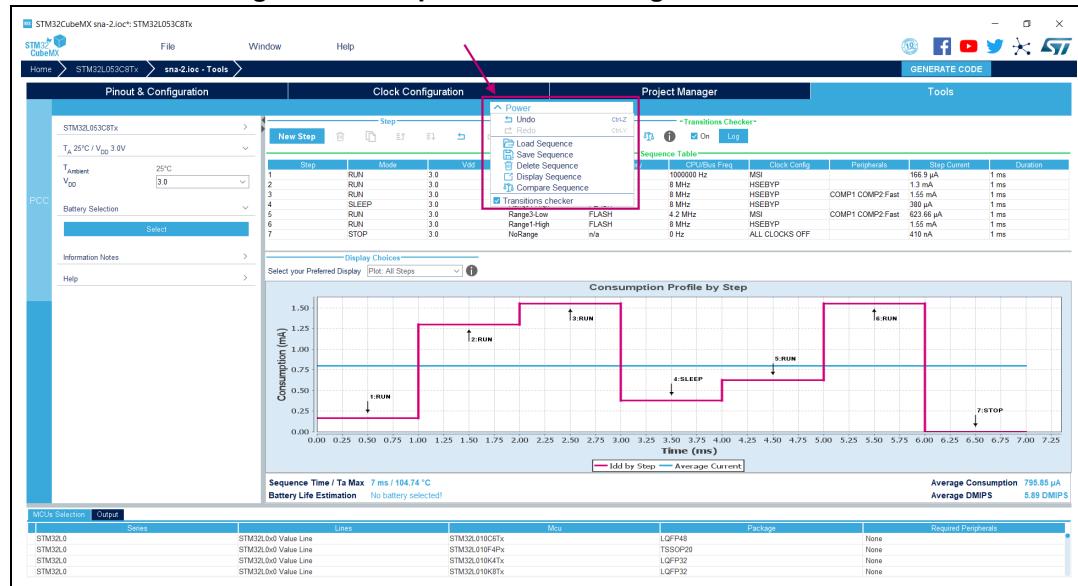
Figure 138. Power Consumption Calculator view after sequence building



### Managing the whole sequence (load, save and compare)

From the power menu (see [Figure 139](#)), the current sequence can be saved, deleted or compared to a previously saved sequence that will be displayed in a dedicated popup window.

Figure 139. Sequence table management functions

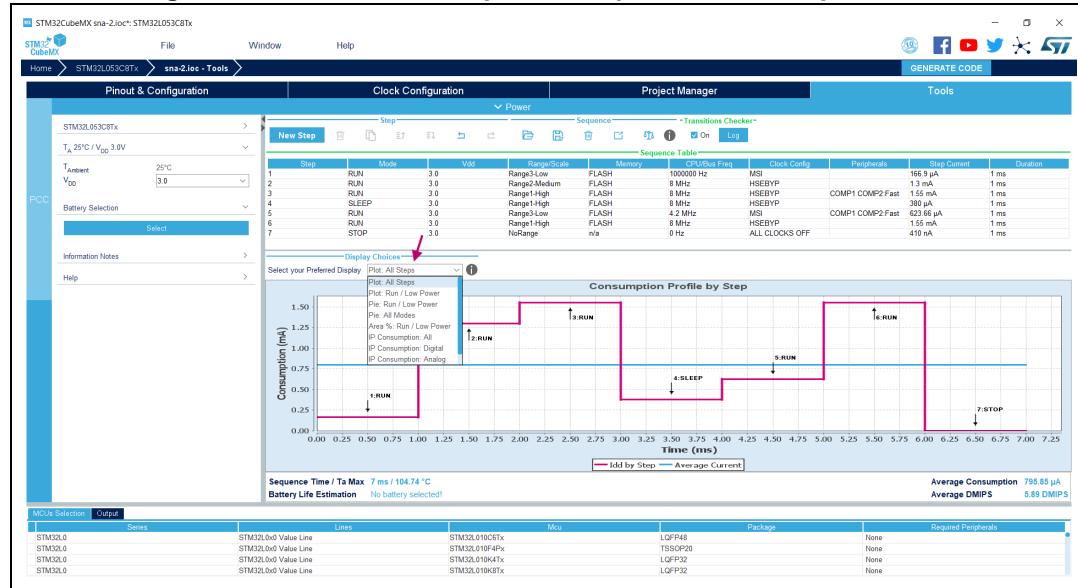


## Managing the results charts and display options

In the Display area, select the type of chart to display (e.g. sequence steps, pie charts, consumption per peripherals). You can also click **External Display** to open the charts in dedicated windows (see [Figure 140](#)).

Right-click on the chart to access the contextual menus: **Properties**, **Copy**, **Save** as png picture file, **Print**, **Zoom** menus, and **Auto Range** to reset to the original view before zoom operations. **Zooming** can also be achieved by mouse selecting from left to right a zone in the chart and **Zoom reset** by clicking the chart and dragging the mouse to the left.

**Figure 140. Power Consumption: Peripherals consumption chart**



## Overview of the Results summary area

This area provides the following information (see [Figure 141](#)):

- Total sequence time, as the sum of the sequence steps durations.
- Average consumption, as the sum of each step consumption weighed by the step duration.
- The average DMIPS (Dhrystone million instructions per second) based on Dhrystone benchmark, highlighting the CPU performance for the defined sequence.
- Battery life estimation for the selected battery model, based on the average power consumption and the battery self-discharge.
- $T_{AMAX}$ : highest maximum ambient temperature value found during the sequence.

**Figure 141. Description of the Results area**

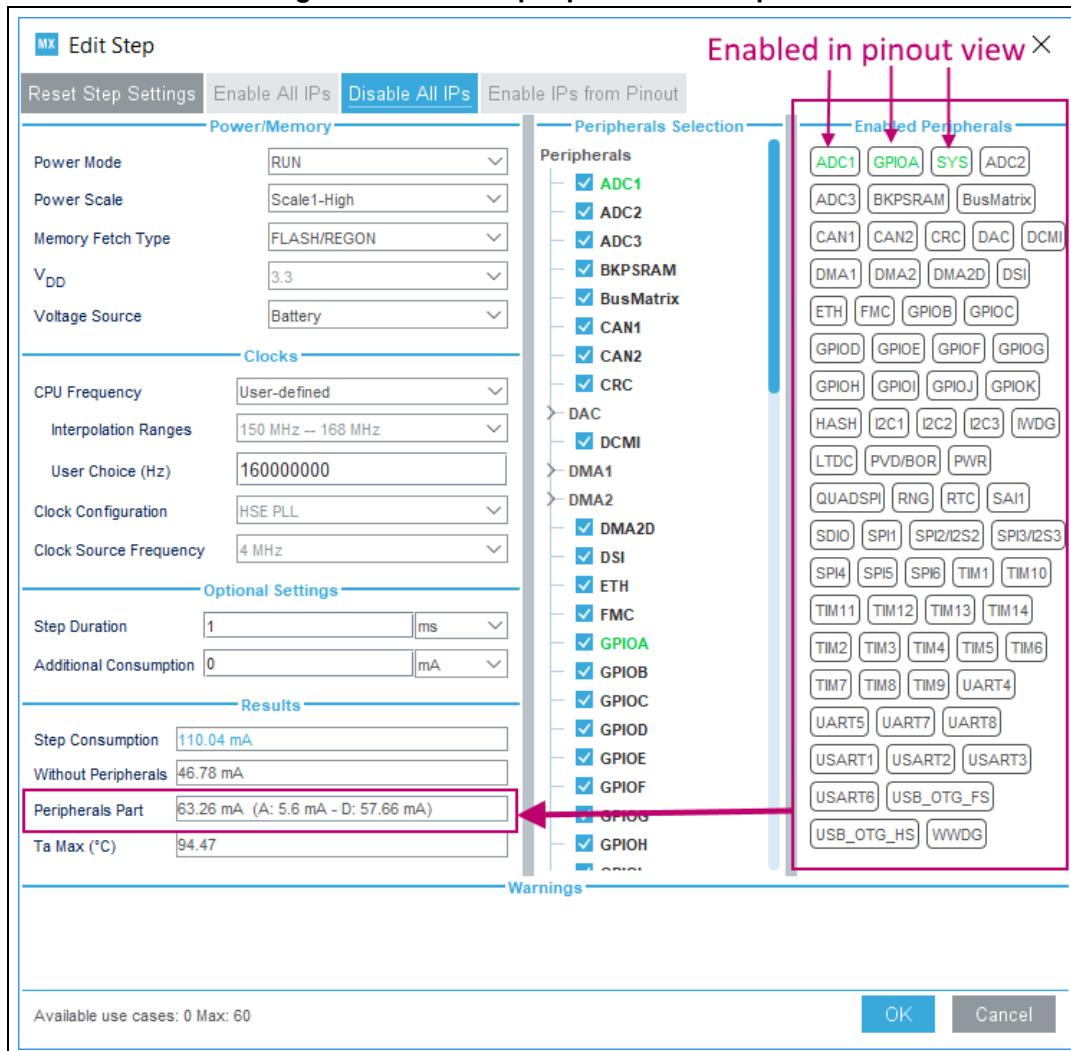
Results Summary		Average Consumption 1.33 mA	
Sequence Time / $T_a$ Max	7 ms / 104.42 °C	Average Consumption	1.33 mA
Battery Life Estimation	8 months , 20 days & 9 hours	Average DMIPS	6.52 DMIPS

## 5.2.4 Power sequence step parameters glossary

The parameters that characterize power sequence steps are the following (refer to [Appendix D: STM32 microcontrollers power consumption parameters](#) for more details):

- Power modes  
To save energy, it is recommended to switch the microcontroller operating mode from running mode, where a maximum power is required, to a low-power mode requiring limited resources.
- $V_{CORE}$  range (STM32L1) or Power scale (STM32F4)  
These parameters are set by software to control the power supply range for digital peripherals.
- Memory Fetch Type  
This field proposes the possible memory locations for application C code execution. It can be either RAM, FLASH or FLASH with ART ON or OFF (only for families that feature a proprietary Adaptive real-time (ART) memory accelerator which increases the program execution speed when executing from Flash memory).  
The performance achieved thanks to the ART accelerator is equivalent to 0 wait state program execution from Flash memory. In terms of power consumption, it is equivalent to program execution from RAM. In addition, STM32CubeMX uses the same selection choice to cover both settings, RAM and Flash memory with ART ON.
- Clock Configuration  
This operation sets the AHB bus frequency or the CPU frequency that will be used for computing the microcontroller power consumption. When there is only one possible choice, the frequencies are automatically configured.  
The clock configuration drop-down list allows to configure the application clocks:
  - the internal or external oscillator sources: MSI, HSI, LSI, HSE or LSE
  - the oscillator frequency
  - other determining parameters, among them PLL ON, LSE Bypass, AHB prescaler value, LCD with duty
- Peripherals  
The peripheral list shows the peripherals available for the selected power mode. The power consumption is given assuming that peripherals are only clocked (e.g. not in use by a running program). Each peripheral can be enabled or disabled. Peripherals individual power consumptions are displayed in a tooltip. An overall consumption due to peripheral analog and digital parts is provided in the step Results area (see [Figure 142](#)).

**Figure 142. Overall peripheral consumption**



The user can select the peripherals relevant for the application:

- None (**Disable All**),
  - Some (using peripheral dedicated checkbox),
  - All (**Activate All**),
  - Or all from the previously defined pinout configuration (**Import Pinout**).

Only the selected and enabled peripherals are taken into account when computing the power consumption.

- Step duration

The user can change the default step duration value. When building a sequence, the user can either create steps according to the application actual power sequence or define them as a percentage spent in each mode. For example, if an application

spends 30% in Run mode, 20% in Sleep and 50% in Stop, the user must configure a 3-step sequence consisting in 30 ms in Run, 20 ms in Sleep and 50 ms in Stop.

- Additional Consumption

This field allows entering an additional consumption resulting from specific user configuration (e.g. MCU providing power supply to other connected devices).

## 5.2.5 Battery glossary

- Capacity (mAh)  
Amount of energy that can be delivered in a single battery discharge.
- Self-discharge (% / month)  
This percentage, over a specified period, represents the loss of battery capacity when the battery is not used (open-circuit conditions), as a result of internal leakage.
- Nominal voltage (V)  
Voltage supplied by a fully charged battery.
- Max. continuous current (mA)  
This current corresponds to the maximum current that can be delivered during the battery lifetime period without damaging the battery.
- Max. pulse current (mA)  
This is the maximum pulse current that can be delivered exceptionally, for instance when the application is switched on during the starting phase.

## 5.2.6 SMPS feature

Some microcontrollers (e.g. STM32L496xxxxP) allow the user to connect an external switched mode power supply (SMPS) to further reduce power consumption.

For such microcontrollers, the Power Consumption Calculator tool offers the following features:

- Selection of SMPS for the current project  
From the left panel, check the **Use SMPS** box to use SMPS (see [Figure 143](#)). By default, ST SMPS model is used.
- Selection of another SMPS model by clicking the **Change** button  
This opens the SMPS database management window in which the user can add a new SMPS model (see [Figure 144](#)). The user can then select a different SMPS model for the current sequence (see [Figure 145](#), [Figure 146](#) and [Figure 147](#))
- Check for invalid SMPS transitions in the current sequence by enabling the SMPS checker  
To do this, select the checkbox to enable the checker and click the **Help** button to open the reference state diagram (see [Figure 148](#)).
- Configuration of SMPS mode for each step (see [Figure 149](#))  
If the SMPS checker is enabled, only the SMPS modes valid for the current step are proposed.

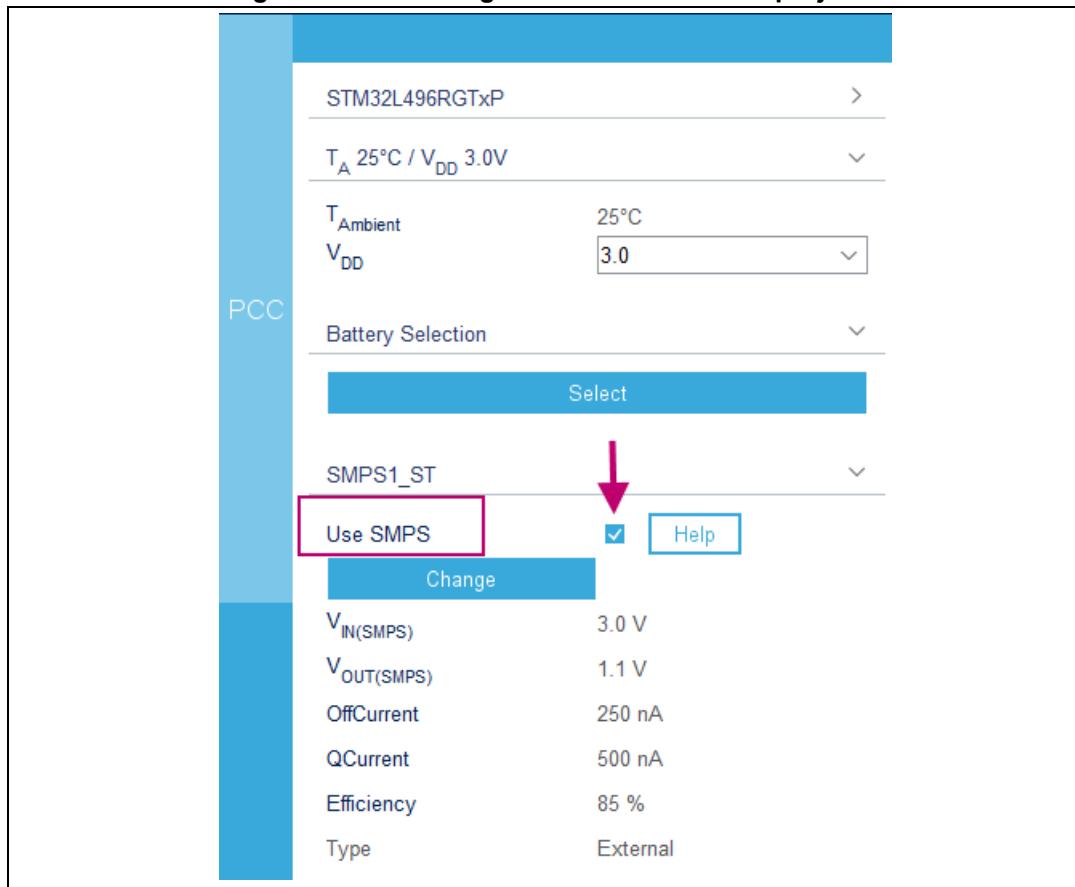
**Figure 143. Selecting SMPS for the current project**

Figure 144. SMPS database - Adding new SMPS models

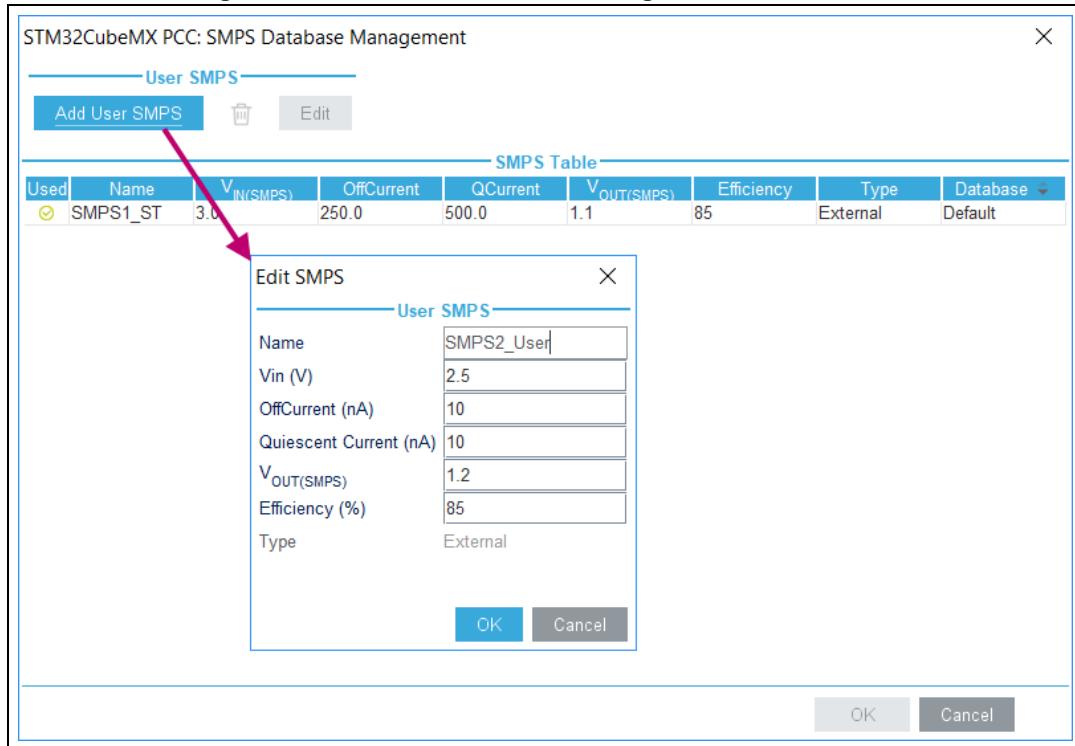
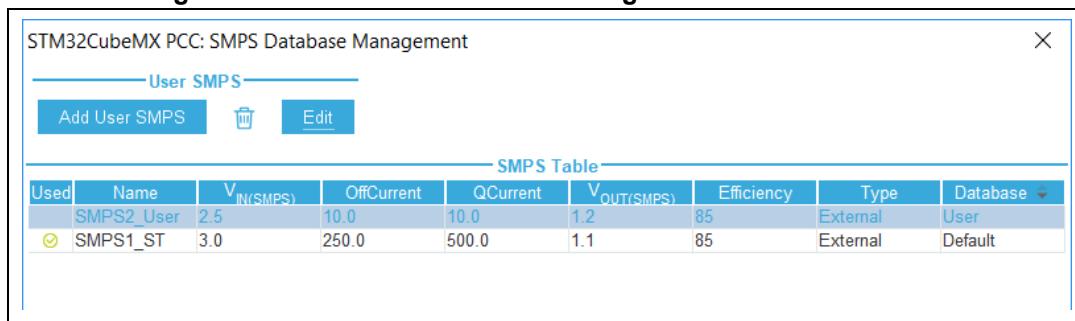
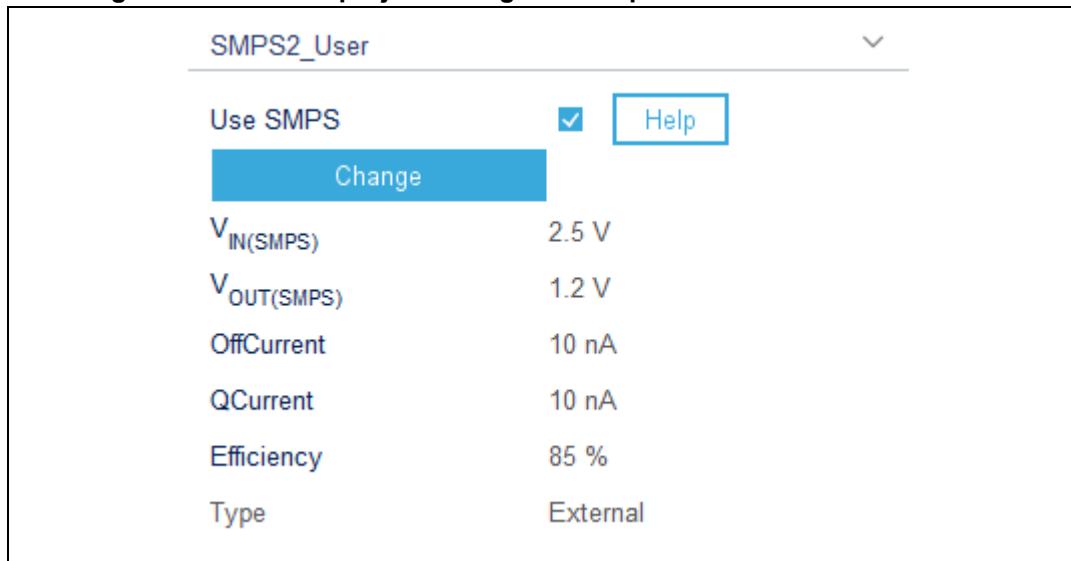


Figure 145. SMPS database - Selecting a different SMPS model



**Figure 146. Current project configuration updated with new SMPS model****Figure 147. SMPS database management window with new model selected**

STM32CubeMX PCC: SMPS Database Management									
User SMPS									
Add User SMPS				Edit					
SMPS Table									
Used	Name	$V_{IN(SMPS)}$	OffCurrent	QCurrent	$V_{OUT(SMPS)}$	Efficiency	Type	Database	▼
✓	SMPS2_User	2.5	10.0	10.0	1.2	85	External	User	
	SMPS1_ST	3.0	250.0	500.0	1.1	85	External	Default	

Figure 148. SMPS transition checker and state diagram helper window

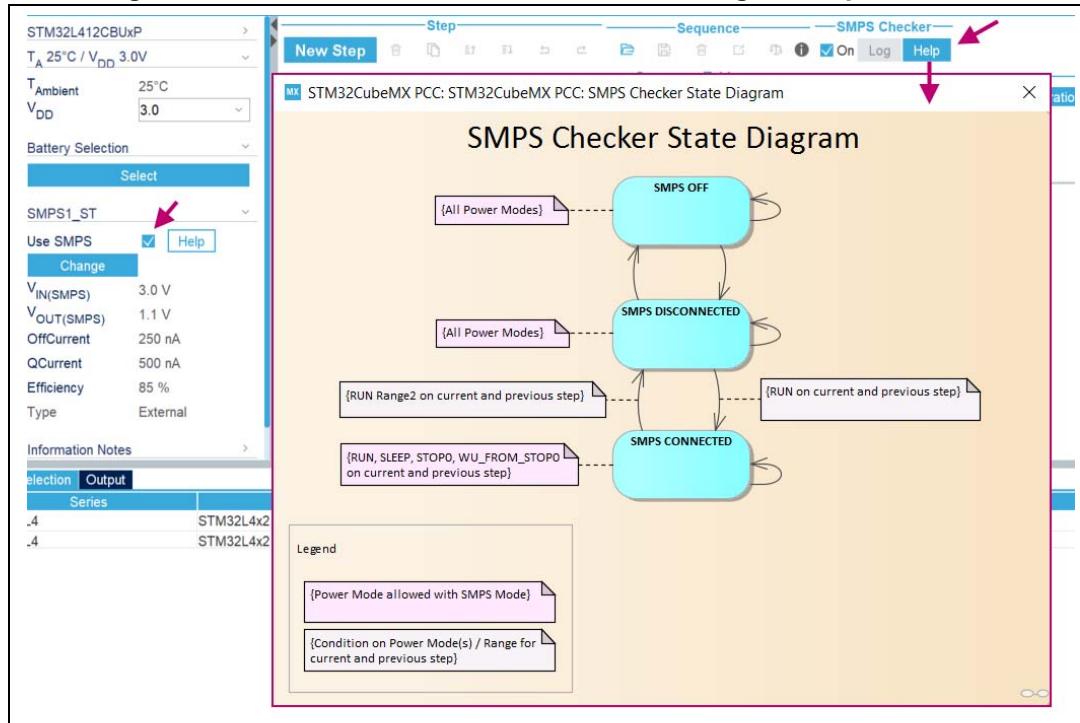
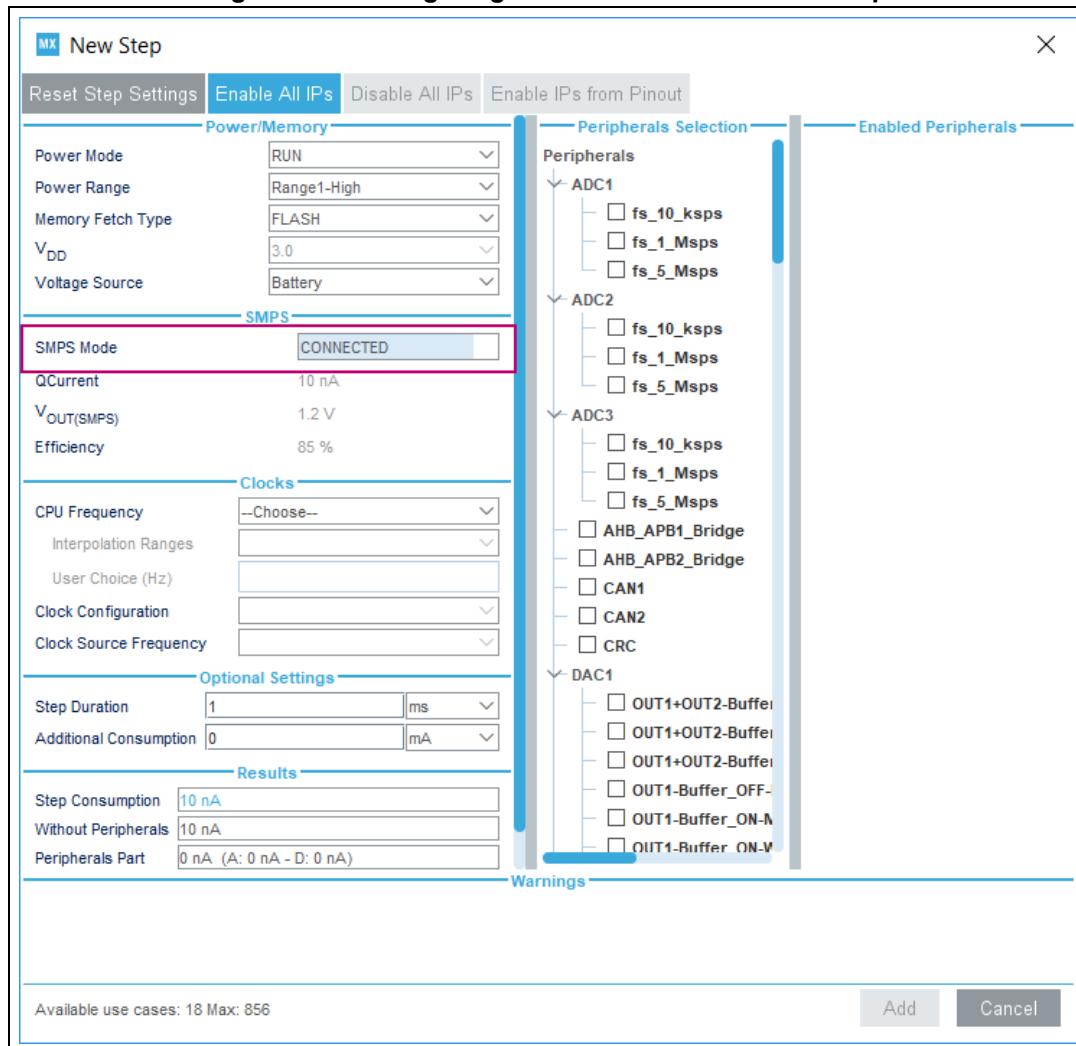


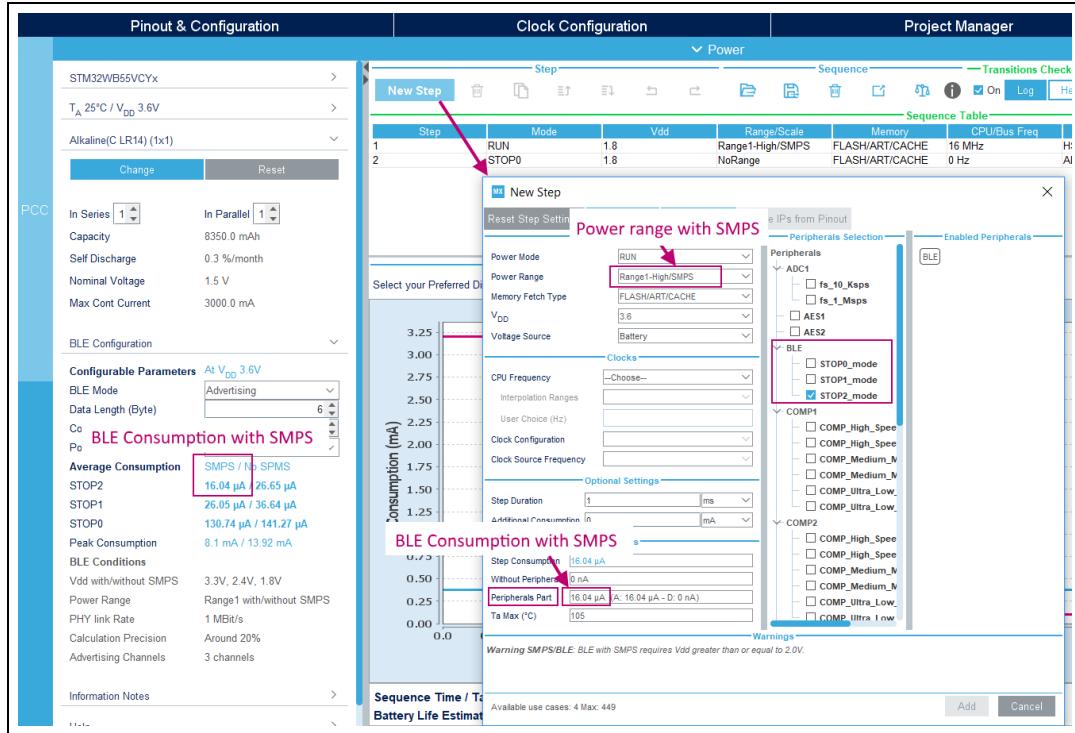
Figure 149. Configuring the SMPS mode for each step



## 5.2.7 BLE support (STM32WB Series only)

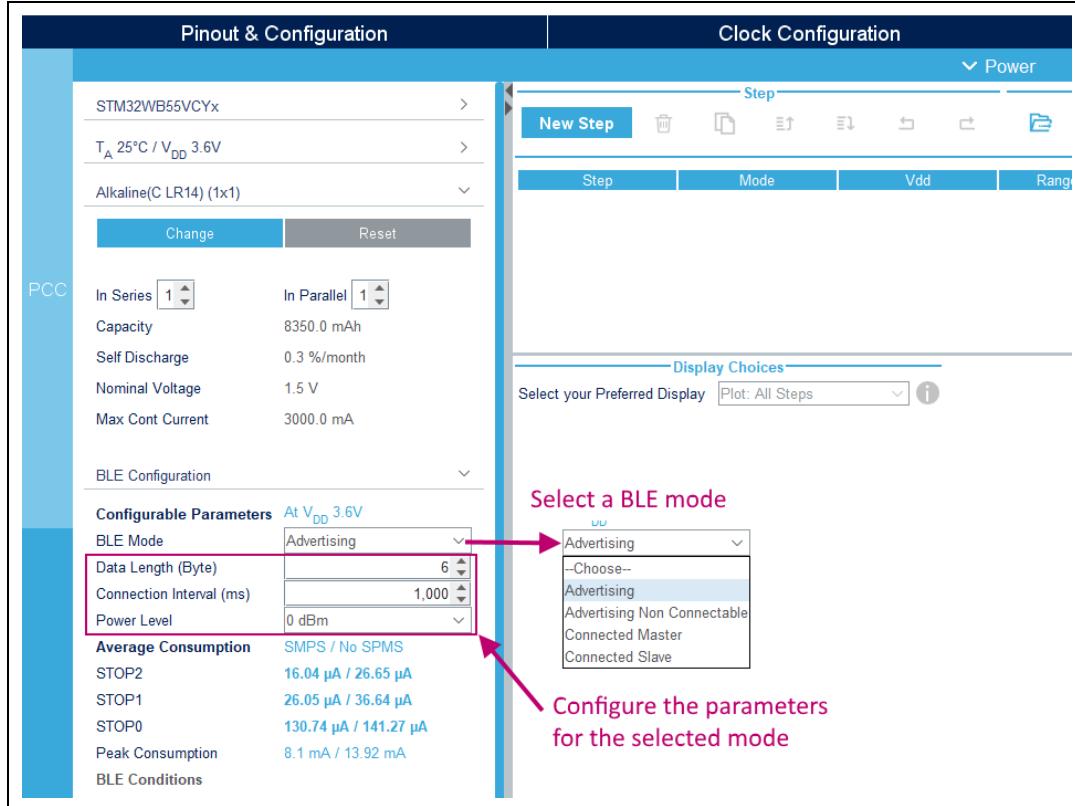
The Power Consumption tool allows the user to take into account the consumption related to the RF peripheral and corresponding BLE functional mode, combined with the usage of the SMPS feature.

**Figure 150. RF related consumption (STM32WB Series only)**



The BLE mode can be selected from the left panel and configured to reflect the user's application relevant settings.

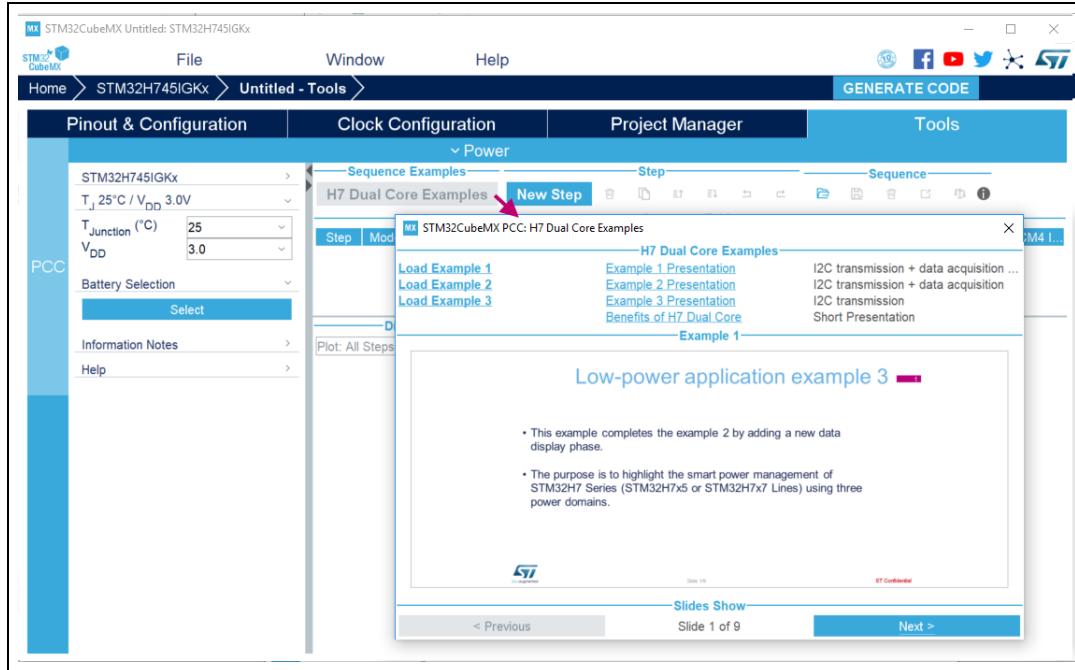
**Figure 151. RF BLE mode configuration (STM32WB Series only)**



### 5.2.8 Example feature (STM32MP1 and STM32H7 dual-core only)

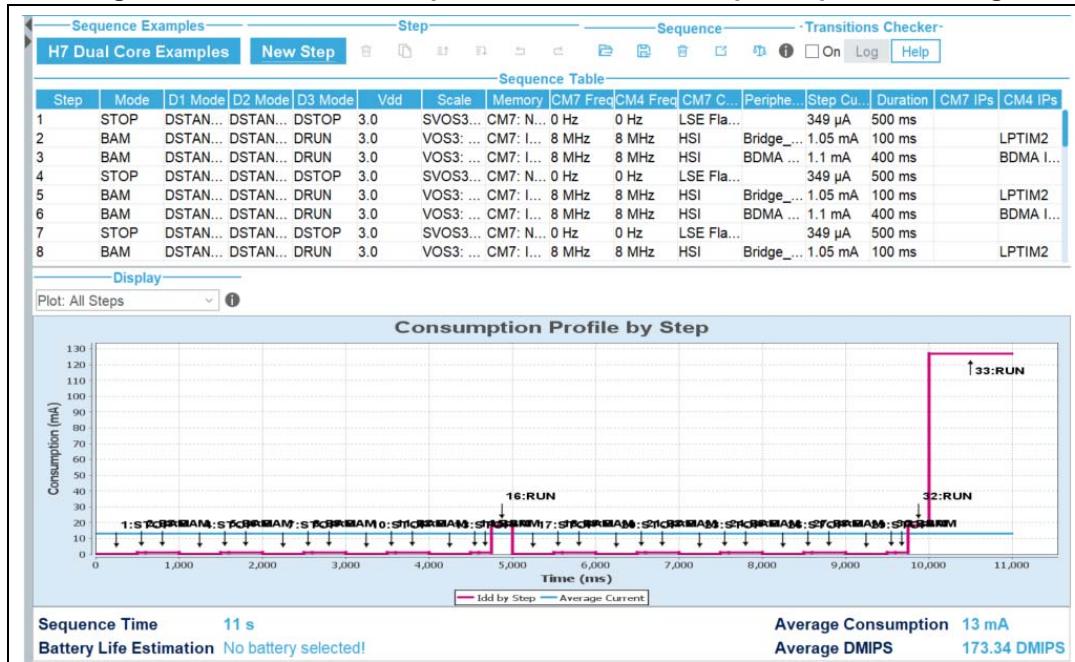
Under the section “Sequence Examples”, the PCC tool allows to access examples: each example come with an explanatory slide-set and a ready-made sequence to be loaded in PCC (see [Figure 152](#)).

Figure 152. Power Consumption Calculator – Example set



Clicking “Load Example N” loads the sequence corresponding to the example N (see Figure 153).

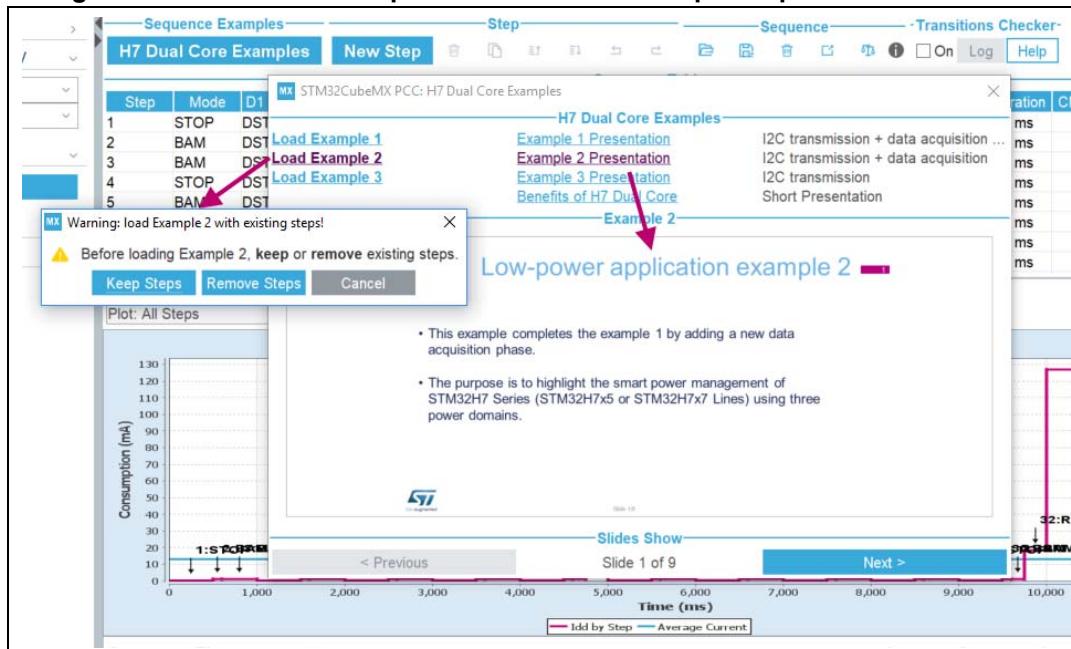
Figure 153. Power Consumption Calculator – Example sequence loading



Clicking “Example N Presentation” displays the explanations for that example.

The example can be changed anytime: the new sequence can be either added to the current sequence, or replace it (see [Figure 154](#)).

**Figure 154. Power Consumption Calculator – Example sequence new selection**



#### Note:

*The examples are provided for a given part number and may require adjustments when used for a different part number. Also, after loading, it is recommended to edit each step and check settings.*

## 5.3 DDR Suite (for STM32MP1 Series only)

DDR SDRAMs are complex high speed devices that need careful PCB design.

The STM32MP15 devices support the following DDR types:

- LPDDR2
- LPDDR3
- DDR3 / DDR3L

They are specified by the JEDEC standard (standardization of interfaces, commands, timings, packages and ballout).

STM32CubeMX has been extended to provide an exhaustive tool suite for the STM32MP1 DDR subsystem. It proposes the following key features.

- **Configuration of DDR** controller and PHY registers is managed automatically based on reduced set of editable parameters.
- **DDR testing** is offered based on a rich tests list. Tests go from basic to stress tests. User can also develop its own tests.
- **DDR tuning** of byte lanes delays is proposed to compensate board design imperfections.

**DDR configuration** is accessible like the other peripherals in the **Pinout & Configuration** view: clicking the DDR from the component panel, opens the mode and configuration panels.

**DDR Test suite testing and tuning** features are available from the **Tools** view.

The DDR suite relies on two important concepts:

- the **DDR timings** as key inputs for the configuration of the DDR Controller and PHY
- the tuning of DDR signals to compensate board design imperfections.

### 5.3.1 DDR configuration

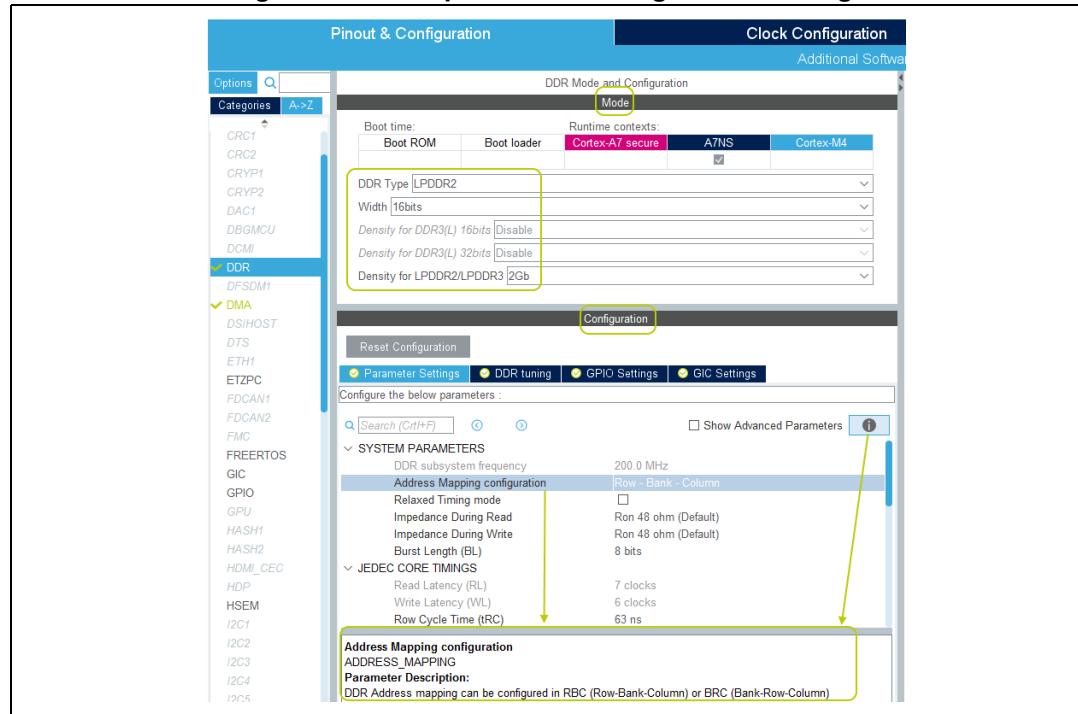
STM32CubeMX allows to set DDR system parameters and JEDEC core timings. The timing parameters are available in the DDR datasheet.

#### DDR type, width and density

The DDR type, width and density parameter settings are required to proceed with the DDR configuration step. This can be done in the mode panel after selecting the DDR in the **Pinout & Configuration** view.

See [Figure 155](#) for an example of LPDDR2 settings.

**Figure 155. DDR pinout and configuration settings**



Another example: for a configuration with two “DDR3 16 bits 2 Gb” chips, settings are “DDR3/DDR3L”, “32 bits” and 4 Gb”.

**Note:** *Contexts for DDR IP cannot be changed, DDR is tied to “Cortex-A7 Non-Secure” identified as “Cortex-A7 NS” in the tool.*

## DDR configuration

Clicking on a parameter will show additional details in the DDR configuration footer.

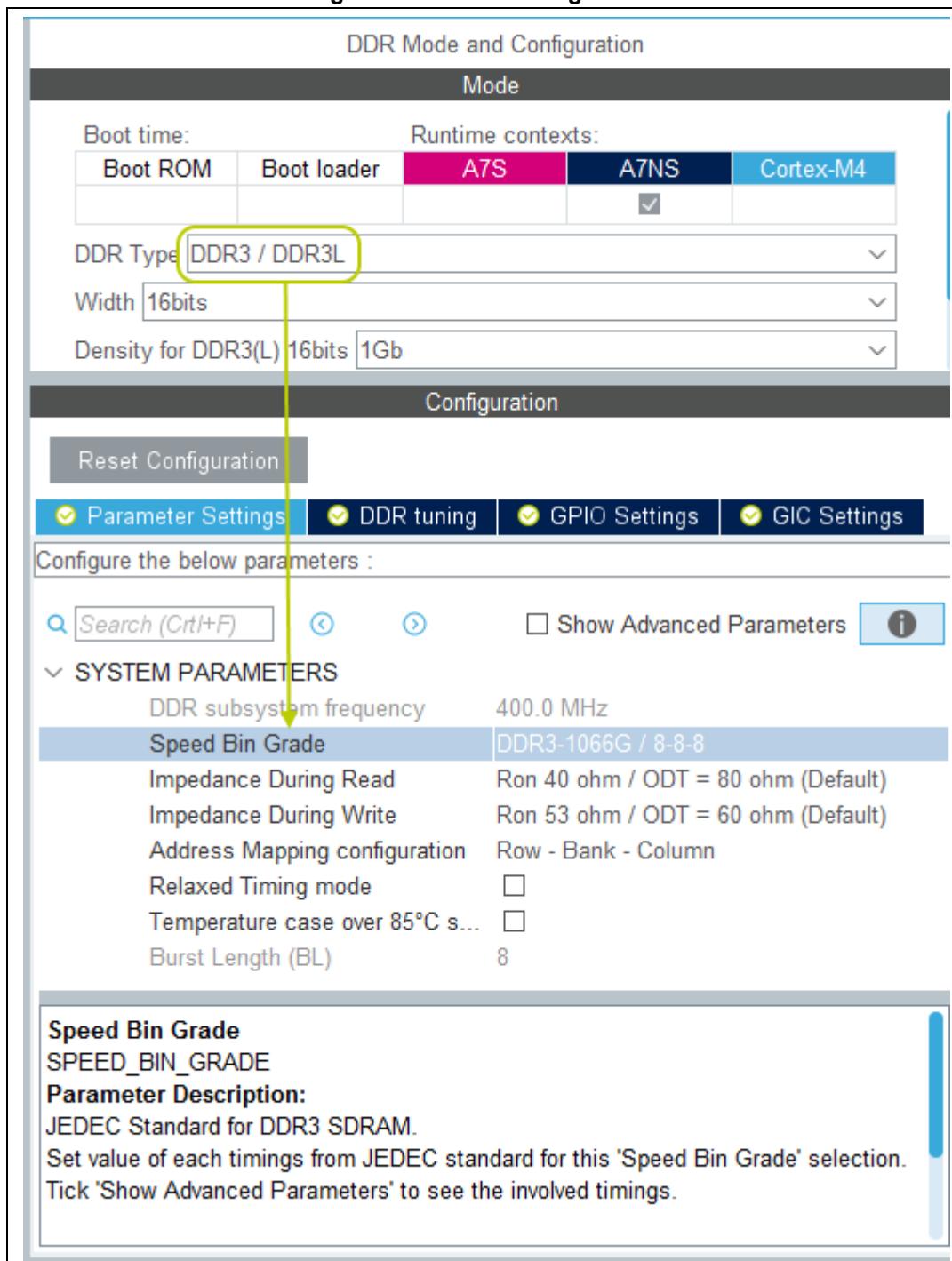
- The DDR frequency is taken from the ‘Clock configuration’ tab, it cannot be changed in the DDR configuration.
- The ‘Relaxed Timing’ mode is used during bring-up phase for trying relaxed key DDR timings value (one  $t_{CK}$  added to  $t_{RC}$ ,  $t_{RCD}$  and  $t_{RP}$  timings)
- Other parameters must be retrieved from the user DDR datasheet.
- Some parameters are read-only: they are for information only and depend on the DDR type.

Clicking “generate code” automatically computes the DDR node of the device tree (DDR Controller and DDR PHY registers values) based on these parameters.

## DDR3 configuration

For DDR3, the configuration is made easier with the selection of a **Speed Bin / Grade** combination, instead of manually editing timing parameters.

Figure 156. DDR3 configuration



The Speed Bin / Grade combination has to match the selected DDR. If the exact combination is not in the pick-list, "1066E / 6-6-6" must be selected for faster DDR Speed bin / Grade, whereas "1066G / 8-8-8" can be used as a relaxed configuration.

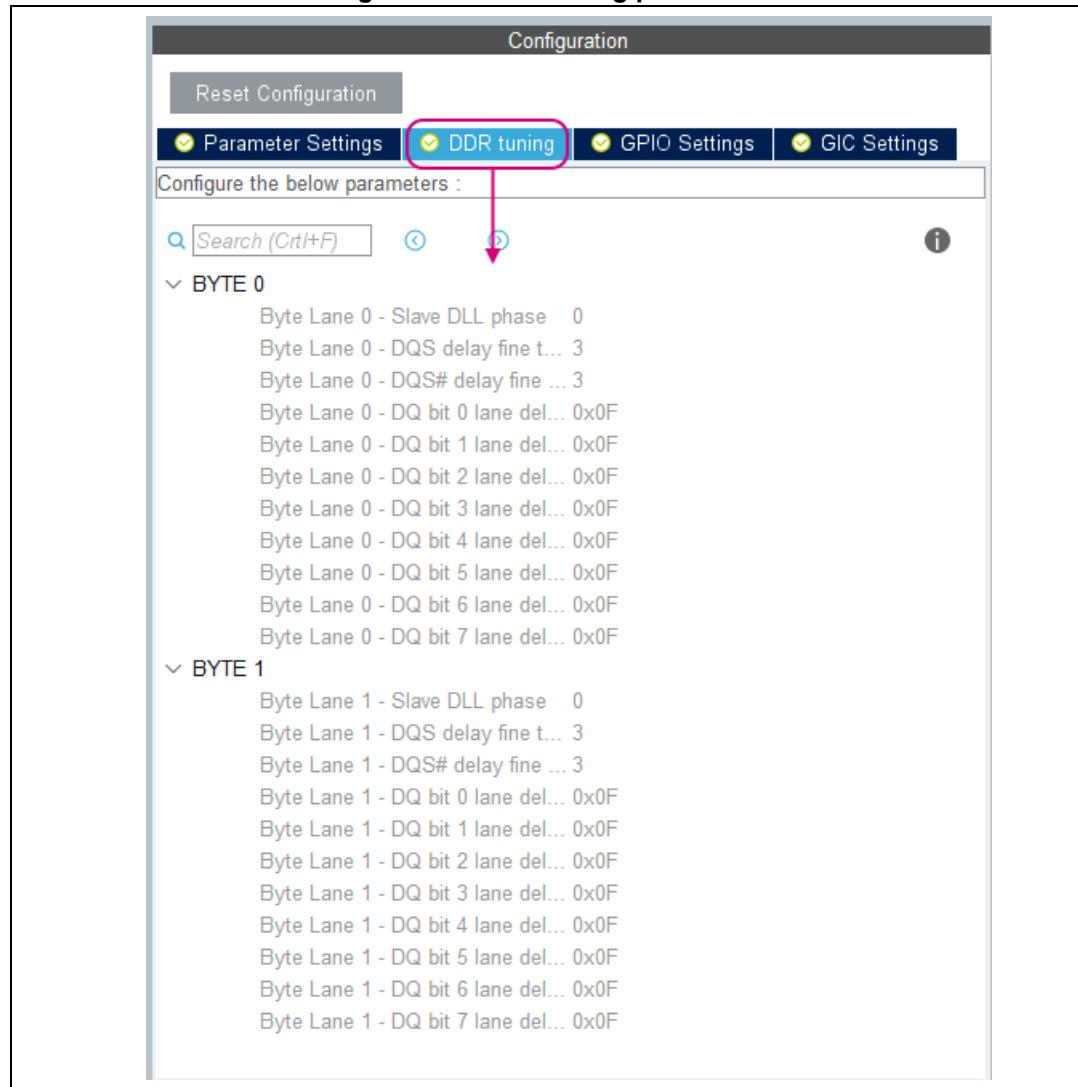
Timing edition is then optional and reserved for advanced users: select Show Advanced parameters to display the list.

### DDR tuning tab (read-only)

Users can check modifications to tuning parameters via the tuning tab. These parameters are read-only in the DDR configuration panel (see [Figure 157](#)), are modified after tuning operations, and are related to DQS position and DQ line delay:

- ‘Slave DLL Phase’, ‘DQS delay fine tuning’ and ‘DQS# delay fine tuning’ defines the position of the DQS strobe signal for a particular byte. This position is the best one regarding DQ line eye diagram.
- ‘DQ bit x lane delay fine tuning’ defines the delay to apply on bit x of particular byte to compensate potential line length variation for this particular bit

**Figure 157. DDR tuning parameter**



### 5.3.2 Connection to the target and DDR register loading

To manage DDR tests and tuning, STM32CubeMX must establish a connection with the target and more specifically with **U-Boot SPL** using the **DDR interactive protocol**:

- the DDR interactive protocol is only available in the **Basic boot scheme U-Boot SPL** binary and supported over the UART4 peripheral instance
- when U-Boot SPL detects a connection to STM32CubeMX on UART4, it stops its initialization process and accepts commands from STM32CubeMX.

There are two connection options:

1. the U-Boot SPL binary is available in Flash memory
2. the U-Boot SPL needs to be loaded in SYSRAM because the DDR has not yet been tested nor tuned (and, consequently, is not fully functional yet).

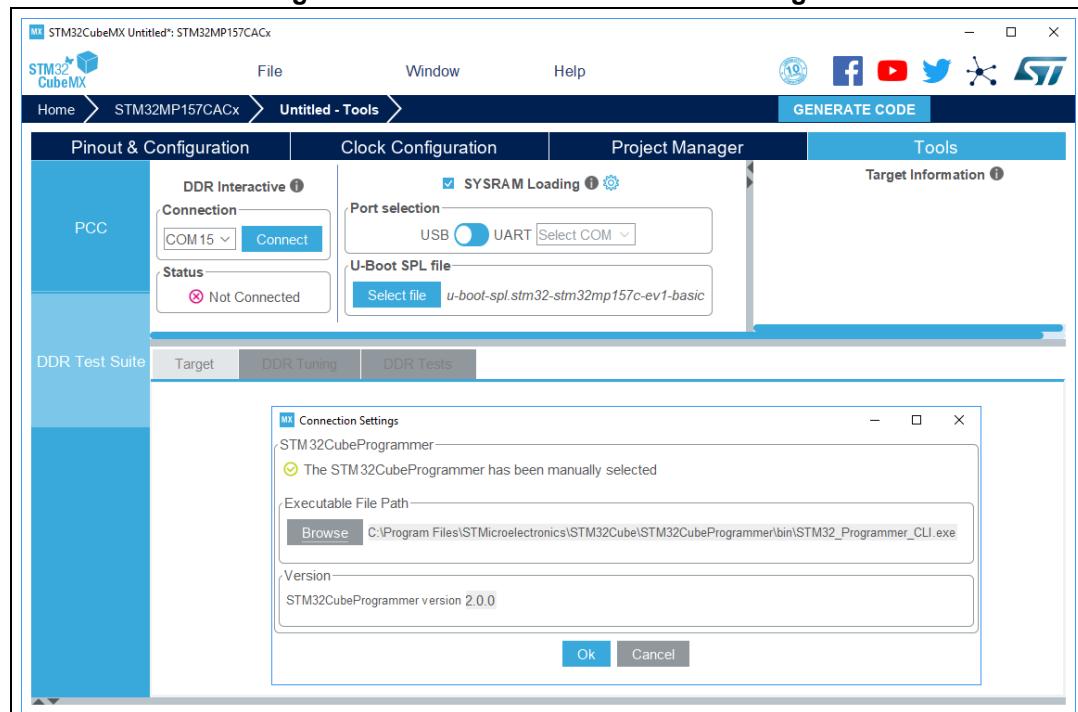
#### Prerequisites

- Installation of ST-Link USB driver to perform firmware upgrades: for Windows, latest version of STSW-LINK009 must be used. For Linux, the STSW-LINK007 driver must be used. Both can be downloaded from [www.st.com](http://www.st.com).
- Installation of STM32CubeProgrammer (for SYSRAM loading only): installer can be downloaded from [www.st.com](http://www.st.com).

#### Connection to the target

The COM port must be selected to connect to the target, as indicated in *Figure 158*.

**Figure 158. DDR Suite - Connection to target**

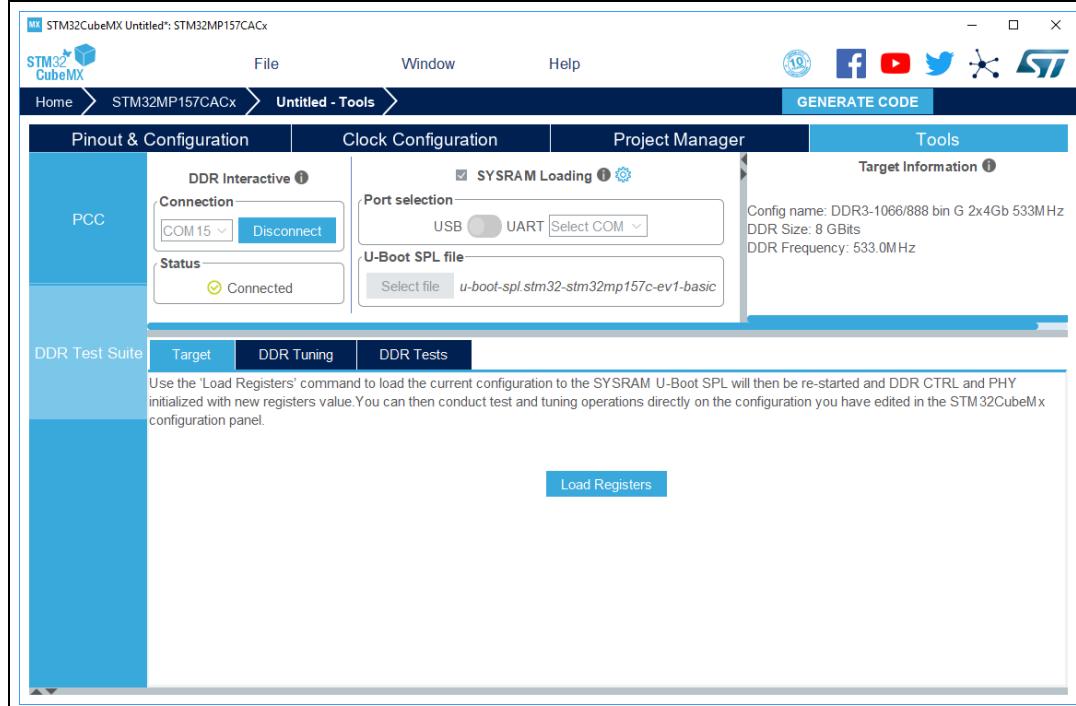


If U-Boot SPL loading in SysRAM is required, it can be performed through UART or USB using the STM32CubeProgrammer tool. If not automatically detected by STM32CubeMX, the STM32CubeProgrammer tool location must be specified in the Connection settings

window: click  to open it. U-Boot SPL file must be manually selected in the build image folder.

Once up, the connection gives the various services and target information (see [Figure 159](#)).

**Figure 159. DDR Suite - Target connected**



## Output/Log messages

STM32CubeMX outputs DDR suite related activity logs (see [Figure 160](#)) and interactive protocol communication logs (see [Figure 161](#)). They are displayed by enabling outputs from the Window menu.

**Figure 160. DDR activity logs**

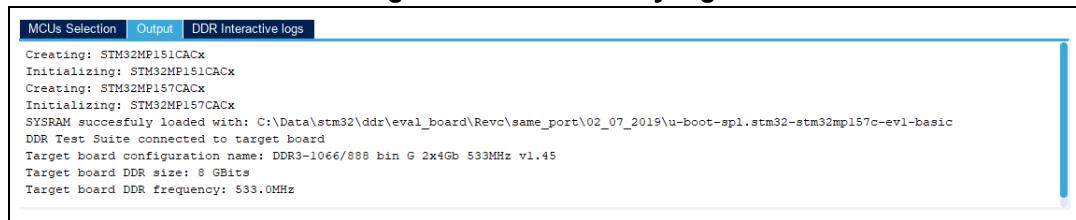


Figure 161. DDR interactive logs

```

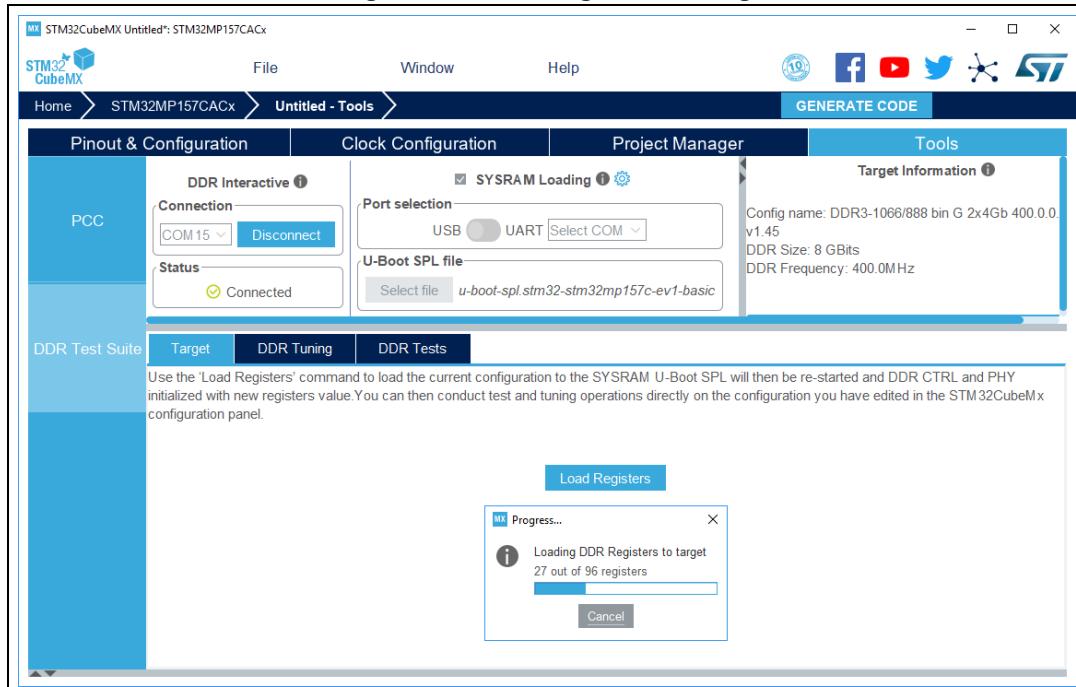
MCUs Selection | Output | DDR Interactive logs
Host > Target info
Target > Host step = 0 : DDR_RESET
Target > Host name = DDR3-1066/888 bin G 2x4Gb 533MHz v1.45
Target > Host size = 0x40000000
Target > Host speed = 533000 kHz
Host > Target step 3
Target > Host step to 3:DDR_READY
Target > Host 1:DDR_CTRL_INIT_DONE
Target > Host 2:DDR_PHY_INIT_DONE
Target > Host 3:DDR_READY
Host > Target print mstr
Target > Host mstr= 0x00040401
Host > Target tuning help
Target > Host tuning:5
Target > Host 0:Read DOS gating:software read DOS Gating:
Target > Host 1:Bit de-skew:::
Target > Host 2:Eye Training:or DQS training:
Target > Host 3:Display registers:::

```

### DDR register loading (optional)

Once connected in DDR interactive mode, user can load the current DDR configuration in SYSRAM.

Figure 162. DDR register loading



This step is optional if the used U-Boot SPL already contains the required DDR configuration. It triggers the DDR Controller and PHY initialization with those registers, and allows the user to quickly test a configuration without generating the device tree and dedicated U-Boot SPL binary file.

### 5.3.3 DDR testing

#### Prerequisites

To proceed with DDR testing:

- The DDR suite must be in connected state
- The DDR configuration must be available in memory, either with the U-Boot SPL (with DDR register file in Device Tree) or in the DDR registers (see [Section 5.3.2](#)).

#### DDR test list

DDR tests are part of the U-Boot SPL (see [Figure 163](#)).

**Figure 163. DDR test list from U-Boot SPL**

DDR Tests		
Id(s)	Test type(s)	Test name(s)
0	All	All
1	Basic	Simple DataBus
2	Basic	DataBusWalking0
3	Basic	DataBusWalking1
4	Basic	AddressPattern
5	Intensive	MemDevice
6	Intensive	SimultaneousSwitchingOutput
7	Intensive	Noise
8	Intensive	NoiseBurst
9	Intensive	Random
10	Intensive with Stress Conditions	FrequencySelectivePattern
11	Intensive	BlockSequential
12	Intensive	Checkerboard
13	Intensive	BitSpread

New tests can be added by modifying the U-boot SPL.

Most of the tests come with parameters to be set prior to execution, such as:

- Address: the memory address where the test is executed. All writes and reads are performed on this address. The given address has to be located in the DDR memory region [DDR base address, DDR base address + DDR size].
- On STM32MP15, DDR base address is 0xC0000000 (as an example, DDR size for 4 Gbits is 0x20000000).
- Loop: number of test iterations before verdict. Same test is repeated [Loop] times. Verdict OK if all tests are OK, KO otherwise.
- Size: the byte size of the region to test. Size must be a multiple of 4 (read/writes are performed on 32-bit unsigned integers) with minimal value equal to 4. Size can be up to DDR size.
- Pattern: the 32-bit pattern to be used for read / write operations.

The DDR Suite embeds an auto-correction feature preventing users to specify wrong values.

All tests are performed with Data cache disabled and Instruction cache enabled.

## DDR test results

The test verdict is reported by the U-Boot SPL: the parameters used for the tests are recalled, along with Pass/Fail status and results details (see [Figure 164](#)). The test history is available in the output and Logs panels (see [Figure 165](#)).

**Figure 164. DDR test suite results**

Execution	
	<b>Run test</b>
Parameter(s)	Value(s)
Address	0xC0000000
Loop	1
Verdict	
Item(s)	Info
Address	0xC0000000
Loop(s)	1
Result	Pass
Result details	no error for 1 loops

**Figure 165. DDR tests history**

MCUs Selection	Output	DDR Interactive logs
Target > Host		step to 3:DDR_READY
Target > Host		1:DDR_CTRL_INIT_DONE
Target > Host		2:DDR_PHY_INIT_DONE
Target > Host		3:DDR_READY
Host > Target		test 2 1 0xC0000000
Target > Host		execute 2:DataBusWalking0
Target > Host		running 1 loops at 0xc0000000
Target > Host		Result: Pass [no error for 1 loops]
Host > Target		test 3 1 0xC0000000
Target > Host		execute 3:DataBusWalking1
Target > Host		running 1 loops at 0xc0000000
Target > Host		Result: Pass [no error for 1 loops]
Host > Target		test 4 4 0xC0000000
Target > Host		execute 4:AddressBus
Target > Host		Result: Pass [address 0xc0000000, size 0x4]
MCUs Selection	Output	DDR Interactive logs
Target board configuration name: DDR3-1066/888 bin G 2x4Gb 400.0.0.0.0MHz v1.45		
Target board DDR size: 8 GBits		
Target board DDR frequency: 400.0MHz		
Current configuration DDR registers loaded to the target board		
DDR test #2 (DataBusWalking0) triggered with parameters: [loop] 1 [addr] 0xC0000000		
DDR test #3 (DataBusWalking1) triggered with parameters: [loop] 1 [addr] 0xC0000000		
DDR test #4 (AddressBus) triggered with parameters: [size] 4 [addr] 0xC0000000		

### 5.3.4 DDR tuning

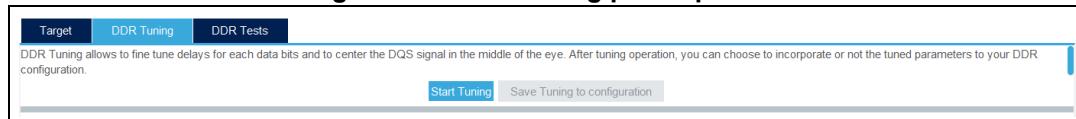
#### Prerequisites

The prerequisites to proceed with DDR tuning are:

- The DDR suite is in connected state
- A valid DDR configuration is available in memory, either with the U-Boot SPL (with DDR register file in Device Tree) or in the DDR registers (see *DDR register loading (optional)*).

Thanks to DDR tuning it is possible to compensate hardware design slight imperfections for best operations (see AN5122, available on [www.st.com](http://www.st.com), for DDR design routing guidelines).

**Figure 166. DDR tuning pre-requisites**



#### Tunable signals

The tunable signals are

- DQS signals: position for each data byte
- the 8 DQ bits: delay for each data byte.

Some DDR registers are dedicated to store the corresponding tuned settings:

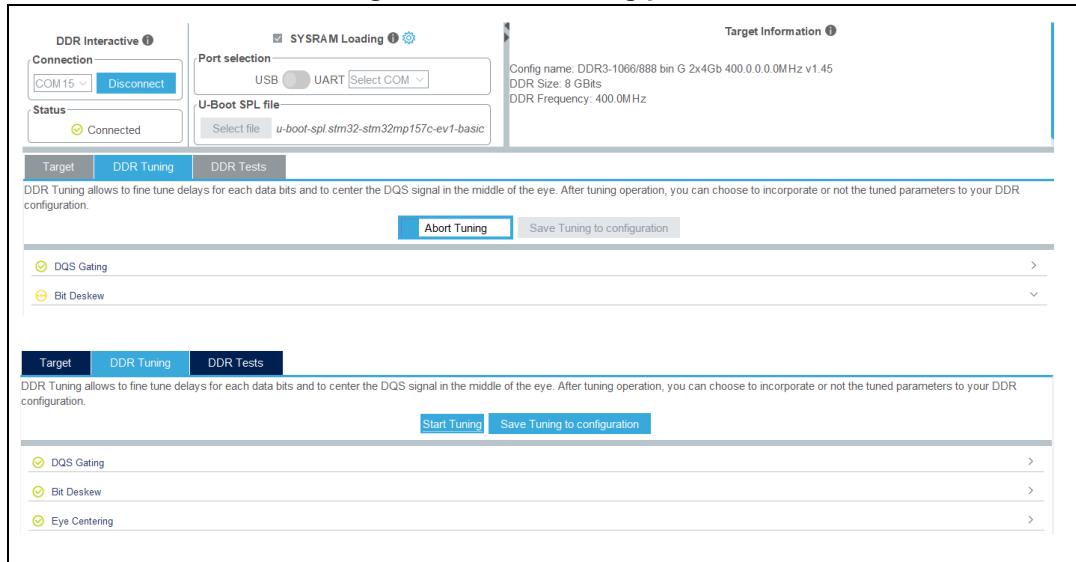
- ‘Slave DDL Phase’, ‘DQS delay fine tuning’ and ‘DQS# delay fine tuning’ define the position of the DQS strobe signal for a particular byte: this position is the best one regarding DQ line eye diagram
- ‘DQ bit x lane delay fine tuning’ defines the delay to apply on bit x of particular byte to compensate potential line length variation for this particular bit.

*Note:* *It is recommended to perform tuning on several boards to make sure that the tuned parameter variation is limited.*

#### Tuning process

Tuning is done in three consecutive steps (see *Figure 167*):

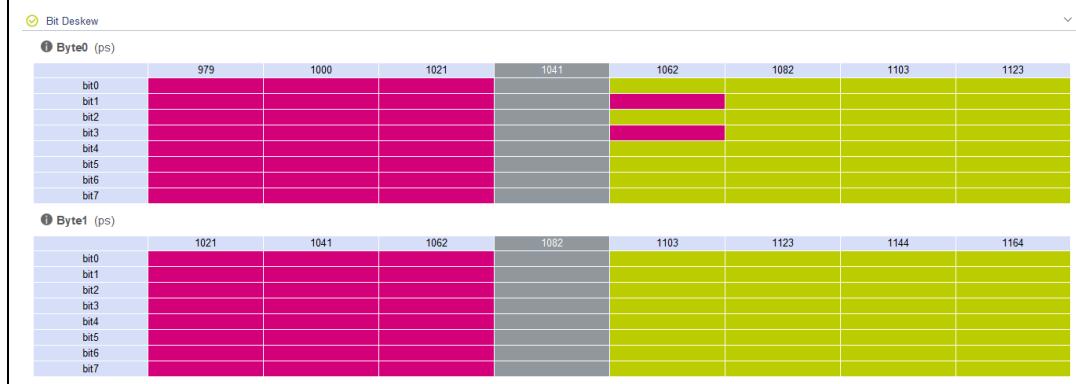
1. DQS gating
2. Bit deskew
3. Eye training

**Figure 167. DDR tuning process**

### Bit deskew

The Bit deskew panel (see [Figure 168](#)) gives a graphical representation of

- the best DQS signal position for the given byte in order to adjust DQ line delay
- the delay to apply for each DQ line of the considered byte. The unit delay value is 20.56 ps. There are four steps. Bit lane delay is thus tunable from 0 to 61.68 ps.

**Figure 168. Bit deskew**

### Eye training (centering)

The Eye training (centering) panel ([Figure 169](#)) gives the final optimum position of the DQS signal in the half-period for each byte:

- DQS position varies coarsely from 36 to 144 degrees (quarter period is 90 degrees)
- DQS position then varies finely around the coarse position with 8 steps, from -61.68 to +82.24 ps

**Figure 169. Eye training (centering) panel**

Byte0 (ps)													T/2		
0	89	179	268	357	446	536	T/4	604	714	804	893	982	1071	1161	T/2
Byte1 (ps)													T/2		
0	89	179	268	357	446	536	T/4	625	714	804	893	982	1071	1161	T/2

### Propagating tuning results

Once tuning is complete, the DDR suite allows the user to propagate the tuned parameters to the current DDR configuration (see [Figure 170](#)). The DDR Tuning tab is refreshed accordingly (see [Figure 171](#)).

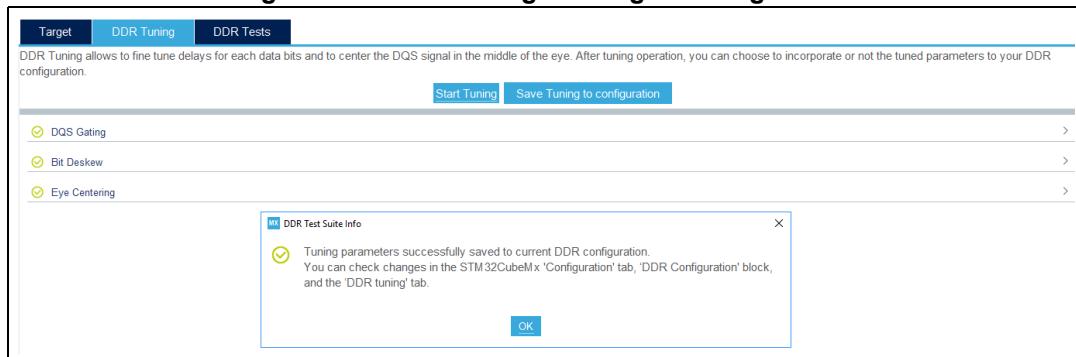
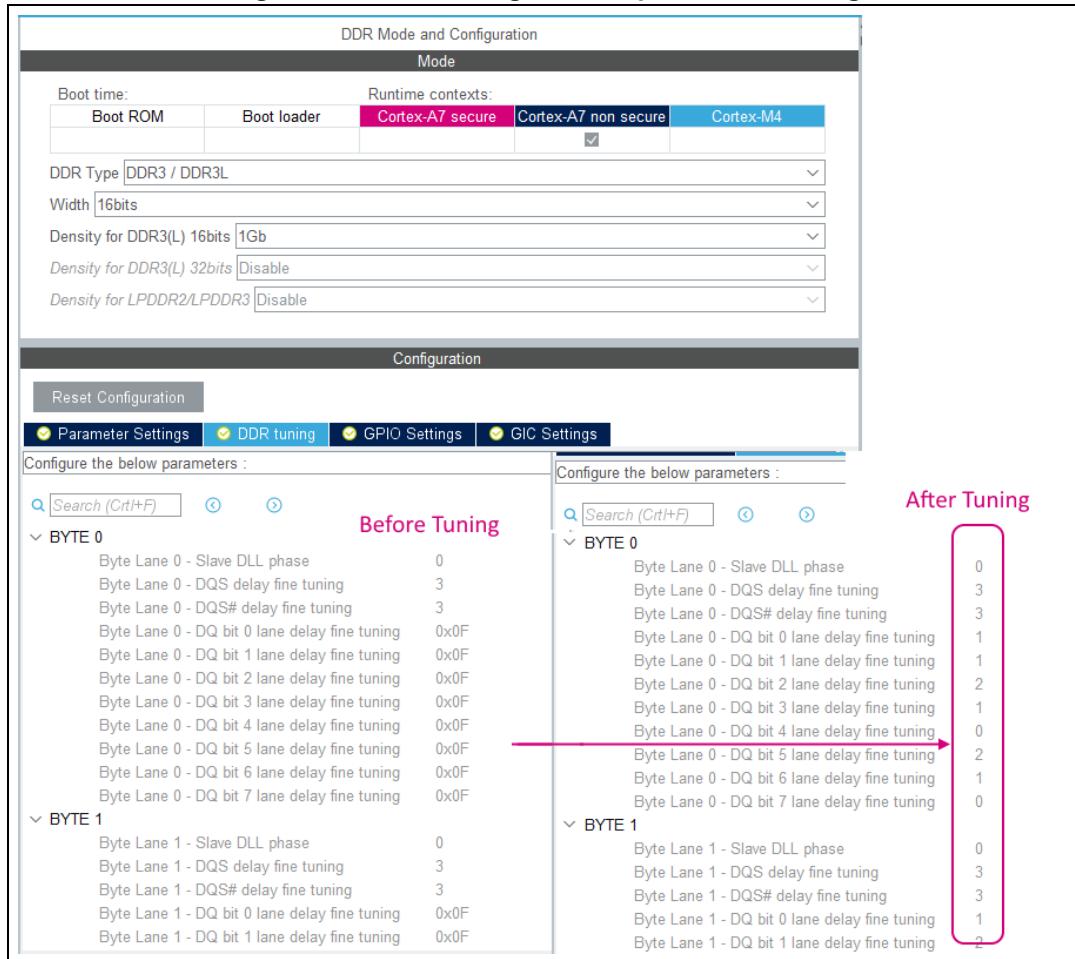
**Figure 170. DDR Tuning - saving to configuration**

Figure 171. DDR configuration update after tuning



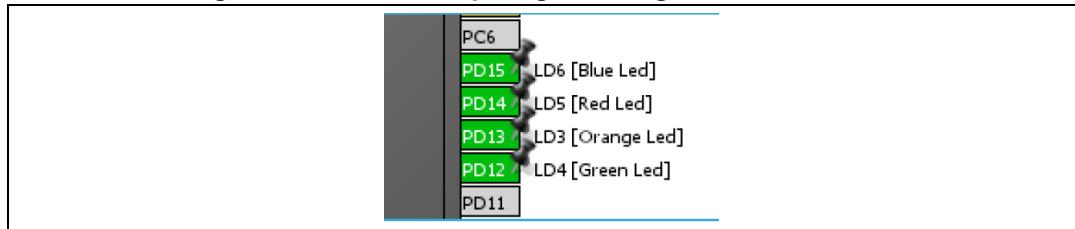
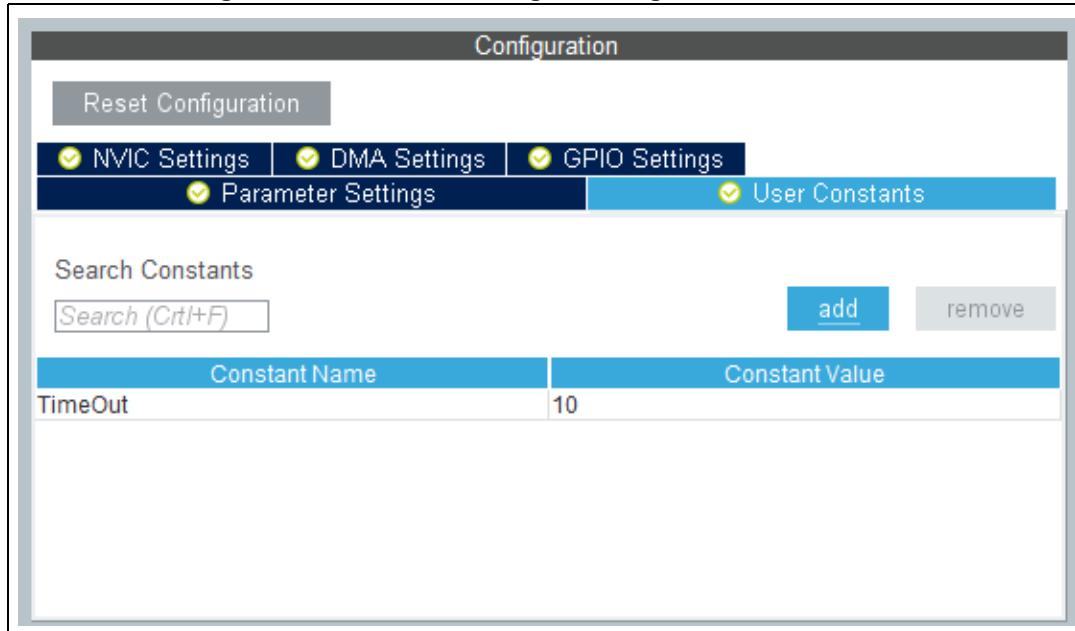
## 6 STM32CubeMX C Code generation overview

### 6.1 STM32Cube code generation using only HAL drivers (default mode)

During the C code generation process, STM32CubeMX performs the following actions:

1. If it is missing, it downloads the relevant STM32Cube MCU package from the user repository. STM32CubeMX repository folder is specified in the **Help > Updater settings** menu.
2. It copies from the firmware package, the relevant files in *Drivers/CMSIS* and *Drivers/STM32F4\_HAL\_Driver* folders and in the *Middleware* folder if a middleware was selected.
3. It generates the initialization C code ( .c/.h files) corresponding to the user MCU configuration and stores it in the *Inc* and *Src* folders. By default, the following files are included:
  - **stm32f4xx\_hal\_conf.h** file: this file defines the enabled HAL modules and sets some parameters (e.g. External High Speed oscillator frequency) to predefined default values or according to user configuration (clock tree).
  - **stm32f4xx\_hal\_msp.c** (MSP = MCU Support package): this file defines all initialization functions to configure the peripheral instances according to the user configuration (pin allocation, enabling of clock, use of DMA and Interrupts).
  - **main.c** is in charge of:
    - Resetting the MCU to a known state by calling the *HAL\_init()* function that resets all peripherals, initializes the Flash memory interface and the SysTick.
    - Configuring and initializing the system clock.
    - Configuring and initializing the GPIOs that are not used by peripherals.
    - Defining and calling, for each configured peripheral, a peripheral initialization function that defines a handle structure that will be passed to the corresponding peripheral *HAL init* function which in turn will call the peripheral HAL MSP initialization function. Note that when LwIP (respectively USB) middleware is used, the initialization C code for the underlying Ethernet (respectively USB peripheral) is moved from main.c to LwIP (respectively USB) initialization C code itself.
  - **main.h** file:
    - This file contains the define statements corresponding to the pin labels set from the **Pinout** tab, as well as the user project constants added from the **Configuration** tab (refer to [Figure 172](#) and [Figure 173](#) for examples):

```
#define MyTimeOut      10
#define LD4_Pin          GPIO_PIN_12
#define LD4_GPIO_Port    GPIOD
#define LD3_Pin          GPIO_PIN_13
#define LD3_GPIO_Port    GPIOD
#define LD5_Pin          GPIO_PIN_14
#define LD5_GPIO_Port    GPIOD
#define LD6_Pin          GPIO_PIN_15
#define LD6_GPIO_Port    GPIOD
```

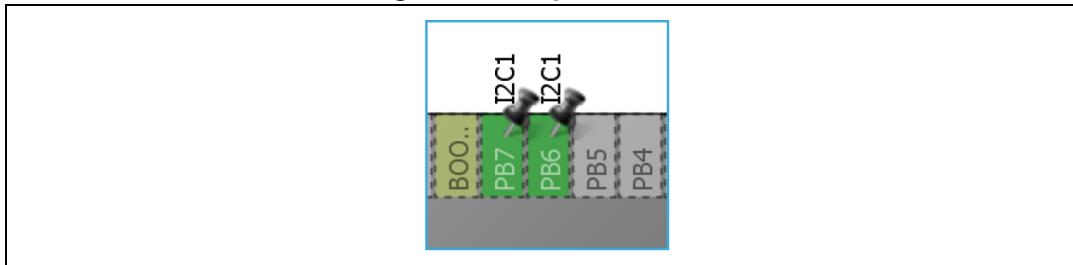
**Figure 172. Labels for pins generating define statements****Figure 173. User constant generating define statements**

In case of duplicate labels, a unique suffix, consisting of the pin port letter and the pin index number, is added and used for the generation of the associated define statements.

In the example of a duplicate I2C1 labels shown in [Figure 174](#), the code generation produces the following code, keeping the I2C1 label on the original port B pin 6 define statements and adding B7 suffix on pin 7 define statements:

```
#define I2C1_Pin          GPIO_PIN_6
#define I2C1_GPIO_Port      GPIOB
#define I2C1B7_Pin          GPIO_PIN_7
#define I2C1B7_GPIO_Port    GPIOB
```

Figure 174. Duplicate labels



In order for the generated project to compile, define statements shall follow strict naming conventions. They shall start with a letter or an underscore as well as the corresponding label. In addition, they shall not include any special character such as minus sign, parenthesis or brackets. Any special character within the label will be automatically replaced by an underscore in the define name.

If the label contains character strings between “[]” or “()”, only the first string listed is used for the define name. As an example, the label “**LD6** [Blue Led]” corresponds the following define statements:

```
#define LD6_Pin    GPIO_PIN_15
#define LD6_GPIO_Port  GPIOD
```

The define statements are used to configure the GPIOs in the generated initialization code. In the following example, the initialization of the pins labeled *Audio\_RST\_Pin* and *LD4\_Pin* is done using the corresponding define statements:

```
/*Configure GPIO pins : LD4_Pin Audio_RST_Pin */
GPIO_InitStruct.Pin = LD4_Pin | Audio_RST_Pin;
GPIO_InitStruct.Mode = GPIO_MODE_OUTPUT_PP;
GPIO_InitStruct.Pull = GPIO_NOPULL;
GPIO_InitStruct.Speed = GPIO_SPEED_LOW;
HAL_GPIO_Init(GPIOD, &GPIO_InitStruct);
```

4. Finally it generates a *Projects* folder that contains the toolchain specific files that match the user project settings. Double-clicking the IDE specific project file launches the IDE and loads the project ready to be edited, built and debugged.

## 6.2 STM32Cube code generation using Low Layer drivers

For all STM32 Series except STM32H7 and STM32P1 Series, STM32CubeMX allows the user to generate peripheral initialization code based either on the peripheral HAL driver or on the peripheral Low Layer (LL) driver.

The choice is made through the Project Manager view (see [Section 4.9.3: Advanced Settings tab](#)).

The LL drivers are available only for the peripherals which require an optimized access and do not have a complex software configuration. The LL services allow performing atomic operations by changing the relevant peripheral registers content:

- Examples of supported peripherals: RCC, ADC, GPIO, I2C, SPI, TIM, USART,...
- Examples of peripherals not supported by LL drivers: USB, SDMMC, FSMC.

The LL drivers are available within the STM32CubeL4 package:

- They are located next to the HAL drivers (`stm32l4_hal_<peripheral_name>`) within the `Inc` and `Src` directory of the `STM32Cube_FW_L4_V1.6\Drivers\STM32L4xx_HAL_Driver` folder.
- They can be easily recognizable by their naming convention:  
`stm32l4_ll_<peripheral_name>`

For more details on HAL and LL drivers refer to the *STM32L4 HAL and Low-layer drivers* user manual (UM1884).

As the decision to use LL or HAL drivers is made on a peripheral basis, the user can mix both HAL and LL drivers within the same project.

The following tables shows the main differences between the three possible STM32CubeMX project generation options: HAL-only, LL-only, and mix of HAL and LL code.

**Table 18. LL versus HAL code generation: drivers included in STM32CubeMX projects**

Project configuration and drivers to be included	HAL only	LL only	Mix of HAL and LL	Comments
CMSIS	Yes	Yes	Yes	-
STM32xxx_HAL_Driver	Only HAL driver files	Only LL driver files	Mix of HAL and LL driver files	Only the driver files required for a given configuration (selection of peripherals) are copied when the project settings option is set to "Copy only the necessary files". Otherwise ("all used libraries" option) the complete set of driver files is copied.

**Table 19. LL versus HAL code generation: STM32CubeMX generated header files**

Generated header files	HAL only	LL only	Mix of HAL and LL	Comments
main.h	Yes	Yes	Yes	This file contains the include statements and the generated define statements for user constants (GPIO labels and user constants).
stm32xxx_hal_conf.h	Yes	No	Yes	This file enables the HAL modules necessary to the project.
stm32xxx_it.h	Yes	Yes	Yes	Header file for interrupt handlers
stm32xx_assert.h	No	Yes	Yes	This file contains the assert macros and the functions used for checking function parameters.

**Table 20. LL versus HAL: STM32CubeMX generated source files**

Generated source files	HAL only	LL only	Mix of HAL and LL	Comments
main.c	Yes	Yes	Yes	This file contains the main functions and optionally STM32CubeMX generated functions.
stm32xxx_hal_msp.c	Yes	No	Yes	<p>This file contains the following functions:</p> <ul style="list-style-type: none"> <li>– HAL_MspInit</li> <li>– for peripherals using HAL drivers: HAL_&lt;Peripheral&gt;_MspInit, HAL_&lt;Peripheral&gt;_MspDeInit,</li> </ul> <p>These functions are available only for the peripherals that use HAL drivers.</p>
stm32xxx_it.c	Yes	Yes	Yes	Source file for interrupt handlers

**Table 21. LL versus HAL: STM32CubeMX generated functions and function calls**

Generated source files	HAL only	LL only	Mix of HAL and LL	Comments
Hal_init()	Called in main.c	Not used	Called in main.c	<p>This file performs the following functions:</p> <ul style="list-style-type: none"> <li>– Configuration of Flash memory prefetch and instruction and data caches</li> <li>– Selection of the SysTick timer as timebase source</li> <li>– Setting of NVIC group priority</li> <li>– MCU low-level initialization.</li> </ul>
Hal_msp_init()	Generated in stm32xxx_hal_msp.c and called by HAL_init()	Not used	Generated in stm32xxx_hal_msp.c And called by HAL_init()	<p>This function performs the peripheral resources configuration<sup>(1)</sup>.</p>
MX_<Peripheral>_Init()	[1]: Peripheral configuration and call to HAL_<Peripheral>_Init()	[2]: Peripheral and peripheral resource configuration <sup>(1)</sup> using LL functions  Call to LL_Peripheral_Init()	<ul style="list-style-type: none"> <li>– When HAL driver is selected for the &lt;Peripheral&gt;, function generation and calls are done following [1]: <i>Peripheral configuration and call to HAL_&lt;Peripheral&gt;_Init()</i></li> <li>– When LL driver selected for the &lt;Peripheral&gt;, function generation and calls are done following [2]: <i>Peripheral and peripheral resource configuration using LL functions</i></li> </ul>	<p>This file takes care of the peripherals configuration.</p> <p>When the LL driver is selected for the &lt;Peripheral&gt;, it also performs the peripheral resources configuration<sup>(1)</sup>.</p>

**Table 21. LL versus HAL: STM32CubeMX generated functions and function calls (continued)**

<b>Generated source files</b>	<b>HAL only</b>	<b>LL only</b>	<b>Mix of HAL and LL</b>	<b>Comments</b>
HAL_<Peripheral>_MspInit()	[3]: Generated in <code>stm32xxx_hal_msp.c</code> when HAL driver selected for the <Peripheral>	Not used	Only HAL driver can be selected for the <Peripheral>: function generation and calls are done following [3]: <i>Generated in <code>stm32xxx_hal_msp.c</code> when HAL driver selected for the &lt;Peripheral&gt;</i>	Peripheral resources configuration <sup>(1)</sup>
HAL_<Peripheral>_MspDeInit()	[4]: Generated in <code>stm32xxx_hal_msp.c</code> when HAL driver selected for the <Peripheral>	Not used	Only HAL driver can be selected for the <Peripheral>: function generation and calls are done following [4]: <i>Generated in <code>stm32xxx_hal_msp.c</code> when HAL driver selected for the &lt;Peripheral&gt;</i>	This function can be used to free peripheral resources.

1. Peripheral resources include:
  - peripheral clock
  - pinout configuration (GPIOs)
  - peripheral DMA requests
  - peripheral Interrupt requests and priorities.

Figure 175. HAL-based peripheral initialization: usart.c code snippet

```
USART Peripheral initialization - HAL-based
void MX_USART1_UART_Init(void)
{
    huart1.Instance = USART1;
    huart1.Init.BaudRate = 115200;
    huart1.Init.WordLength = UART_WORDLENGTH_7B;
    huart1.Init.StopBits = UART_STOPBITS_1;
    ...
    if (HAL_UART_Init(&huart1) != HAL_OK)
    {
        Error_Handler();
    }
}
void HAL_UART_MspInit(UART_HandleTypeDef* uartHandle)
{
    GPIO_InitTypeDef GPIO_InitStruct;
    if(uartHandle->Instance==USART1)
    {
        /* Peripheral clock enable */
        __HAL_RCC_USART1_CLK_ENABLE();
        /* USART1 GPIO Configuration */
        GPIO_InitStruct.Pin = GPIO_PIN_10;
        GPIO_InitStruct.Mode = GPIO_MODE_AF_PP;
        GPIO_InitStruct.Pull = GPIO_PULLUP;
        ...
        HAL_GPIO_Init(GPIOB, &GPIO_InitStruct);
    }
}
void HAL_UART_MspDeInit(UART_HandleTypeDef* uartHandle)
{
    if(uartHandle->Instance==USART1)
    {
        /* Peripheral clock disable */
        __HAL_RCC_USART1_CLK_DISABLE();
        /* USART1 GPIO Configuration */
        HAL_GPIO_DeInit(GPIOA, GPIO_PIN_10);
        HAL_GPIO_DeInit(GPIOB, GPIO_PIN_6);
    }
}
```

Figure 176. LL-based peripheral initialization: usart.c code snippet

```
USART Peripheral Initialization using LL drivers
void MX_USART1_UART_Init(void)
{
    LL_USART_InitTypeDef USART_InitStruct;
    LL_GPIO_InitTypeDef GPIO_InitStruct;
    /* Peripheral clock enable */
    LL_APB2_GRP1_EnableClock(LL_APB2_GRP1_PERIPH_USART1);

    /**USART1 GPIO Configuration           Peripheral Resources Configuration
     PA10      -----> USART1_RX
     PB6       -----> USART1_TX
    */
    GPIO_InitStruct.Pin = LL_GPIO_PIN_10;
    GPIO_InitStruct.Mode = LL_GPIO_MODE_ALTERNATE;
    GPIO_InitStruct.Speed = LL_GPIO_SPEED_FREQ_VERY_HIGH;
    GPIO_InitStruct.Pull = LL_GPIO_PULL_UP;
    GPIO_InitStruct.Alternate = LL_GPIO_AF_7;
    LL_GPIO_Init(GPIOA, &GPIO_InitStruct);

    GPIO_InitStruct.Pin = LL_GPIO_PIN_6;
    GPIO_InitStruct.Mode = LL_GPIO_MODE_ALTERNATE;
    GPIO_InitStruct.Speed = LL_GPIO_SPEED_FREQ_VERY_HIGH;
    GPIO_InitStruct.Pull = LL_GPIO_PULL_UP;
    GPIO_InitStruct.Alternate = LL_GPIO_AF_7;
    LL_GPIO_Init(GPIOB, &GPIO_InitStruct);

Peripheral Configuration
    USART_InitStruct.BaudRate = 115200;
    USART_InitStruct.DataWidth = LL_USART_DATAWIDTH_7B;
    USART_InitStruct.StopBits = LL_USART_STOPBITS_1;
    USART_InitStruct.Parity = LL_USART_PARITY_NONE;
    USART_InitStruct.TransferDirection = LL_USART_DIRECTION_TX_RX;
    USART_InitStruct.HardwareFlowControl = LL_USART_HWCONTROL_NONE;
    USART_InitStruct.OverSampling = LL_USART_OVERSAMPLING_16;

    LL_USART_Init(USART1, &USART_InitStruct);
    LL_USART_ConfigAsyncMode(USART1);
}
```

Figure 177. HAL versus LL: main.c code snippet

<pre><b>main.c HAL-based</b> /*  * Includes ----- #include "main.h" #include "stm32l4xx_hal.h" #include "usart.h" #include "gpio.h"  void SystemClock_Config(void); void Error_Handler(void);  int main(void) {     /* Reset of all peripherals,     Initializes the Flash interface and the Systick.     */     HAL_Init();      /* Configure the system clock */     SystemClock_Config();      /* Initialize all configured peripherals */     MX_GPIO_Init();     MX_USART1_UART_Init(); }</pre>	<pre><b>main.c LL-based</b> /*  * Includes ----- #include "main.h" #include "usart.h" #include "gpio.h"  void SystemClock_Config(void); void Error_Handler(void);  int main(void) {     /* Reset of all peripherals,     Initializes the Flash interface and the Systick.     */     LL_Init();      /* Configure the system clock */     SystemClock_Config();      /* Initialize all configured peripherals */     MX_GPIO_Init();     MX_USART1_UART_Init(); }</pre>
--	---

## 6.3 Custom code generation

STM32CubeMX supports custom code generation by means of a FreeMarker template engine (see <http://www.freemarker.org>).

### 6.3.1 STM32CubeMX data model for FreeMarker user templates

STM32CubeMX can generate a custom code based on a FreeMarker template file (.ftl extension) for any of the following MCU configuration information:

- List of MCU peripherals used by the user configuration
- List of parameters values for those peripherals
- List of resources used by these peripherals: GPIO, DMA requests and interrupts.

The user template file must be compatible with STM32CubeMX data model. This means that the template must start with the following lines:

```
[#ftl]
[#list configs as dt]
[#assign data = dt]
[#assign peripheralParams = dt.peripheralParams]
[#assign peripheralGPIOParams = dt.peripheralGPIOParams]
[#assign usedIPs = dt.usedIPs]
```

and end with

```
[/#list]
```

A sample template file is provided for guidance (see [Figure 178](#)).

STM32CubeMX will also generate user-specific code if any is available within the template.

As shown in the below example, when the sample template is used, the ftl commands are provided as comments next to the data they have generated:

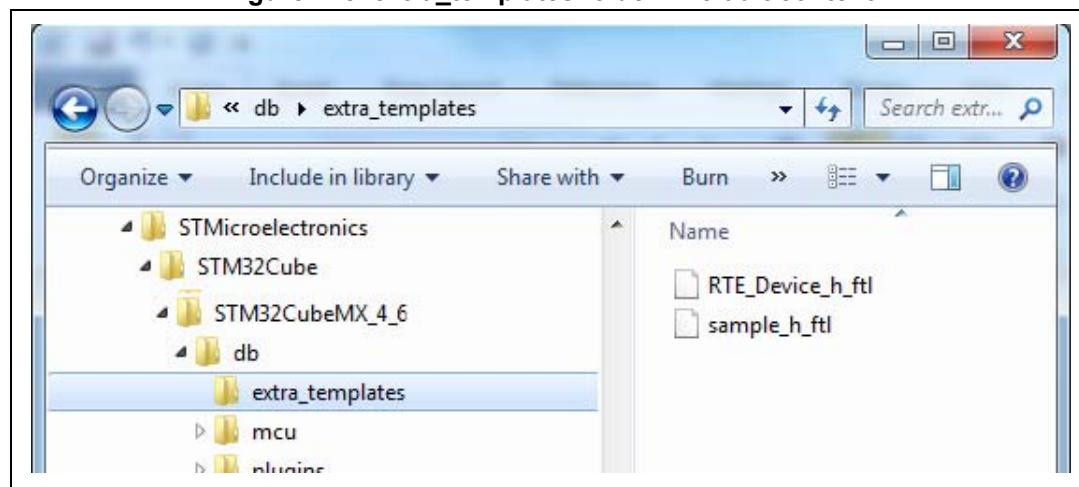
FreeMarker command in template:

```
 ${peripheralParams.get("RCC").get("LSI_VALUE")}
```

Resulting generated code:

```
 LSI_VALUE : 32000      [peripheralParams.get("RCC").get("LSI_VALUE")]
```

**Figure 178. extra\_templates folder - Default content**



### 6.3.2 Saving and selecting user templates

The user can either place the FreeMarker template files under STM32CubeMX installation path within the db/extra\_templates folder or in any other folder.

Then for a given project, the user will select the template files relevant for its project via the **Template Settings** window accessible from the Code Generator Tab in the **Project Manager** view menu (see [Section 4.9](#))

### 6.3.3 Custom code generation

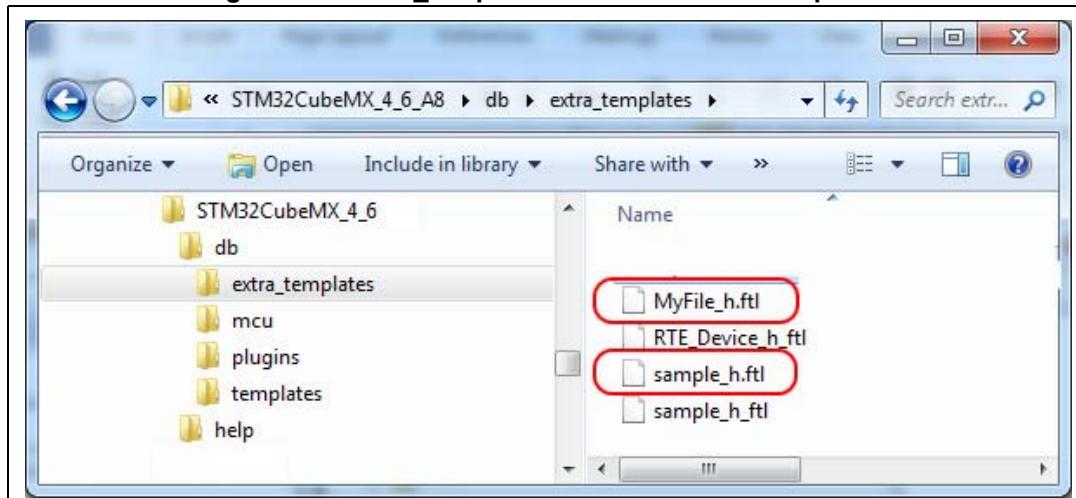
To generate custom code, the user must place the FreeMarker template file under STM32CubeMX installation path within the db/extra\_templates folder (see [Figure 179](#)).

The template filename must follow the naming convention <user filename>\_<file extension>.ftl in order to generate the corresponding custom file as <user filename>.<file extension>.

By default, the custom file is generated in the user project root folder, next to the .ioc file (see [Figure 180](#)).

To generate the custom code in a different folder, the user shall match the destination folder tree structure in the extra\_template folder (see [Figure 181](#)).

**Figure 179. extra\_templates folder with user templates**



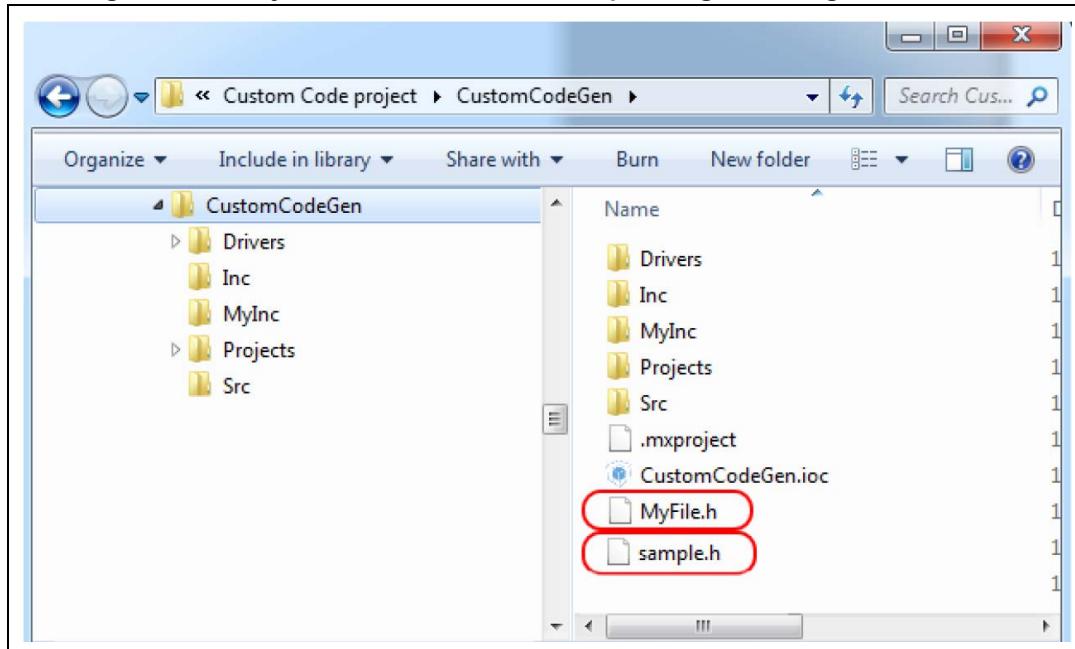
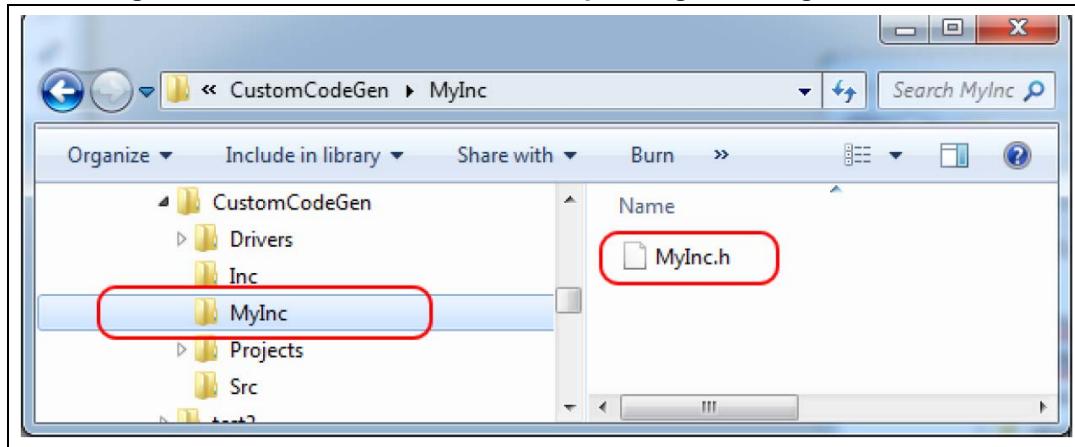
**Figure 180. Project root folder with corresponding custom generated files****Figure 181. User custom folder for templates**

Figure 182. Custom folder with corresponding custom generated files



## 6.4 Additional settings for C project generation

STM32CubeMX allows specifying additional project settings through the .extSettings file. This file must be placed in the same project folder and at the same level as the .ioc file.

As an example, additional settings can be used when external tools call STM32CubeMX to generate the project and require specific project settings.

### Possible entries and syntax

All entries are optional. They are organized under the followings three categories: ProjectFiles, Groups or Others.

- [ProjectFiles]: section where to specify additional include directories

#### Syntax

```
HeaderPath = <include directory 1 path>;< include directory 2 path >
```

#### Example

```
HeaderPath=../../IIR_Filter_int32/Inc ;
```

- [Groups]: section where to create new groups of files and/or add files to a group

#### Syntax

```
<Group name> = <file pathname1>;< file pathname2>
```

#### Example

```
Doc=$ PROJ_DIR$..\readme.txt
```

```
Lib=C:\libraries\mylib1.lib; C:\libraries\mylib2.lib;
```

```
Drivers/BSP/MyRefBoard = C:\MyRefBoard\BSP\board_init.c;
```

```
C:\MyRefBoard\BSP\board_init.h;
```

- [Others] section where to enable HAL modules and/or specify preprocessor define statements

- Enabling pre-processor define statements

Preprocessor define statements can be specified using the following syntax after the [Others] line:

#### Syntax

```
Define = <define1_name>;<define2_name>
```

#### Example

- Define = USE\_STM32F429I\_DISCO**
- Enabling HAL modules in generated stm32f4xx\_hal\_conf.h
- HAL modules can be enabled using the following syntax after the [Others] line:

#### Syntax

```
HALModule = <ModuleName1>; <ModuleName1>;
```

#### Example

```
HALModule=I2S;I2C
```

### .extSettings file example and generated outcomes

For the purpose of the example, a new project is created by selecting the STM32F429I-DISCO board from STM32CubeMX board selector. The EWARM toolchain is selected in the Project tab of the **Project Manager** view. The project is saved as *MyF429IDiscoProject*. In the project folder, next to the generated .ioc file, a .extSettings text file is placed with the following contents:

#### [Groups]

```
Drivers/BSP/STM32F429IDISCO=C:\Users\frq09031\STM32Cube\Repository\STM3
2Cube_FW_F4_V1.14.0\Drivers\BSP\STM32F429I-
Discovery\stm32f429i_discovery.c;
C:\Users\frq09031\STM32Cube\Repository\STM32Cube_FW_F4_V1.14.0\Drivers\
BSP\STM32F429I-Discovery\stm32f429i_discovery.h
Lib=C:\Users\frq09031\STM32Cube\Repository\STM32Cube_FW_F4_V1.14.0\
Middlewares\Third_Party\FreeRTOS\Source\portable\IAR\ARM_CM4F\portasm.s
Doc=$PROJ_DIR$..\readme.txt
```

#### [Others]

```
Define = USE_STM32F429I_DISCO
HALModule = UART;SPI
```

Upon project generation, the presence of this .extSettings file triggers the update of:

- the project MyF429IDiscoProject.ewp file in EWARM folder (see [Figure 183](#))
- the stm32f4xx\_hal\_conf.h file in the project Inc folder (see [Figure 184](#))
- the project view within EWARM user interface as shown in [Figure 185](#) and [Figure 186](#).

**Figure 183. Update of the project .ewp file (EWARM IDE) for preprocessor define statements**

```

<settings>
  <name>ICCARM</name>
  <archiveVersion>2</archiveVersion>
  <data>
    <version>28</version>
    <wantNonLocal>1</wantNonLocal>
    <debug>1</debug>
    <option>
      <name>CCDDefines</name>
      <state>USE_HAL_DRIVER</state>
      <state>STM32F429I</state>
      <state>USE_STM32F429I_DISCO</state>
    </option>
  </data>
</settings>

```

**Figure 184. Update of stm32f4xx\_hal\_conf.h file to enable selected modules**

```

stm32f4xx_hal_conf.h
/*
 * #define HAL_RTC_MODULE_ENABLED   */
/* #define HAL_SAI_MODULE_ENABLED   */
/* #define HAL_SD_MODULE_ENABLED   */
/* #define HAL_MMC_MODULE_ENABLED   */
#define HAL_SPI_MODULE_ENABLED
/* #define HAL_TIM_MODULE_ENABLED   */
#define HAL_UART_MODULE_ENABLED
/* #define HAL_USART_MODULE_ENABLED   */
/* #define HAL_IRDA_MODULE_ENABLED   */
/* #define HAL_SMARTCARD_MODULE_ENABLED   */
/* #define HAL_WWDG_MODULE_ENABLED   */
/* #define HAL_PCD_MODULE_ENABLED   */
/* #define HAL_HCD_MODULE_ENABLED   */
*/

```

**Figure 185. New groups and new files added to groups in EWARM IDE**

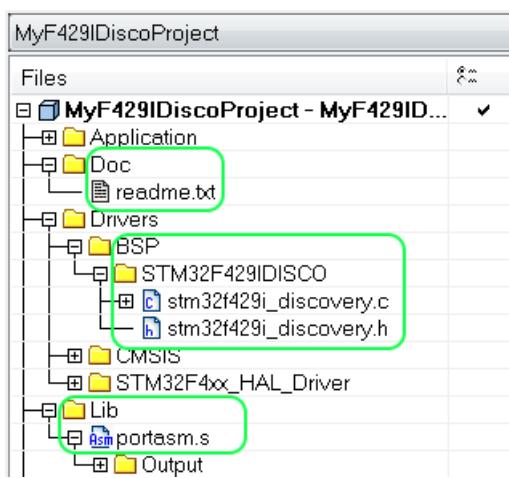
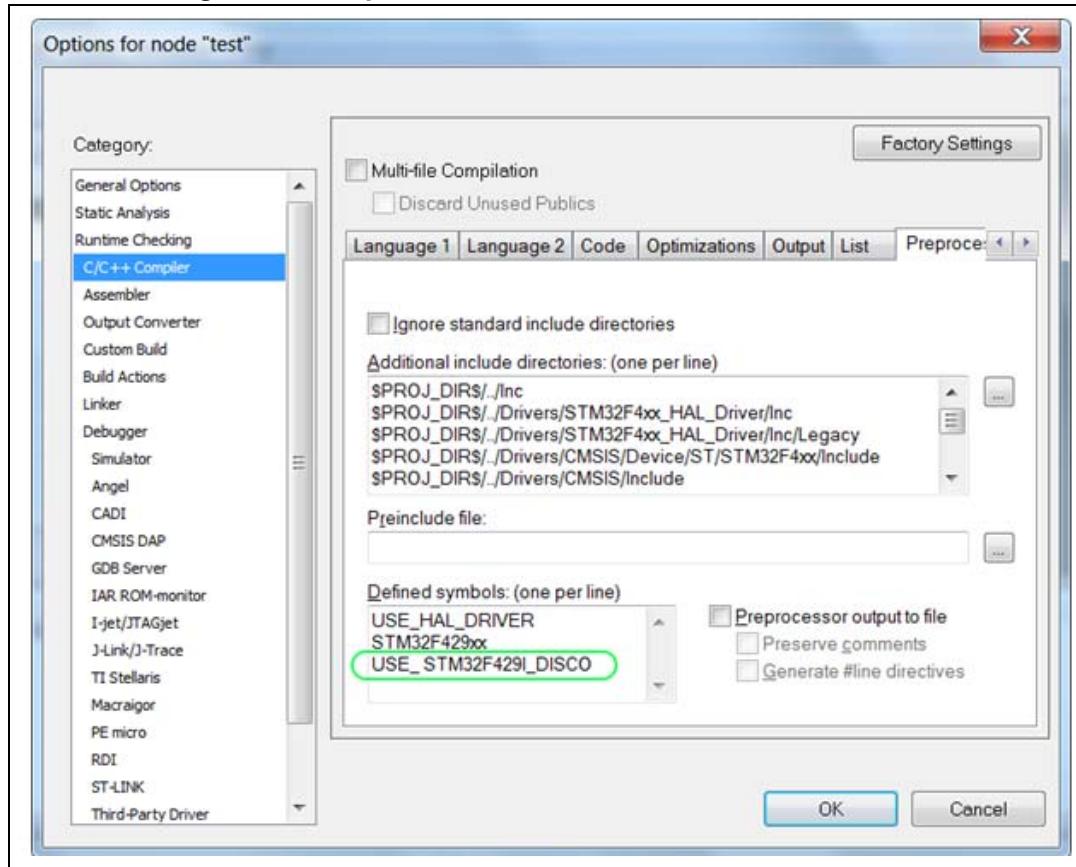


Figure 186. Preprocessor define statements in EWARM IDE

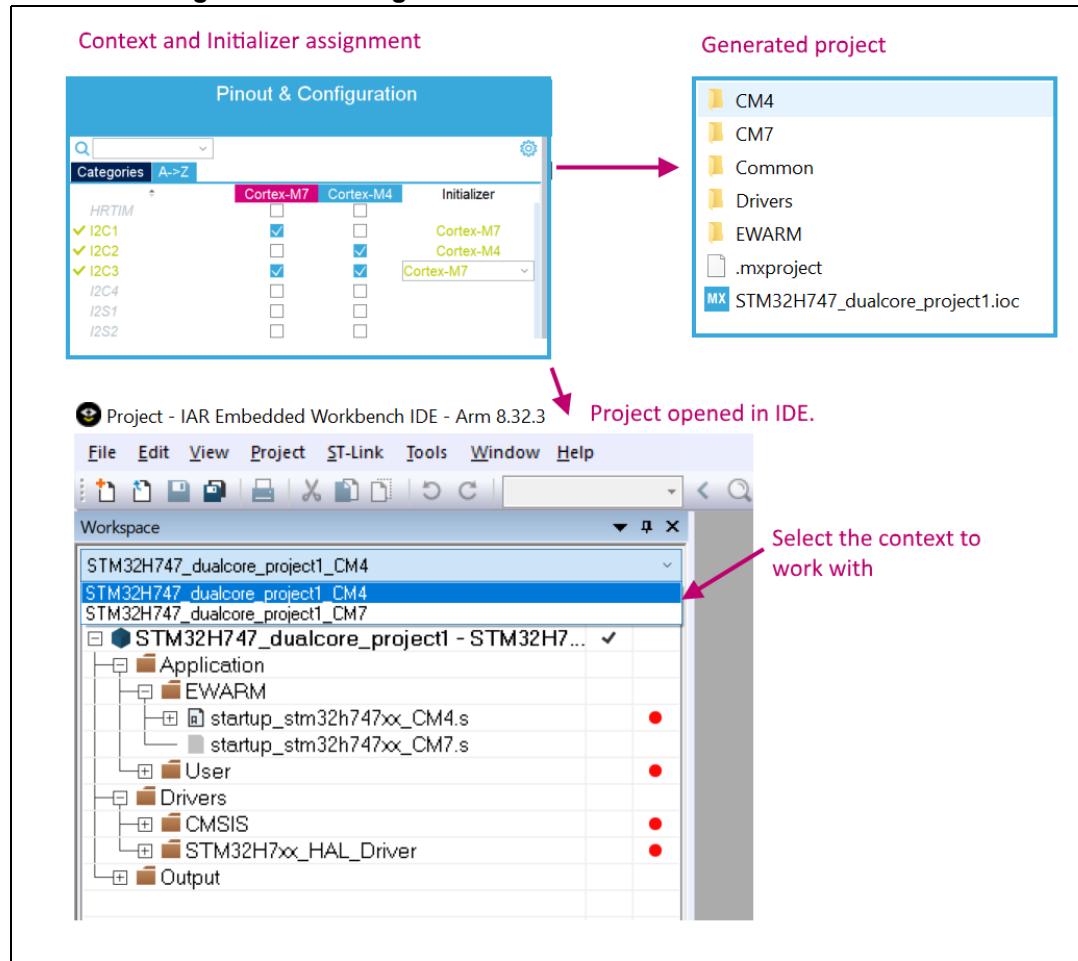


## 7

## Code generation for dual-core MCUs (STM32H7 dual-core product lines only)

For working with Arm Cortex-M dual-core products, STM32CubeMX generates code for both cores automatically according to the context assignment and initializer choices made in the user interface (see [Section 4.6: Pinout & Configuration view for STM32H7 dual-core product lines](#) for details).

**Figure 187. Code generation for STM32H7 dual-core devices**



### Generated initialization code

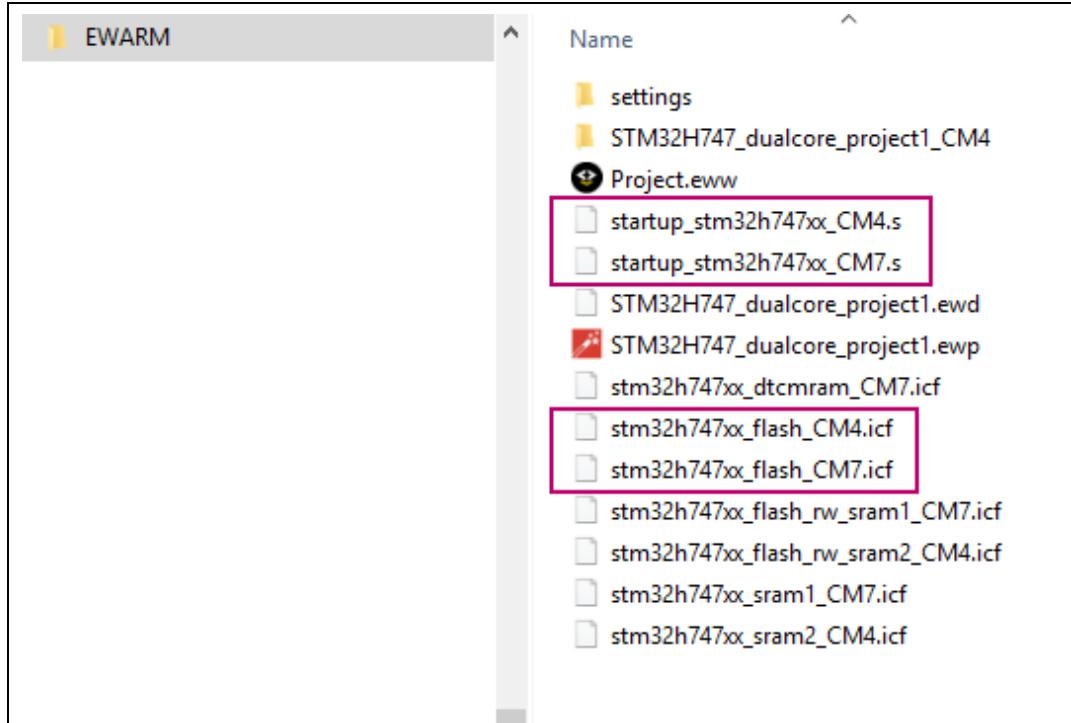
The code is generated in CM4, CM7 and Common folders. The Common folder holds the system\_stm32h7xx.c, that contains the clock tree settings.

When a peripheral or middleware is assigned to both contexts, the function MX\_<name>\_init will be generated for both contexts but will be called only from the initializer side.

### Generated startup and linker files

Each configuration (\_M4 or \_M7) of the project shall come with a startup file and a linker file, each suffixed with \_M4 or \_M7 respectively.

Figure 188. Startup and linker files for STM32H7 dual-core devices



### Generated boot mode code

STM32CubeMX supports only one mode of boot for now, where both ARM Cortex-M cores boot at once.

The other boot modes will be introduced later as a project option in the project manager view:

- Arm Cortex-M7 core booting, Arm Cortex-M4 gated
- Arm Cortex-M4 core booting, Arm Cortex-M7 gated
- A first core booting executing from flash, loads the second core code to the SRAM then enables the second core to boot.

STM32CubeMX uses template files delivered with STM32CubeH7 MCU packages as reference.

## 8 Code generation with Trustzone enabled (STM32L5 Series only)

In STM32CubeMX project manager view, all project generation options remain available.

However, the choice of toolchains is limited to the IDEs/compilers supporting the Cortex®-M33 core:

- EWARM v8.32 or higher
- MDK-ARM v5.27 or higher (ARM compiler 6)
- STM32CubeIDE (GCC v4.2 or higher)

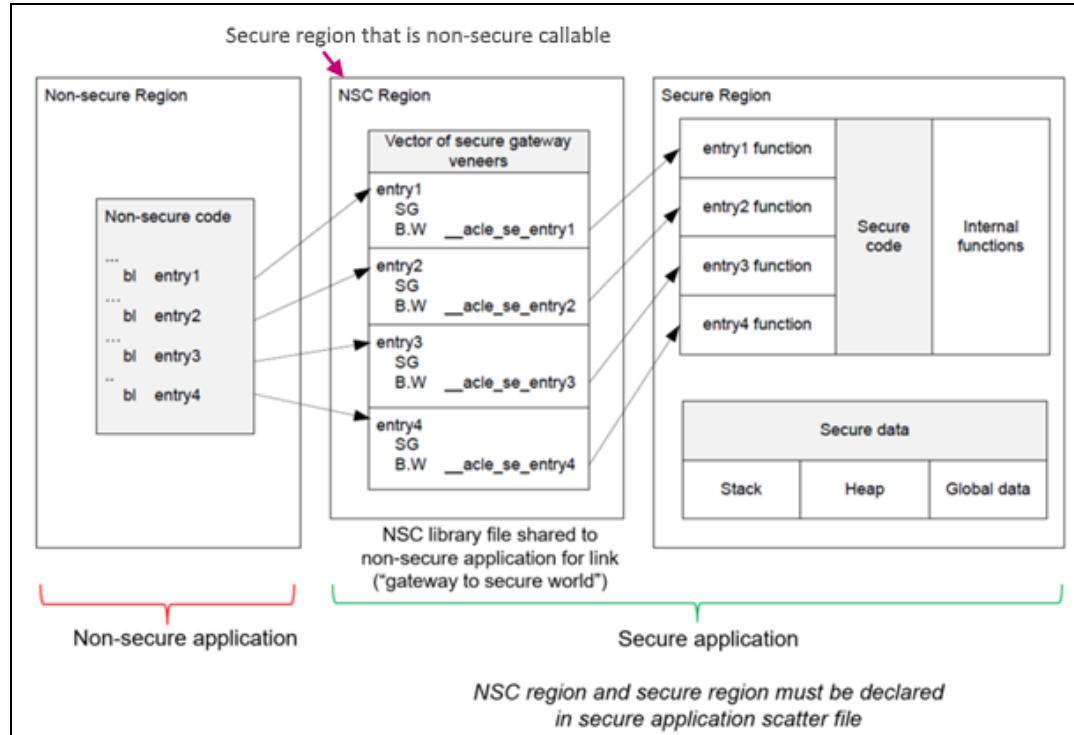
Upon product selection, STM32CubeMX requires to choose between enabling TrustZone or not.

- When TrustZone is enabled, STM32CubeMX generates two C projects: one secured and one non-secured. After compilation, two images are available for download, one for each context.
- When TrustZone is disabled, STM32CubeMX generates a non-secured C project as it is done for other products not supporting TrustZone.

### Specificities

When Trustzone is enabled, the project generation must be adjusted to ensure that secure and non-secure images can be built.

**Figure 189. ARMv8-M Trustzone overview of building secure and non-secure images**



When TrustZone is enabled for the project, STM32CubeMX generates three folders:

- NonSecure for non-secure code
- Secure for secure code
- Secure\_nsclib for non-secure callable region

See [Figure 190](#) (use TZ\_BasicStructure\_project\_inCubeIDE.png) and [Figure 191](#) (use STM32L5\_STM32CubeMX\_Project\_settings\_inCubeIDE.png).

**Figure 190. Project explorer view for STM32L5 TrustZone enabled projects**

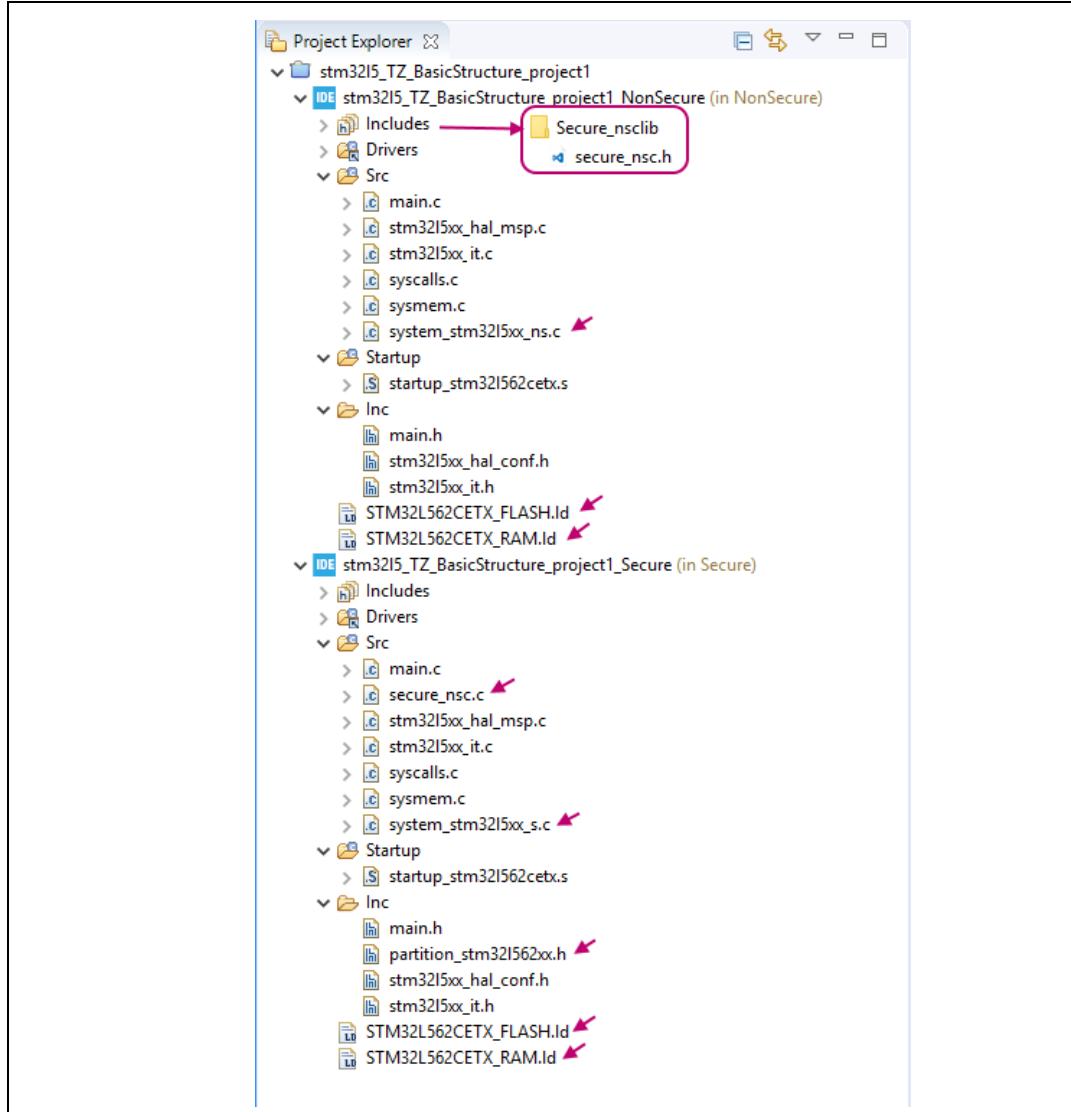
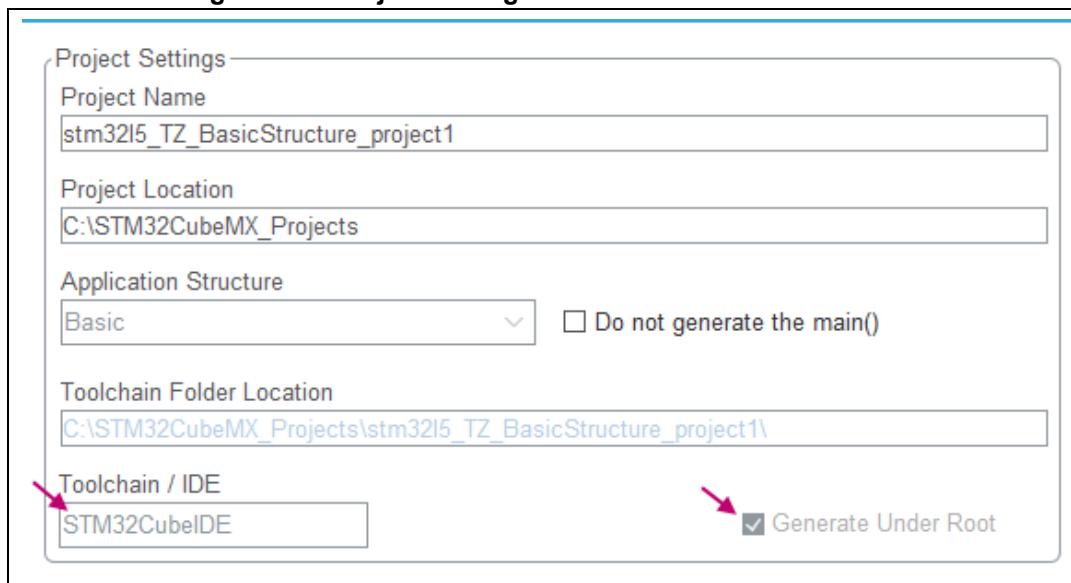


Figure 191. Project settings for STM32CubeIDE toolchain



STM32CubeMX also generates specific files, detailed in [Table 22](#).

Table 22. Files generated when TrustZone is enabled

File	Folder	Details
The product core secure/non-secure partitioning .h “template” file Example: partition_stm32l552xx.h	Secure	Initial setup for secure / non-secure zones for ARMCM33 based on CMSIS CORE V5.3.1 partition_ARMCM33.h Template. It initializes Security attribution unit (SAU) CTRL register, setup behavior of Sleep and Exception Handling, Floating Point Unit and Interrupt Target.
secure_nsclib.h file	Secure_nsclib	Must be filled by the user with the list of non-secure callable APIs. Templates are available as reference in STM32L5Cube embedded software package in Templates\TrustZone\Secure_nsclib folders.
System_stm32l5xx_s.c	Secure	CMSIS Cortex-M33 device peripheral access layer system source file to be used in secure application when the system implements security.

**Table 22. Files generated when TrustZone is enabled (continued)**

File	Folder	Details
System_stm32l5xx_ns.c	NonSecure	CMSIS Cortex-M33 device peripheral access layer system source file to be used in non-secure application when the system implements security.
STM32L562CETX_FLASH STM32L562CETX_RAM or STM32L552CETX_FLASH STM32L552CETX_RAM	Secure, NonSecure	Linker files for the secure and non-secure memory layouts. File extensions and naming conventions: – .icf (EWARM) – .sct (MDK-ARM), or – .ld (GCC compiler toolchains)

**9**

# Device tree generation (STM32MP1 Series only)

The Device tree in Linux is used to provide a way to describe non-discoverable hardware. STMicroelectronics is widely using the device tree for all the platform configuration data, including DDR configuration.

Linux developers can manually edit device tree source files (dts), but as an alternative STM32CubeMX offers a partial device-tree generation service to reduce effort and to ease new comers. STM32CubeMX intends to generate partially device trees corresponding to board level configuration. Partial means that the entire (board level) device-trees are not generated, but only main sections that usually imply huge efforts and can cause compilation errors and dysfunction:

- folders structure and files to folders distribution
- dtsi and headers inclusions
- pinCtrl and clocks generation
- System-On-Chip device nodes positioning
- multi-core related configurations (Etzpc binding, resources manager binding, peripherals assignment)

**9.1**

## Device tree overview

To run properly, any piece of software needs to get the hardware description of the platform on which it is executed, including the kind of CPU, the memory size and the pin configuration. Current Linux kernels and U-boot have put such non-discoverable hardware description in a separate binary, the device tree blob (dtb). The device tree blob is compiled from the device tree source files (dts) using the dtc compiler provided with the OpenSTLinux distribution.

The device tree structure consist of a board level file (.dts) that includes two device tree source include files (.dtsi): a soc level file and a –pinctrl file, that lists the pin muxing configurations.

The device tree structure is very close to C language multiple level structures with the “root” (/) being the highest level then “peripherals” being sub-nodes described further in the hierarchy (see figures [192](#), [193](#) and [194](#)).

STM32CubeMX generation uses widely overloading mechanisms to complete or change some SOC devices definitions when user configurations require it.

Figure 192. STM3CubeMX generated DTS – Extract 1

```

System and Board information
model = "STMicroelectronics custom STM32CubeMX board";
compatible = "st,stm32mp157c-project2-mx", "st,stm32mp157";

memory@c0000000 {
    ...
};

/* USER CODE BEGIN root */
/* USER CODE END root */ ← User customization

clocks {
    clk_lsi: clk-lsi {
        #clock-cells = <0>;
        compatible = "fixed-clock";
        clock-frequency = <32000>;
        u-boot,dm-pre-reloc;
    };
    ...
};

}; /*root*/

&pinctrl { ← Pin control configuration, including GPIO configuration
    u-boot,dm-pre-reloc;
    tim1_pins_mx: tim1_mx-0 {
        pins {
            pinmux = <STM32_PINMUX('A', 8, AF1)>, /* TIM1_CH1 */
                    <STM32_PINMUX('A', 9, AF1)>; /* TIM1_CH2 */
            bias-disable;
            drive-push-pull;
            slew-rate = <0>;
        };
    };
};

```

Figure 193. STM3CubeMX generated DTS – Extract 2

```

&m4_rproc{ ← Multi-core management
    recovery;

    m4_system_resources{
        status = "okay";

        /* USER CODE BEGIN m4_system_resources */
        /* USER CODE END m4_system_resources */
    };

    status = "okay";

    /* USER CODE BEGIN m4_rproc */
    /* USER CODE END m4_rproc */
};

&m4_timers1{ ← Peripheral assignment to Cortex-M4 run time context
    pinctrl-names = "rproc_default", "rproc_sleep";
    pinctrl-0 = <&tim1_pins_mx>;
    pinctrl-1 = <&tim1_sleep_pins_mx>;
    status = "okay";

    /* USER CODE BEGIN m4_timers1 */
    /* USER CODE END m4_timers1 */
};

```

**Figure 194. STM32CubeMX generated DTS – Extract 3**

```
&timers2{                                Peripheral node structure with
    status = "okay";                      PinCtrl configuration
                                            Status configuration
                                            User customization

    /* USER CODE BEGIN timers2 */          /* USER CODE BEGIN timers2 */
    /* USER CODE END timers2 */            /* USER CODE END timers2 */

    pinctrl{                                /* USER CODE BEGIN pinctrl */
        pinctrl-names = "default", "sleep";
        pinctrl-0 = <&tim2_pwm_pins_mx>;
        pinctrl-1 = <&tim2_pwm_sleep_pins_mx>;
        status = "okay";
    };
};

/* USER CODE BEGIN dts_addons */          /* USER CODE BEGIN dts_addons */
/* USER CODE END dts_addons */            /* USER CODE END dts_addons */
```

For more details refer to “Device Tree for Dummies” from Thomas Petazzoni, available on <https://elinux.org>.

For more information about STM32MP1 Series device tree specificities, refer to ST Wiki <https://wiki.st.com/stm32mpu>.

## 9.2 STM32CubeMX Device tree generation

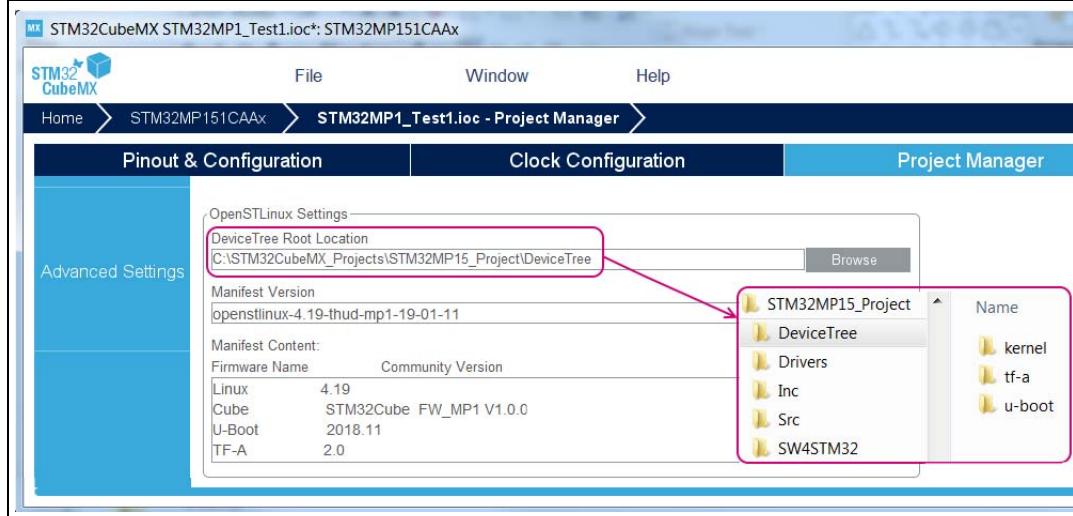
For STM32MP1 Series, STM32CubeMX code generation feature has been extended to generate Device trees (DT) targeting the supported firmware:

- a single DT for configuring both TF-A and SP\_min
- a DT for configuring U-Boot
- a DT for configuring Linux kernel

DTS generation is accessible through the same **GENERATE CODE** button.

The DT generation path can be configured from the Project Manager view, in the Advanced Settings tab, under OpenSTLinux Settings (see [Figure 195](#)). For each Device tree STM32CubeMX generates Device tree source (DTS) files.

**Figure 195. Project settings for configuring Device tree path**



The Device tree structure consists of:

- a complete clock-tree
- a complete pin control
- a complete multi-cores references definition
- a set of device nodes and sub-nodes
- user sections that can be filled to have complete and bootable Device trees (contents will not be lost at next generation).

The generated DTS files reflect the user configuration, such as the assignment of peripherals to runtime contexts and boot loaders, or clock tree settings.

STM32CubeMX DT generation ensures the coherency between the different DTs. Additionally, it generates the DDR configuration file as a part of the TF-A and U-Boot Device trees.

These files along with the files they include will be compiled to create the device tree blob for the targeted firmware.

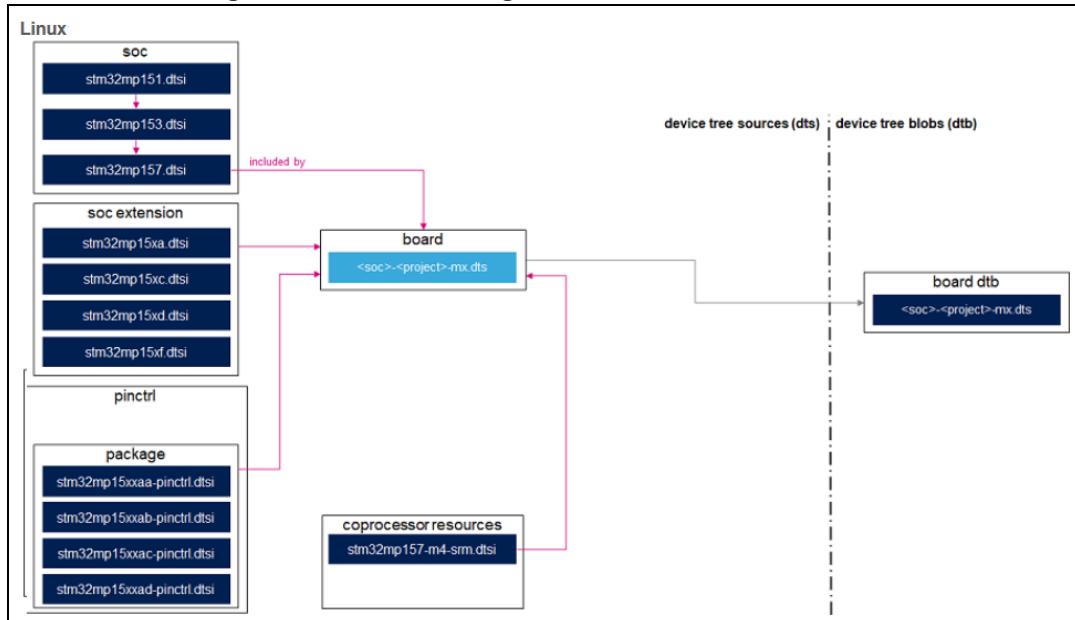
### 9.2.1

### Device tree generation for Linux kernel

STM32CubeMX only generates the “board” file for Linux. This file includes the “soc” file and the “pinctrl” file corresponding to the selected package.

The device tree nodes generated by STM32CubeMX can be completed by filling the user sections, following the device tree bindings available in the Linux kernel source code Documentation/devicetree/bindings/ folder.

Figure 196. Device tree generation for the Linux kernel

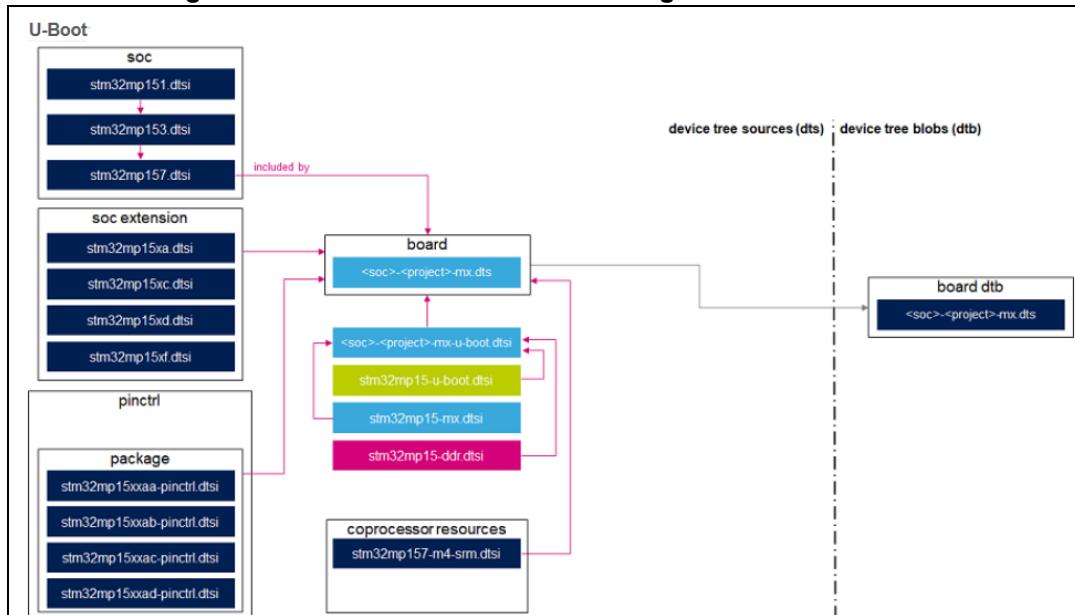


## 9.2.2 Device tree generation for U-boot

STM32CubeMX makes a copy of Linux dts file for U-Boot and completes it with two new files: one for the “ddr” configuration and one for U-Boot add-ons, mainly consisting in using the “u-boot,dm-pre-reloc” property whenever needed.

The device tree nodes generated by STM32CubeMX can be completed by filling the user sections, following the device tree bindings available in U-Boot source code Documentation/devicetree/bindings/ folder.

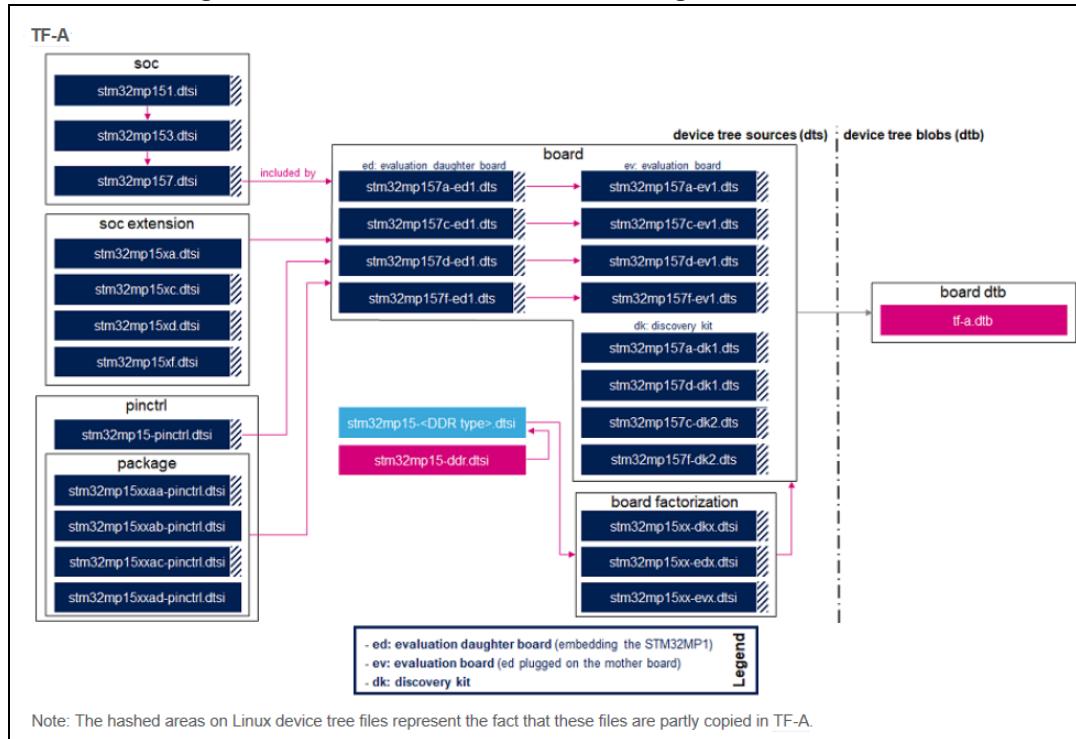
Figure 197. STM32CubeMX Device tree generation for U-boot



### 9.2.3 Device tree generation for TF-A

To save space, STM32CubeMX generates a “board” dts file for TF-A that is a lighter version of the Linux “board” dts file. This file includes the already lighter dtssi files versions on “soc” and “pinctrl” sides, coming with TF-A. The same “ddr” configuration file generated for U-Boot is reused for TF-A.

**Figure 198. STM32CubeMX Device tree generation for TF-A**



The device tree nodes generated by STM32CubeMX can be completed by filling the user sections, following the device tree bindings available in TF-A source code docs/devicetree/bindings/ folder.

## 10 Support of additional software components using CMSIS-Pack standard

The CMSIS-Pack standard describes a delivery mechanism for software components, device parameters, and evaluation board support.

The XML-based package description (pdsc) file describes the content of a software pack (file collection). It includes source code, header files, software libraries, documentation and source code templates. A software pack consists of the complete file collection along with the pdsc file, shipped in ZIP-format. After installing a software pack, all the included software components are available to the development tools.

A software component is a collection of source modules, header and configuration files as well as libraries. Packs containing software components can also include example projects and user code templates.

Refer to <http://www.keil.com> website for more details.

STM32CubeMX supports third-party and other STMicroelectronics embedded software solutions, delivered as software packs. STM32CubeMX enables to:

1. Install software packs and check for updates (see [Section 3.4.4](#)).
2. Select software components for the current project (see [Section 4.13](#)). Once this is done, the selected components appear in the tree view (see [Figure 199](#)).
3. Enable the software component from the tree view (see [Figure 200](#)). Use contextual help to get more details on the selection.
4. Configure software components (see [Figure 200](#)). This function is possible only for components coming with files in STM32CubeMX proprietary format.
5. Generate the C project for selected toolchains (see [Figure 201](#)).
  - a) Software components files are automatically copied to the project.
  - b) Software component configuration and initialization code are automatically generated. This function is possible only for components coming with files in STM32CubeMX proprietary format.

**Figure 199. Selecting a CMSIS-Pack software component**

Packs	Pack / Bundle / Component	Version	Selection
STMicroelectronics.X-CUBE-BLE1		4.4.0	
Wireless_Application			SensorDemo
Application			
Wireless_BlueNRG-MS			
Controller			<input checked="" type="checkbox"/>
HCl_TL			Basic
HCl_TL_INTERFACE			UserBoard
Utils			<input checked="" type="checkbox"/>

Figure 200. Enabling and configuring a CMSIS-Pack software component

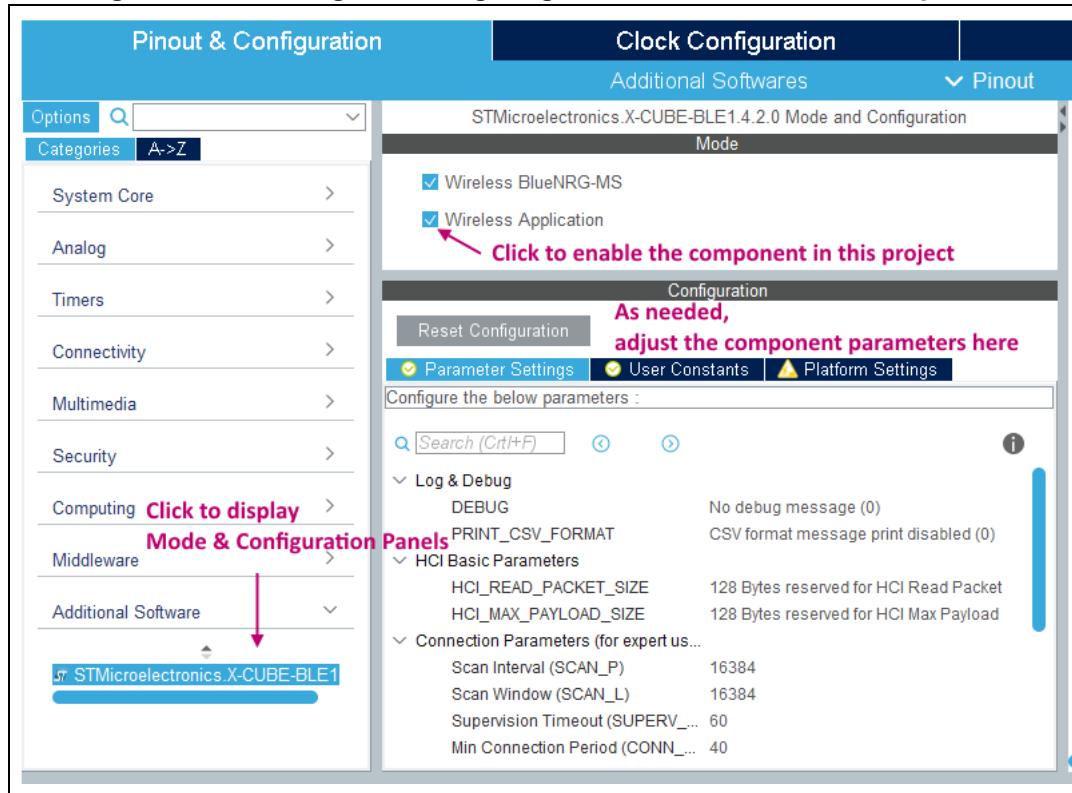
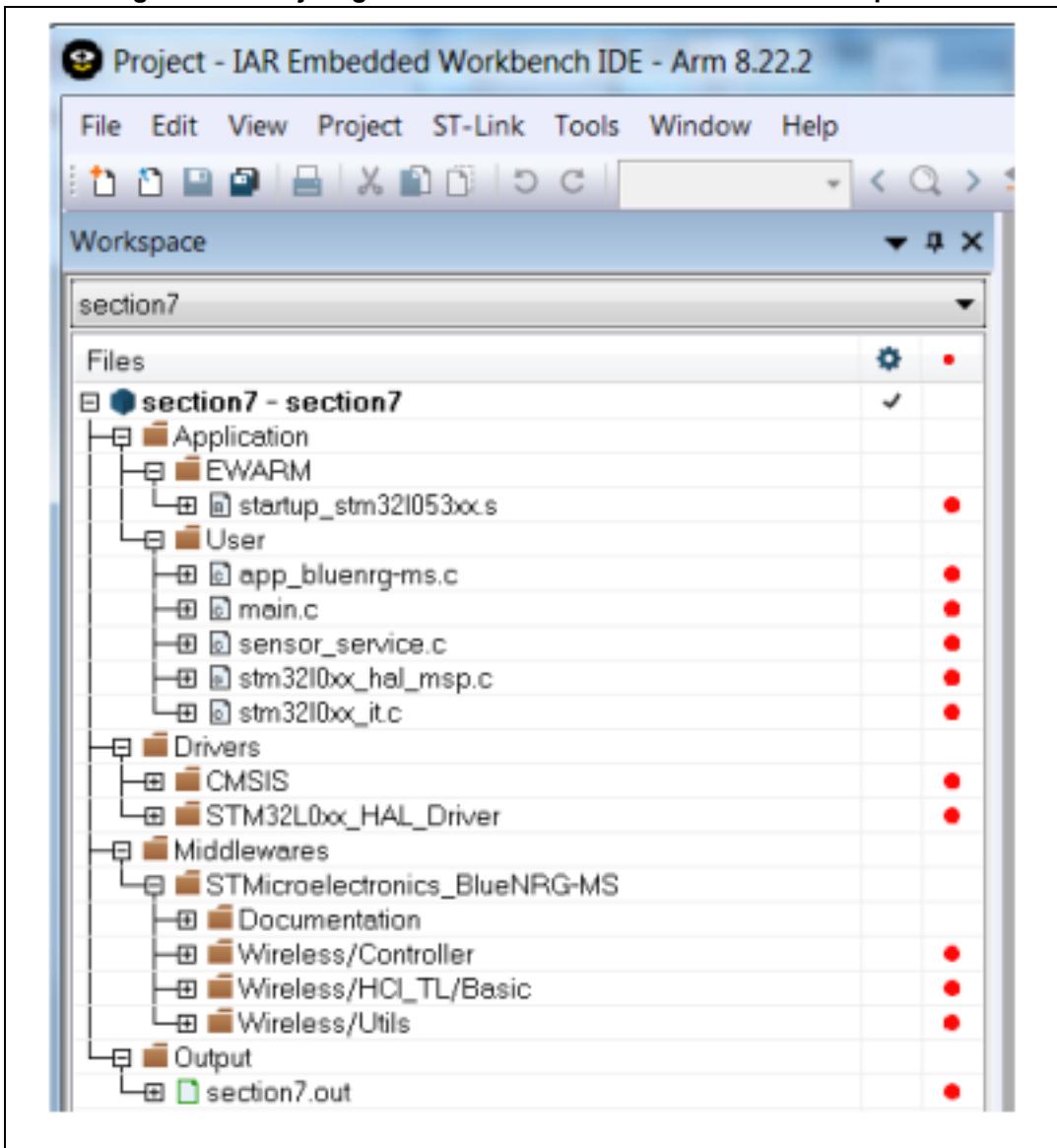


Figure 201. Project generated with CMSIS-Pack software component



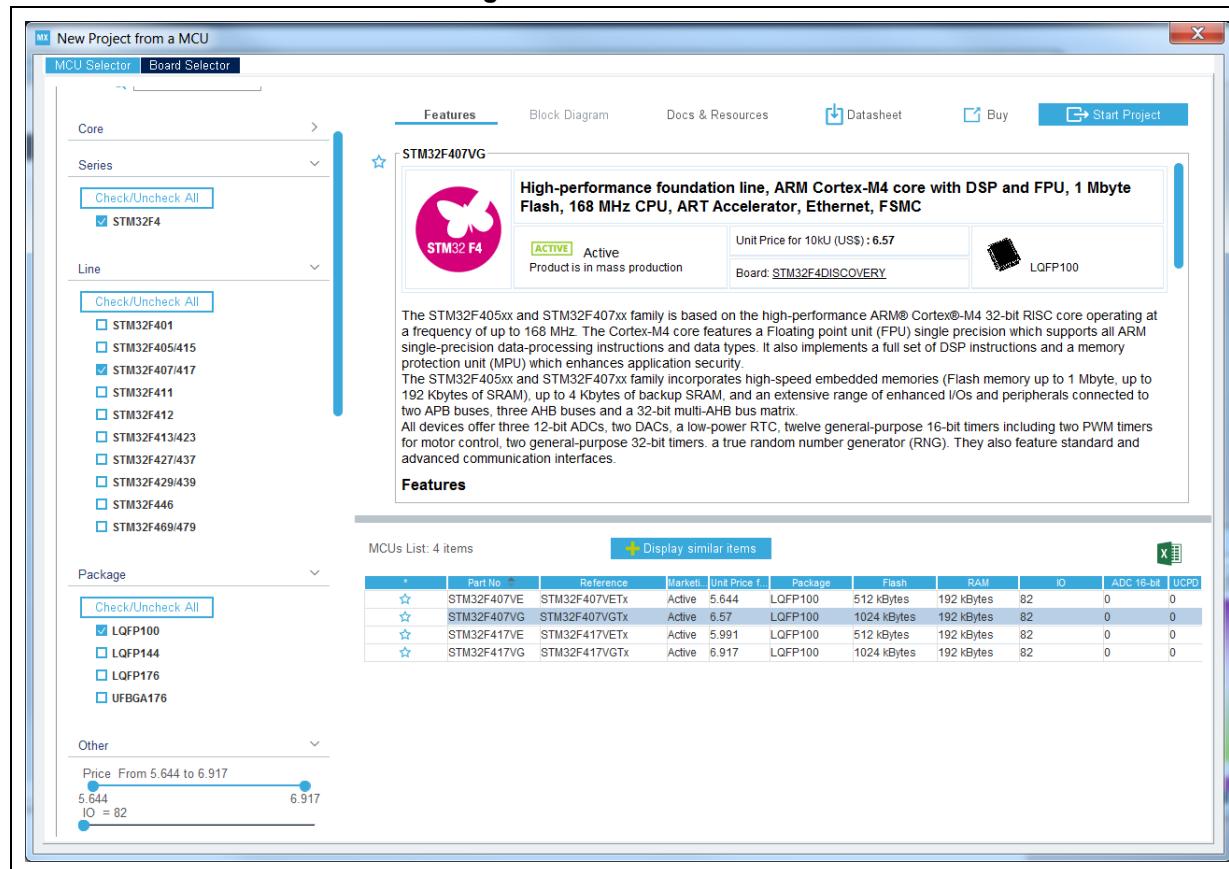
## 11 Tutorial 1: From pinout to project C code generation using an MCU of the STM32F4 Series

This section describes the configuration and C code generation process. It takes as an example a simple LED toggling application running on the STM32F4DISCOVERY board.

### 11.1 Creating a new STM3CubeMX Project

1. Select **File > New project** from the main menu bar or **New project** from the Home page.
2. Select the **MCU Selector** tab and filter down the STM32 portfolio by selecting STM32F4 as 'Series', STM32F407 as 'Lines', and LQFP100 as 'Package' (see [Figure 202](#)).
3. Select the STM32F407VGTx from the MCU list and click **OK**.

**Figure 202. MCU selection**



STM3CubeMX views are then populated with the selected MCU database ([Figure 203](#)). Optionally, remove the MCUs Selection bottom window by deselecting **Window> Outputs** submenu (see [Figure 204](#)).

Figure 203. Pinout view with MCUs selection

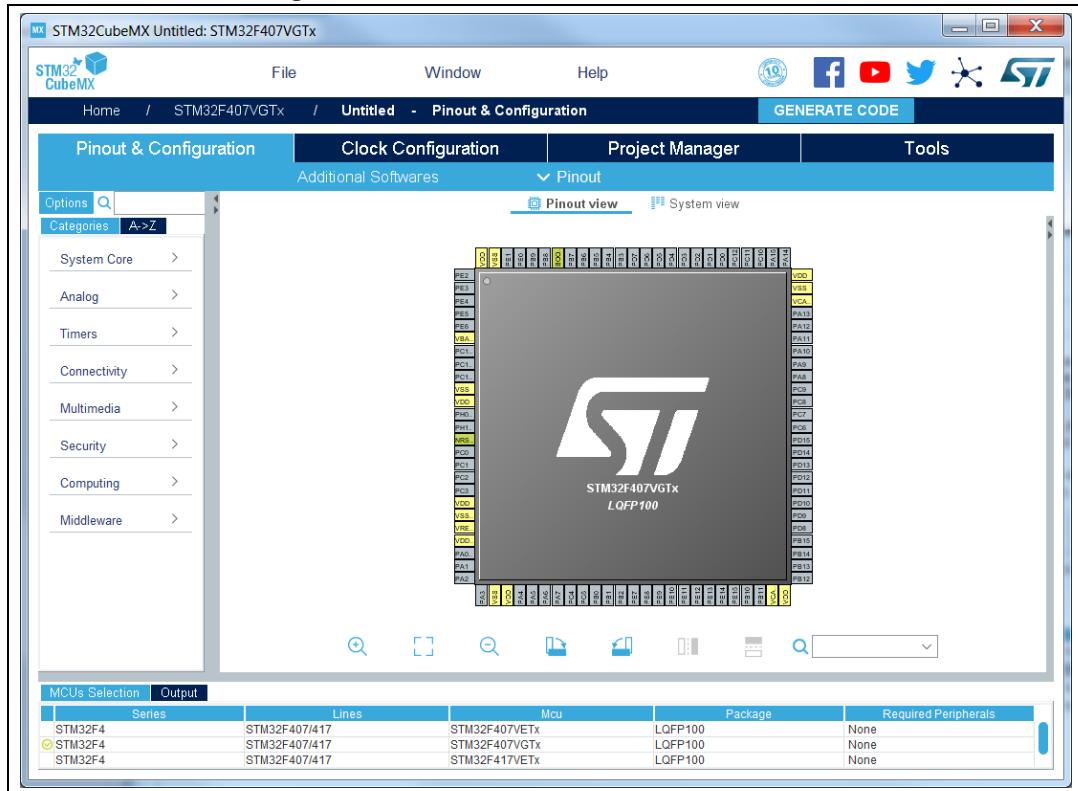
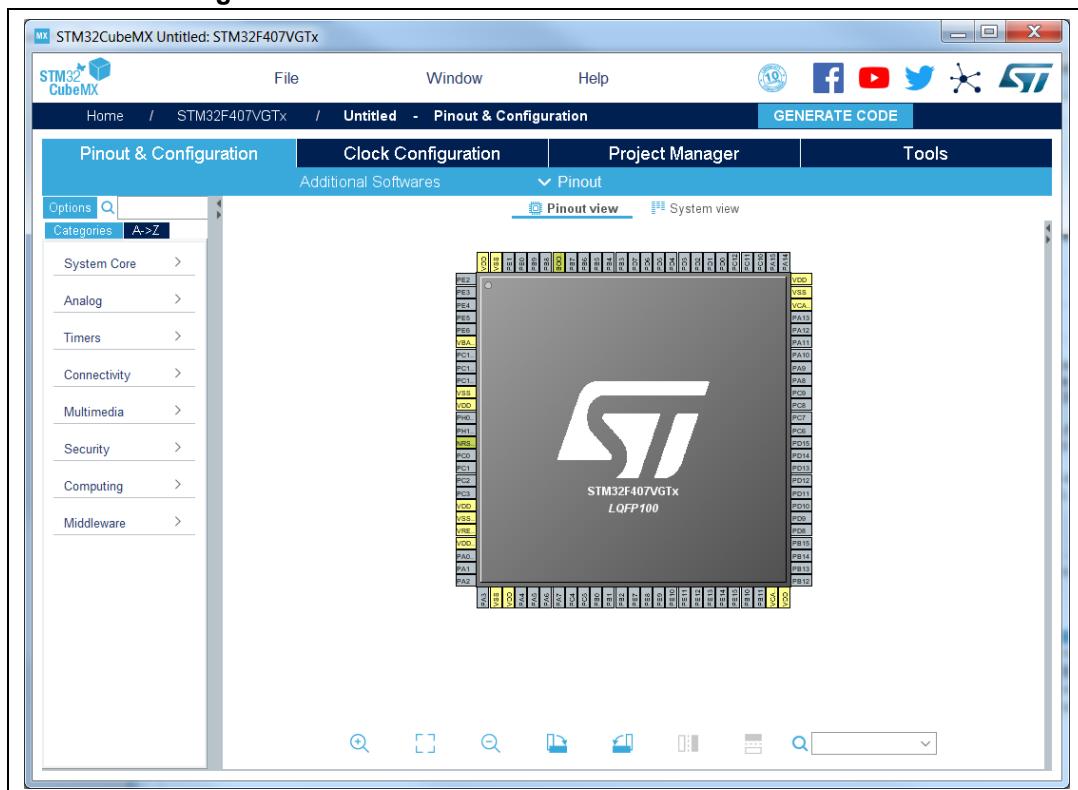


Figure 204. Pinout view without MCUs selection window



## 11.2 Configuring the MCU pinout

For a detailed description of menus, advanced actions and conflict resolutions, refer to [Section 4](#) and [Appendix A](#).

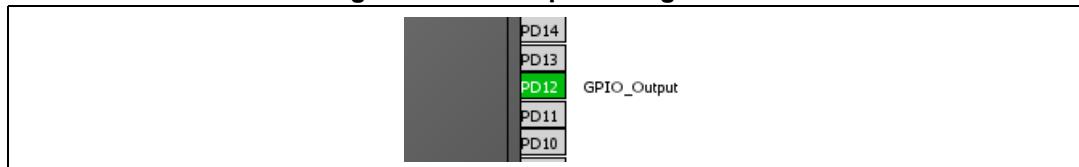
1. By default, STM32CubeMX shows the **Pinout** view.
2. By default,  [Keep Current Signals Placement](#) is unchecked allowing STM32CubeMX to move the peripheral functions around and to find the optimal pin allocation, that is the one that accommodates the maximum number of peripheral modes.

Since the MCU pin configurations must match the STM32F4DISCOVERY board, enable  [Keep Current Signals Placement](#) for STM32CubeMX to maintain the peripheral function allocation (mapping) to a given pin.

This setting is saved as a user preference in order to be restored when reopening the tool or when loading another project.

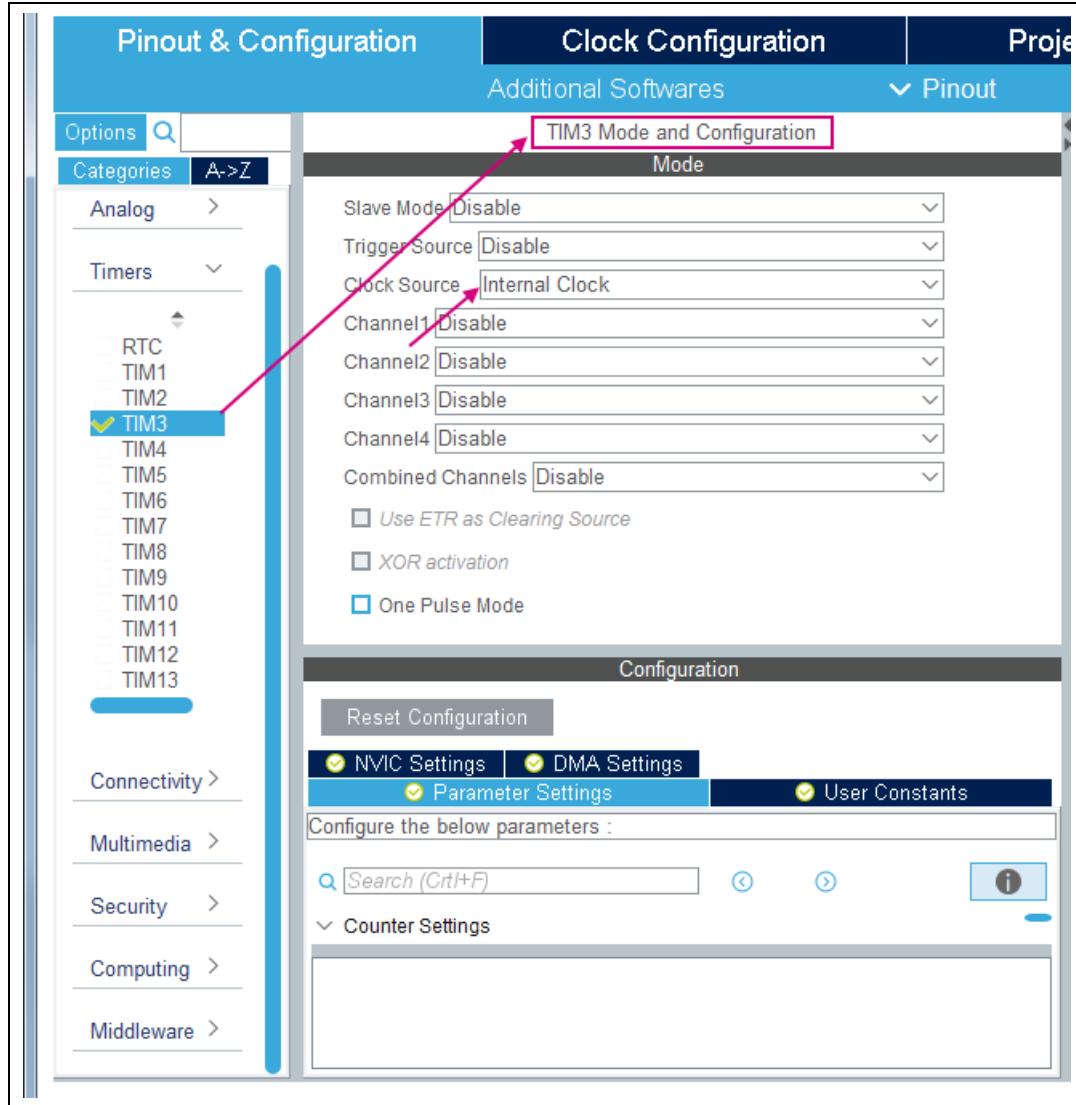
3. Select the required peripherals and peripheral modes:
  - a) Configure the GPIO to output the signal on the STM32F4DISCOVERY green LED by right-clicking PD12 from the **Pinout** view, then select **GPIO\_Output**:

**Figure 205. GPIO pin configuration**



- b) Enable a timer to be used as timebase for toggling the LED. This is done by selecting Internal Clock as TIM3 clock source from the peripheral tree (see [Figure 206](#)).

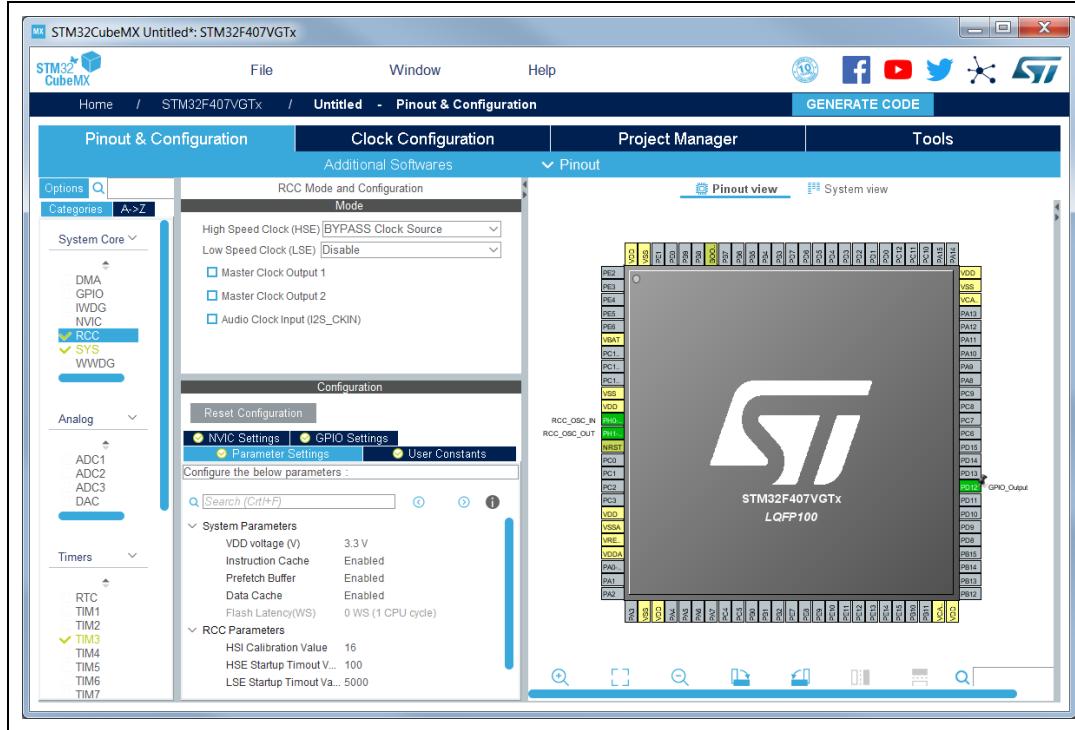
Figure 206. Timer configuration



## Tutorial 1: From pinout to project C code generation using an MCU of the STM32F4 Series

- c) You can also configure the RCC to use an external oscillator as potential clock source (see [Figure 207](#)).

**Figure 207. Simple pinout configuration**



This completes the pinout configuration for this example.

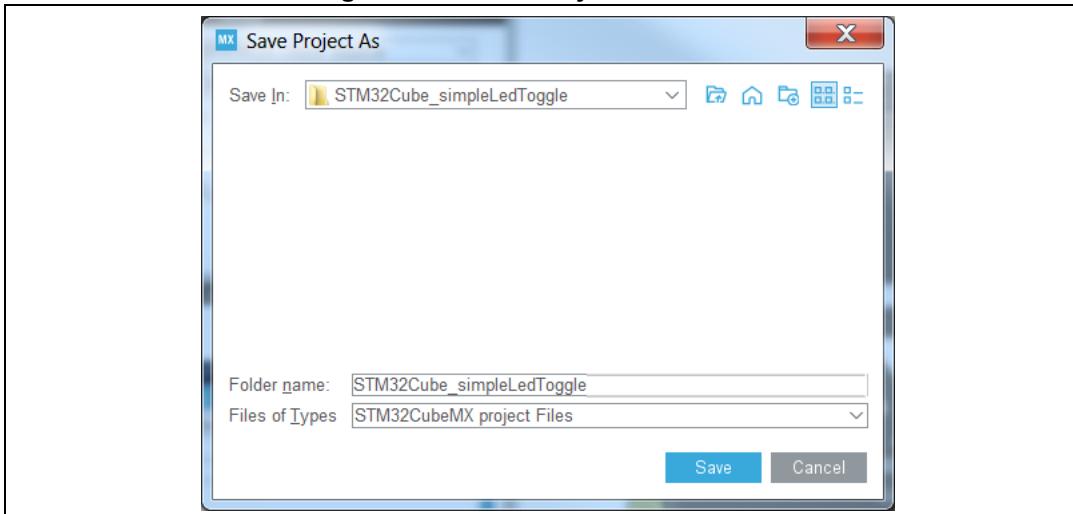
**Note:** Starting with STM32CubeMX 4.2, the user can skip the pinout configuration by directly loading ST Discovery board configuration from the **Board selector** tab.

## 11.3 Saving the project

1. Click  to save the project.

When saving for the first time, select a destination folder and filename for the project. The .ioc extension is added automatically to indicate this is an STM32CubeMX configuration file.

Figure 208. Save Project As window



2. Click  to save the project under a different name or location.

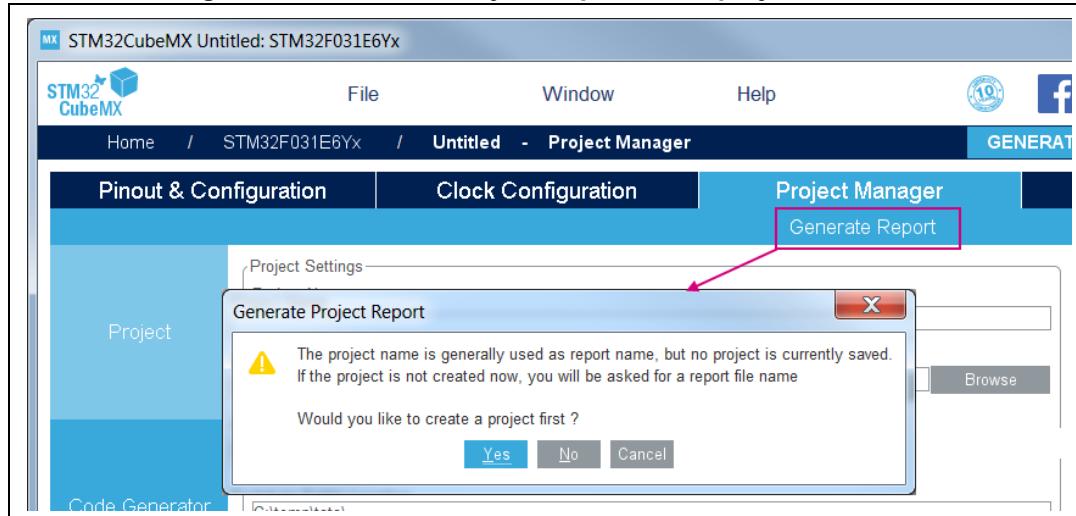
## 11.4 Generating the report

Reports can be generated at any time during the configuration:

1. Click  to generate .pdf and .txt reports.

If a project file has not been created yet, a warning prompts the user to save the project first and requests a project name and a destination folder (see [Figure 209](#)). An .ioc file is then generated for the project along with a .pdf and .txt reports with the same name.

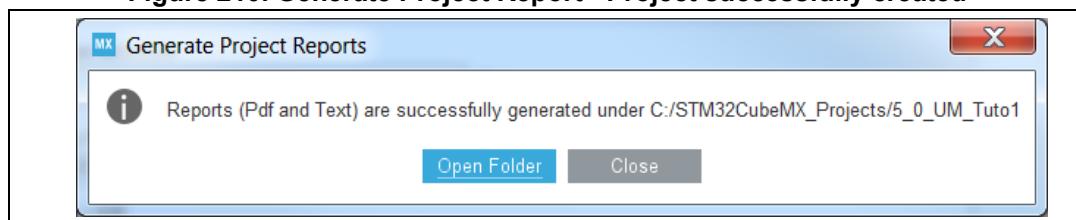
**Figure 209. Generate Project Report - New project creation**



Answering **No** will require to provide a name and location for the report only.

As shown in [Figure 210](#), a confirmation message is displayed when the operation is successful.

**Figure 210. Generate Project Report - Project successfully created**



2. Open the .pdf report using Adobe Reader or the .txt report using your favorite text editor. The reports summarize all the settings and MCU configuration performed for the project.

## 11.5 Configuring the MCU clock tree

The following sequence describes how to configure the clocks required by the application based on an STM32F4 MCU.

STM32CubeMX automatically generates the system, CPU and AHB/APB bus frequencies from the clock sources and prescalers selected by the user. Wrong settings are detected

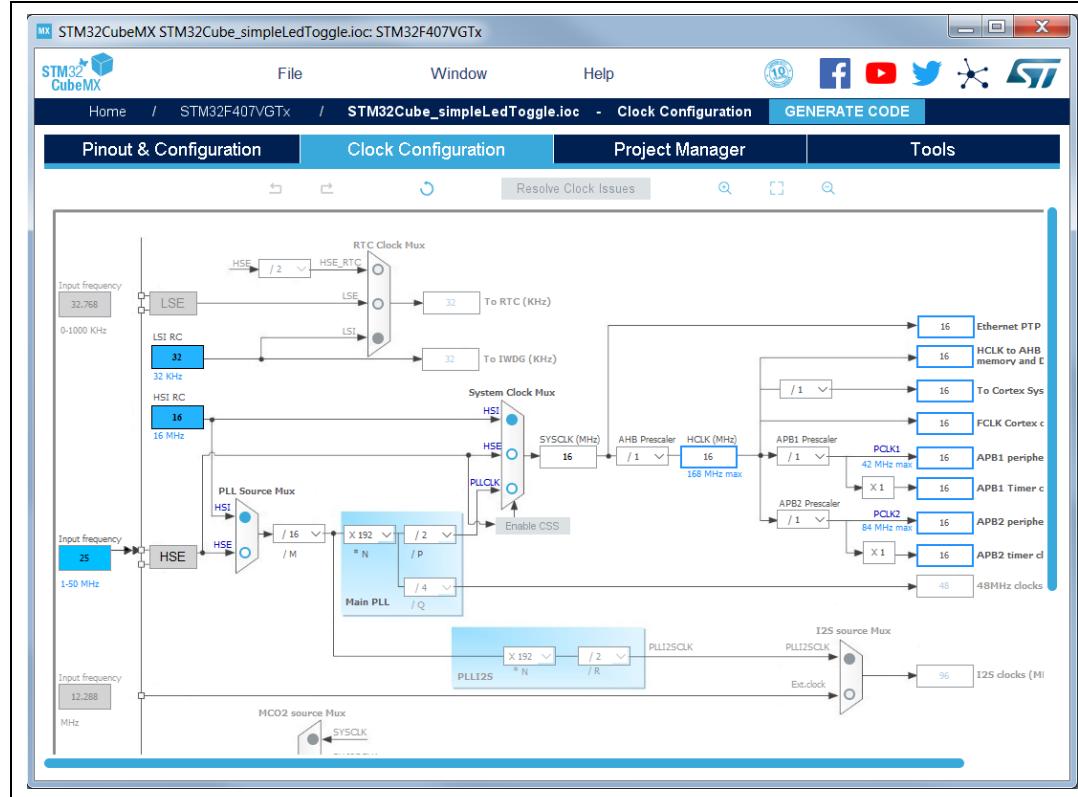
and highlighted in fuchsia through a dynamic validation of minimum and maximum conditions. Useful tooltips provide a detailed description of the actions to undertake when the settings are unavailable or wrong. User frequency selection can influence some peripheral parameters (e.g. UART baud rate limitation).

STM32CubeMX uses the clock settings defined in the Clock tree view to generate the initialization C code for each peripheral clock. Clock settings are performed in the generated C code as part of RCC initialization within the project main.c and in stm32f4xx\_hal\_conf.h (HSE, HSI and external clock values expressed in Hertz).

Follow the sequence below to configure the MCU clock tree:

1. Click the **Clock Configuration** tab to display the clock tree (see [Figure 211](#)).
- The internal (HSI, LSI), system (SYSCLK) and peripheral clock frequency fields cannot be edited. The system and peripheral clocks can be adjusted by selecting a clock source, and optionally by using the PLL, prescalers and multipliers.

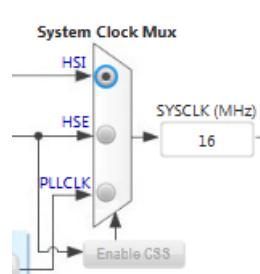
**Figure 211. Clock tree view**



- First select the clock source (HSE, HSI or PLLCLK) that will drive the system clock of the microcontroller.

In the example taken for the tutorial, select HSI to use the internal 16 MHz clock (see *Figure 212*).

**Figure 212. HSI clock enabled**



To use an external clock source (HSE or LSE), the RCC peripheral shall be configured in the **Pinout** view since pins will be used to connect the external clock crystals (see *Figure 213*).

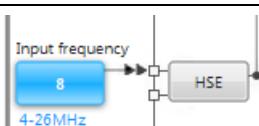
**Figure 213. HSE clock source disabled**



Other clock configuration options for the STM32F4DISCOVERY board:

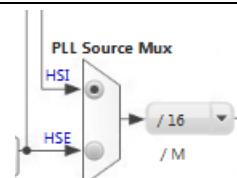
- Select the external HSE source and enter 8 in the HSE input frequency box since an 8 MHz crystal is connected on the discovery board:

**Figure 214. HSE clock source enabled**



- Select the external PLL clock source and the HSI or HSE as the PLL input clock source.

**Figure 215. External PLL clock source enabled**



3. Keep the core and peripheral clocks to 16 MHz using HSI, no PLL and no prescaling.

**Note:** *Optionally, further adjust the system and peripheral clocks using PLL, prescalers and multipliers:*

*Other clock sources independent from the system clock can be configured as follows:*

- *USB OTG FS, Random Number Generator and SDIO clocks are driven by an independent output of the PLL.*
  - *I2S peripherals come with their own internal clock (PLLI2S), alternatively derived by an independent external clock source.*
  - *USB OTG HS and Ethernet Clocks are derived from an external source.*
4. Optionally, configure the prescaler for the Microcontroller Clock Output (MCO) pins that allow to output two clocks to the external circuit.
  5. Click  to save the project.
  6. Go to the **Configuration** tab to proceed with the project configuration.

## 11.6 Configuring the MCU initialization parameters

**Caution:** The C code generated by STM32CubeMX covers the initialization of the MCU peripherals and middlewares using the STM32Cube firmware libraries.

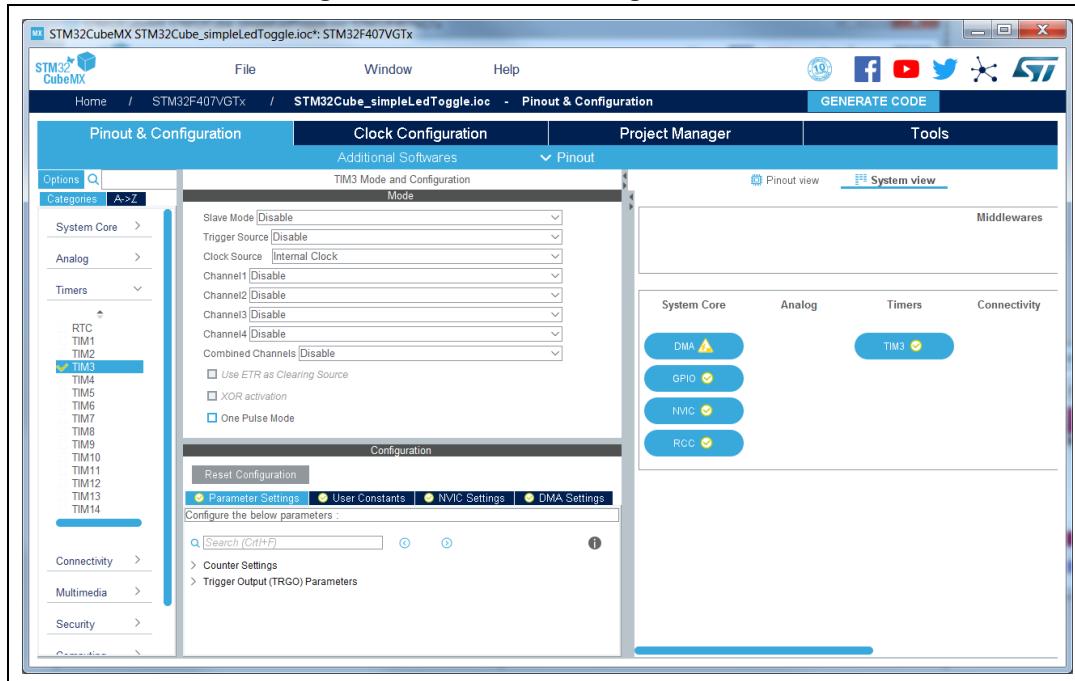
### 11.6.1 Initial conditions

From the **Pinout & Configuration** tab, select and configure (one by one) every component (peripheral, middleware, additional software) required by the application using the **Mode** and **Configuration** panels (see [Figure 216](#)).

Tooltips and warning messages are displayed when peripherals are not properly configured (see [Section 4: STM32CubeMX user interface](#) for details).

**Note:** *The RCC peripheral initialization will use the parameter configuration done in this view as well as the configuration done in the Clock tree view (clock source, frequencies, prescaler values, etc...).*

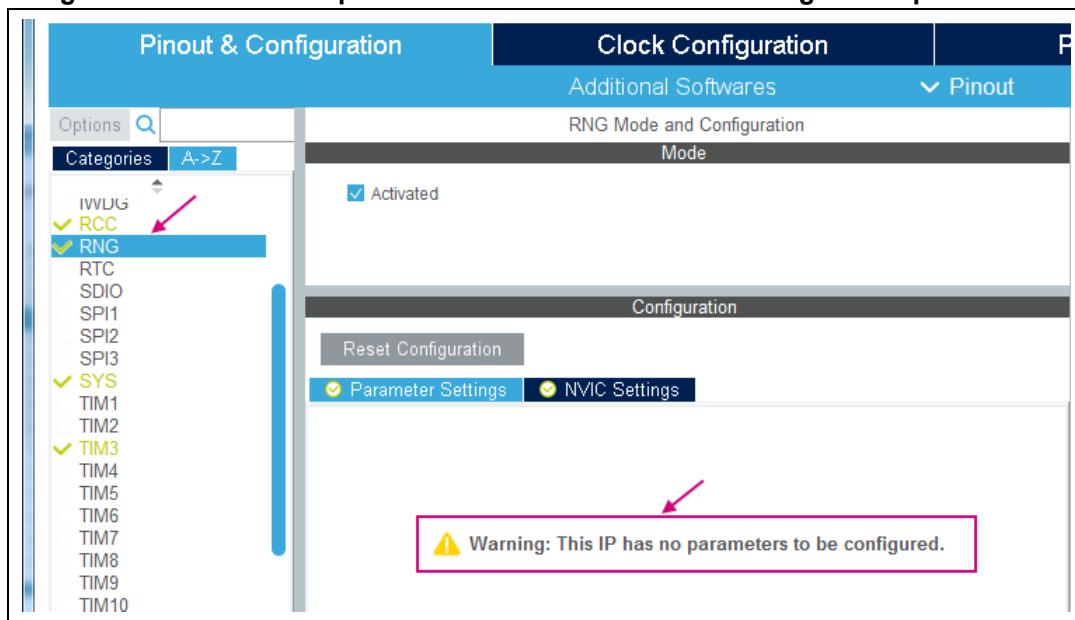
Figure 216. Pinout & Configuration view



## 11.6.2 Configuring the peripherals

Each peripheral instance corresponds to a dedicated button in the main panel. Some peripheral modes have no configurable parameters, as illustrated below.

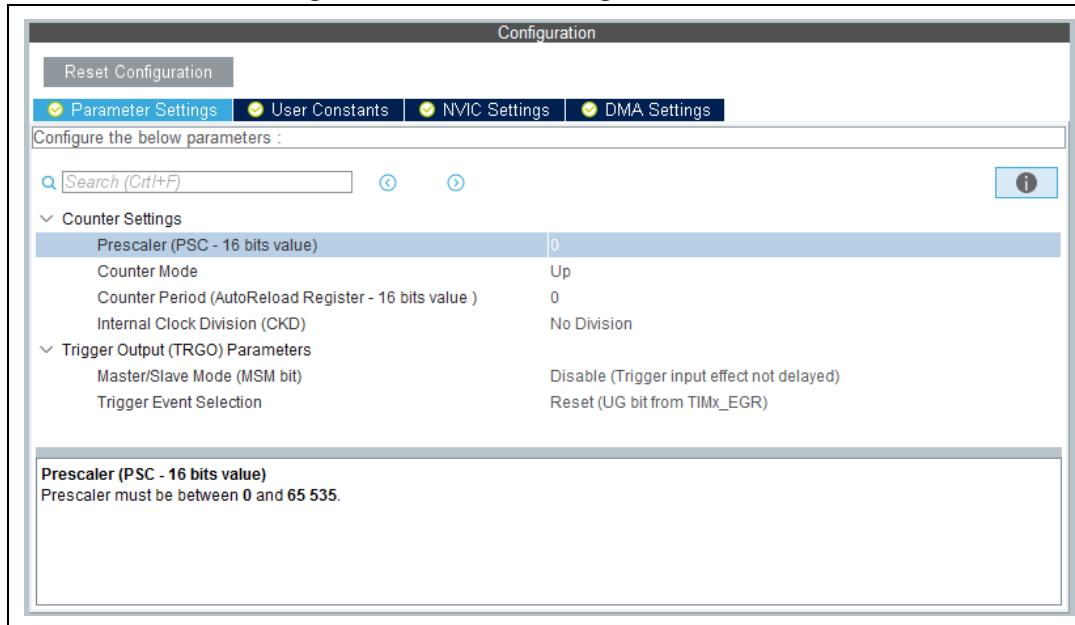
Figure 217. Case of Peripheral and Middleware without configuration parameters



Follow the steps below to proceed with peripheral configuration:

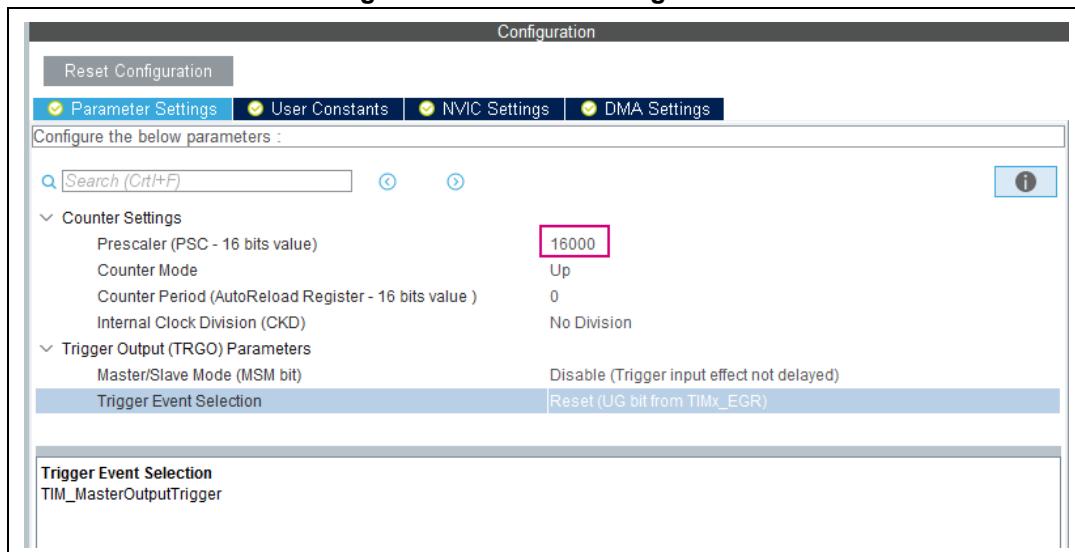
1. Click the peripheral button to open the corresponding configuration window.  
In our example  
a) click **TIM3** to open the timer configuration window.

**Figure 218. Timer 3 configuration window**



- b) with a 16 MHz APB clock (Clock tree view), set the prescaler to 16000 and the counter period to 1000 to make the LED blink every millisecond.

**Figure 219. Timer 3 configuration**

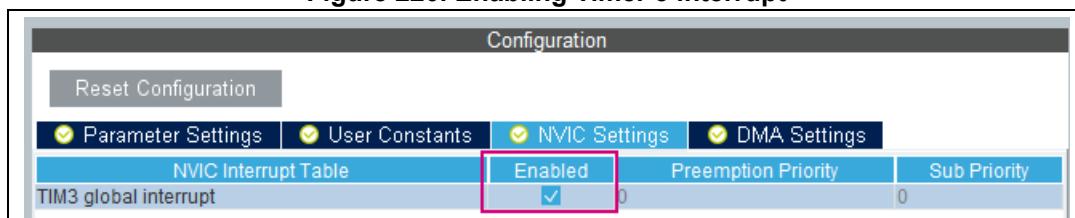


2. Optionally, and when available, select:
  - The **NVIC Settings** tab to display the NVIC configuration and enable interruptions for this peripheral.
  - The **DMA Settings** tab to display the DMA configuration and to configure DMA transfers for this peripheral.

In the tutorial example, the DMA is not used and the GPIO settings remain unchanged. The interrupt is enabled, as shown in [Figure 220](#).

  - The **GPIO Settings** tab to display the GPIO configuration and to configure the GPIOs for this peripheral.
  - Insert an item:
  - The **User Constants** tab to specify constants to be used in the project.

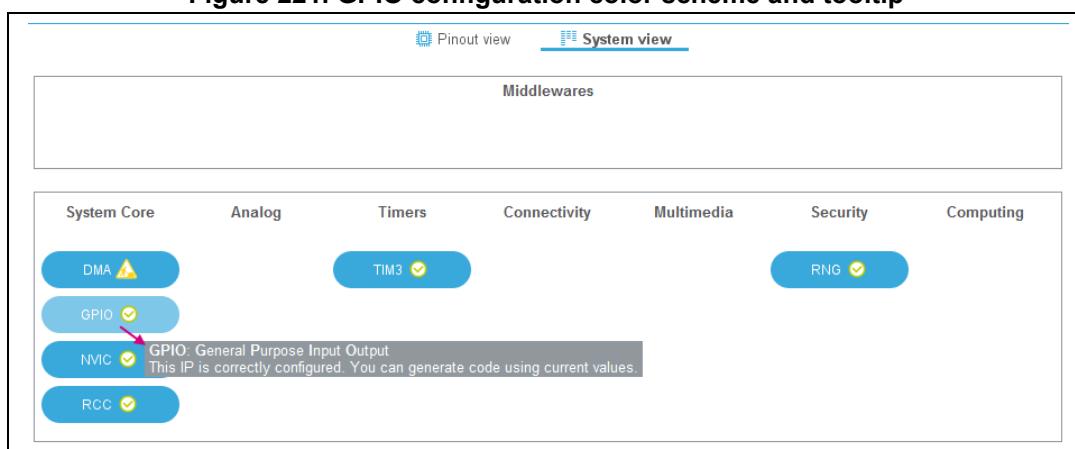
**Figure 220. Enabling Timer 3 interrupt**



### 11.6.3 Configuring the GPIOs

The user can adjust all pin configurations from this window. A small icon along with a tooltip indicates the configuration status.

**Figure 221. GPIO configuration color scheme and tooltip**

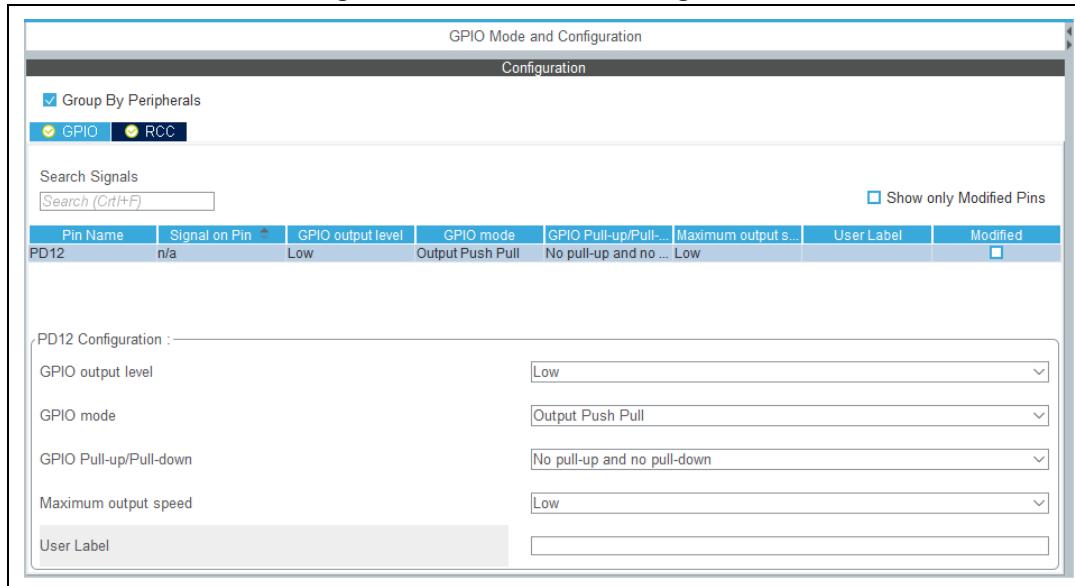


Follow the sequence below to configure the GPIOs:

1. Click the **GPIO** button in the Configuration view to open the **Pin Configuration** window below.
2. The first tab shows the pins that have been assigned a GPIO mode but not for a dedicated peripheral and middleware. Select a Pin Name to open the configuration for that pin.

In the tutorial example, select PD12 and configure it in output push-pull mode to drive the STM32F4DISCOVERY LED (see *Figure 222*).

**Figure 222. GPIO mode configuration**



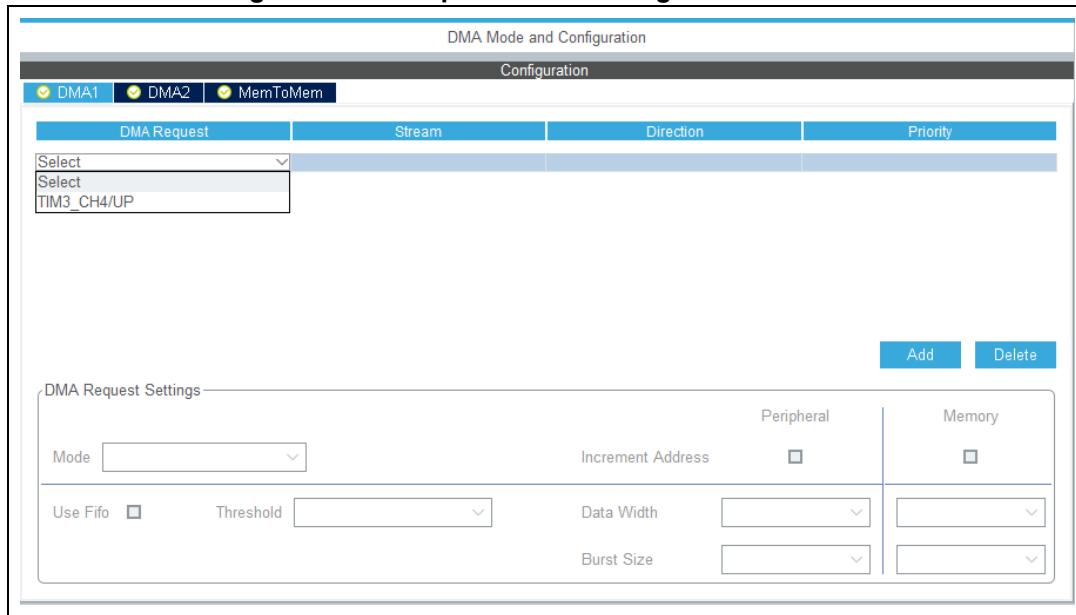
#### 11.6.4 Configuring the DMAs

This is not required for this example. It is recommended to use DMA transfers to offload the CPU. The DMA Configuration window provides a fast and easy way to configure the DMAs (see [Figure 223](#)):

1. add a new DMA request and select among a list of possible configurations.
2. select among the available streams.
3. select the Direction: Memory to Peripheral or Peripheral to Memory.
4. select a Priority.
5. enable the FIFO.

**Note:** *Configuring the DMA for a given peripheral and middleware can also be performed using the Peripheral and Middleware configuration window.*

**Figure 223. DMA parameters configuration window**

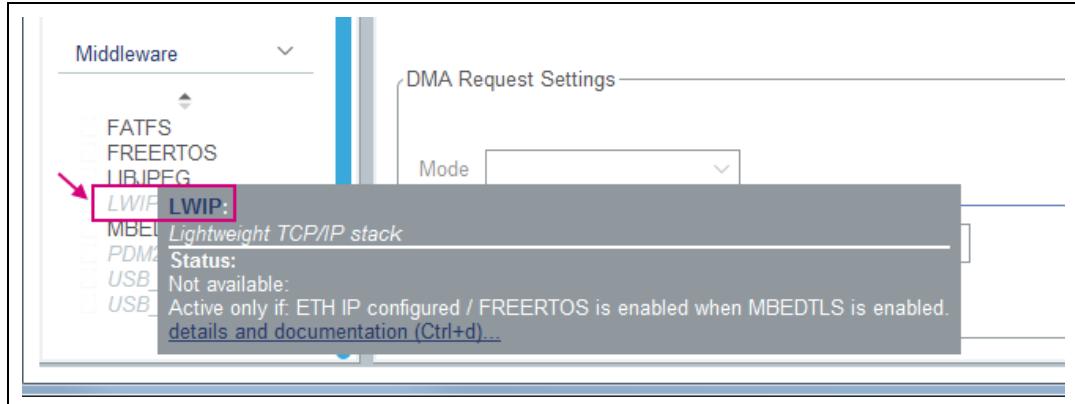


### 11.6.5 Configuring the middleware

This is not required for the example taken for the tutorial.

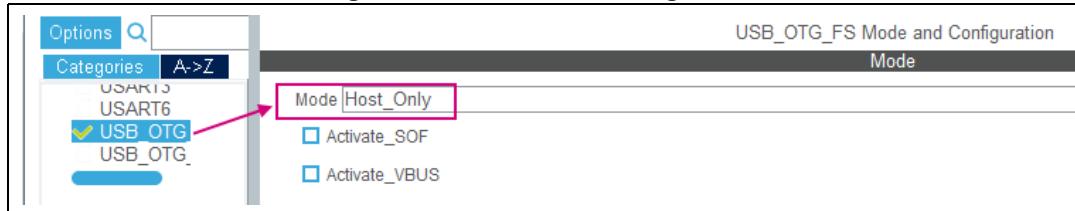
If a peripheral is required for a middleware mode, the peripheral must be configured in the **Pinout** view for the middleware mode to become available. A tooltip can guide the user as shown below.

**Figure 224. Middleware tooltip**



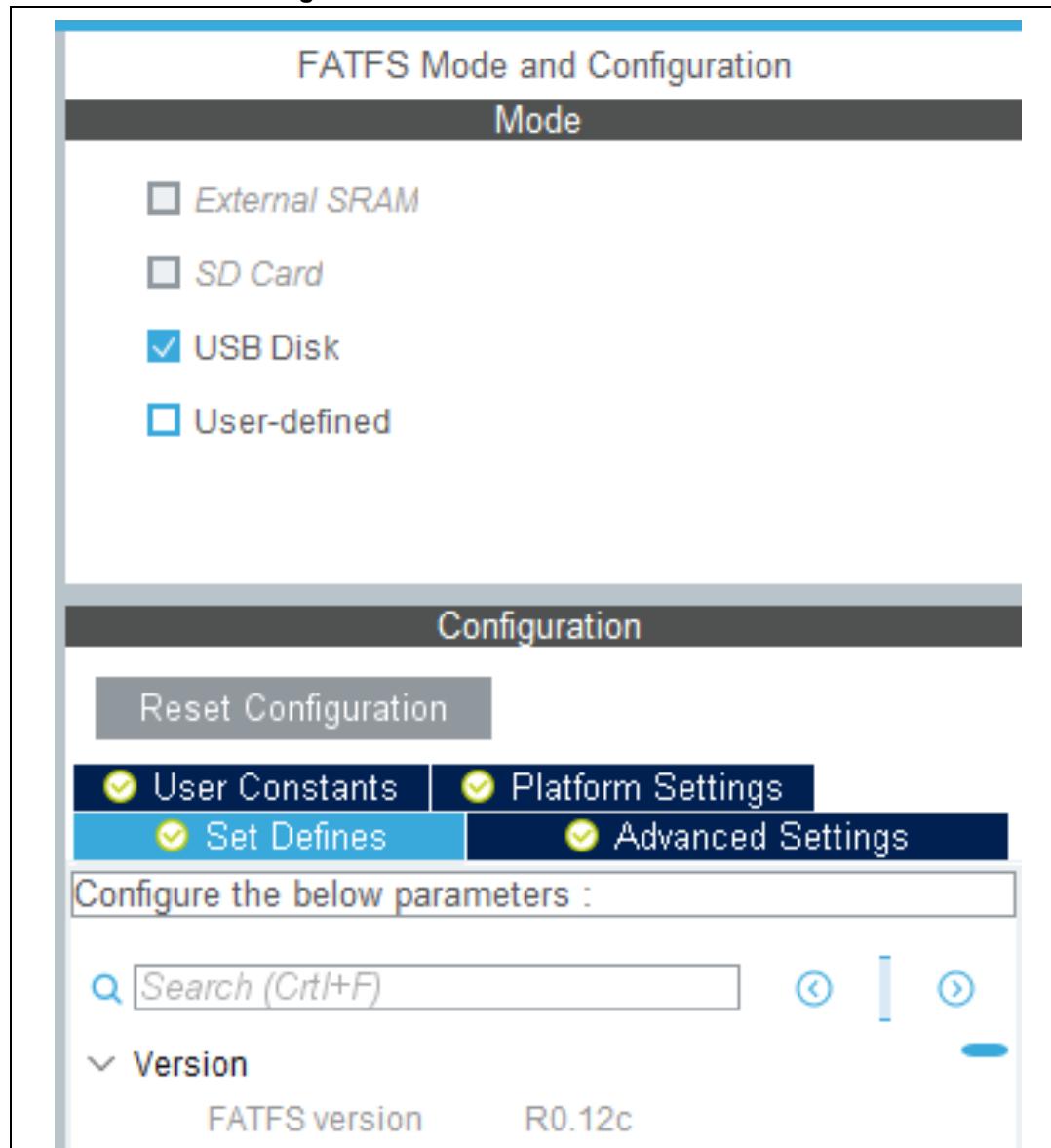
1. Configure the USB peripheral from the **Pinout** view.

**Figure 225. USB Host configuration**



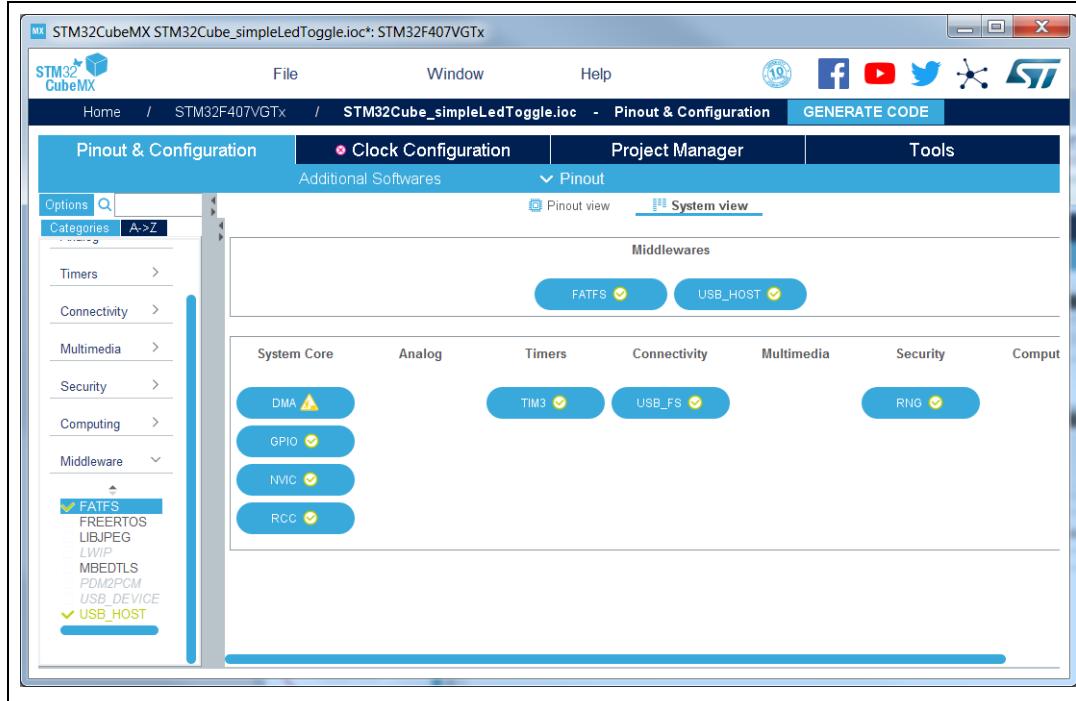
2. Select MSC\_FS class from USB Host middleware.
3. Select the checkbox to enable FatFs USB mode in the tree panel.

Figure 226. FatFs over USB mode enabled



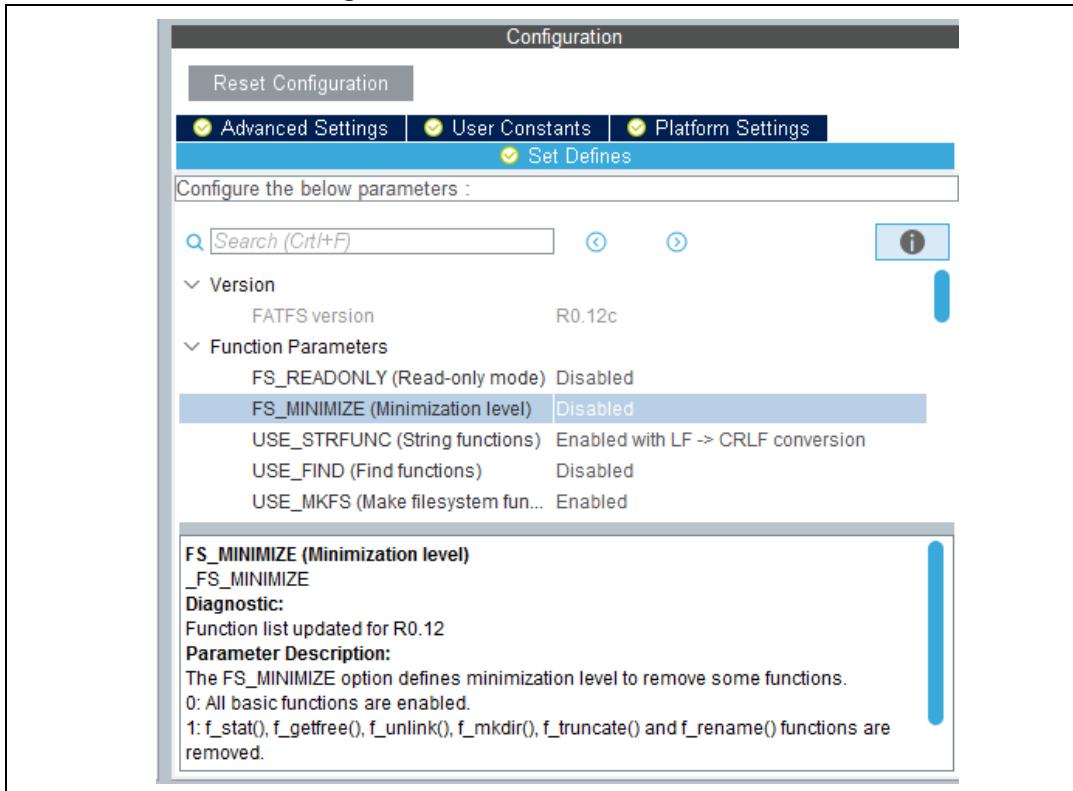
4. Select the **Configuration** view. FatFs and USB buttons are then displayed.

Figure 227. System view with FatFs and USB enabled



5. FatFs and USB using default settings are already marked as configured . Click **FatFs** and **USB** buttons to display default configuration settings. You can also change them by following the guidelines provided at the bottom of the window.

Figure 228. FatFs define statements



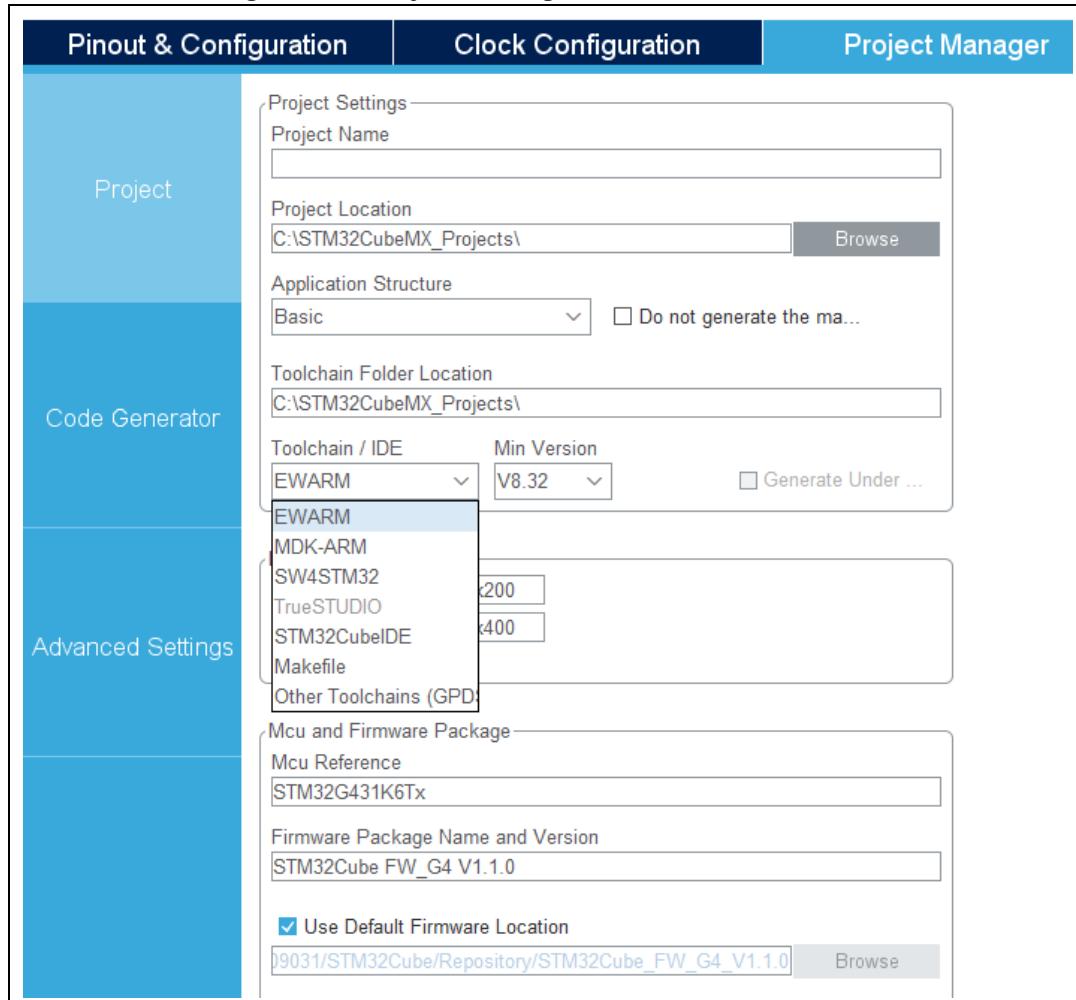
## 11.7 Generating a complete C project

### 11.7.1 Setting project options

Default project settings can be adjusted prior to C code generation as shown in [Figure 229](#).

1. Select the **Project Manager** view to update project settings and generation options.
2. Select the **Project Tab** and choose a Project **name**, **location**, a **toolchain** and a **toolchain version** to generate the project (see [Figure 229](#)).

**Figure 229. Project Settings and toolchain selection**



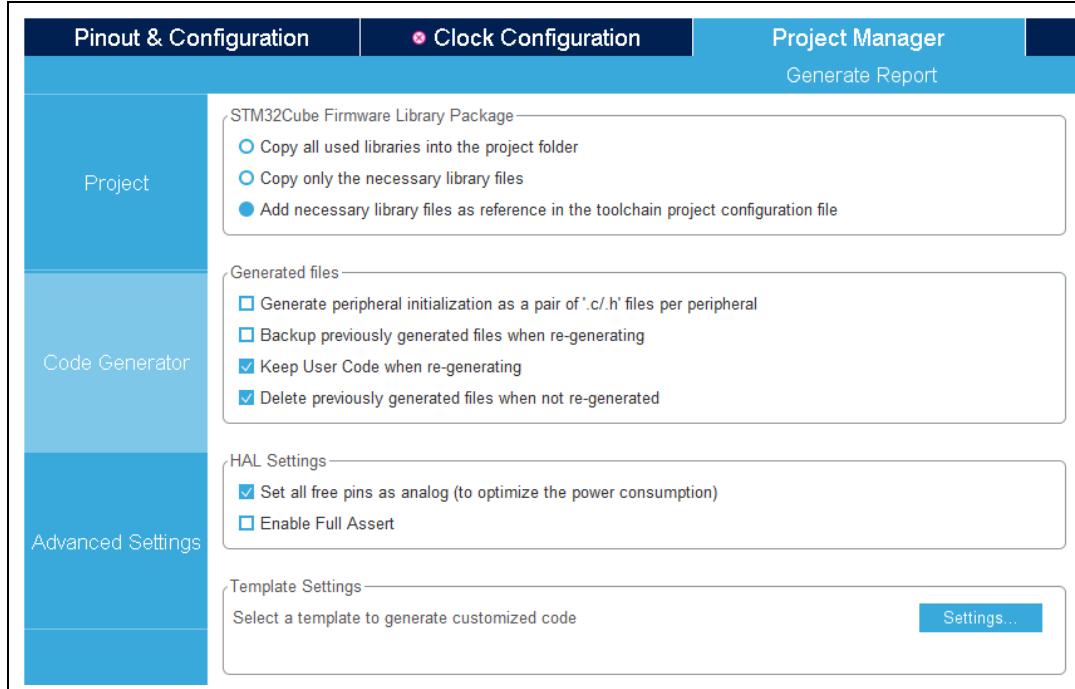
3. Select the **Code Generator** tab to choose various C code generation options:
  - The library files copied to *Projects* folder.
  - C code regeneration (e.g. what is kept or backed up during C code regeneration).
  - HAL specific action (e.g. set all free pins as analog I/Os to reduce MCU power consumption).

In the tutorial example, select the settings as displayed in [Figure 230](#) and click **OK**.

## Tutorial 1: From pinout to project C code generation using an MCU of the STM32F4 Series

Note: A dialog window appears when the firmware package is missing. Go to next section for explanation on how to download the firmware package.

Figure 230. Project Manager menu - Code Generator tab

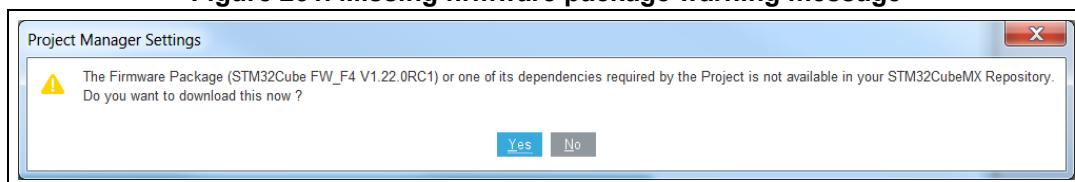


### 11.7.2 Downloading firmware package and generating the C code

1. Click **GENERATE CODE** to generate the C code.

During C code generation, STM32CubeMX copies files from the relevant STM32Cube MCU package into the project folder so that the project can be compiled. When generating a project for the first time, the firmware package is not available on the user PC and a warning message is displayed:

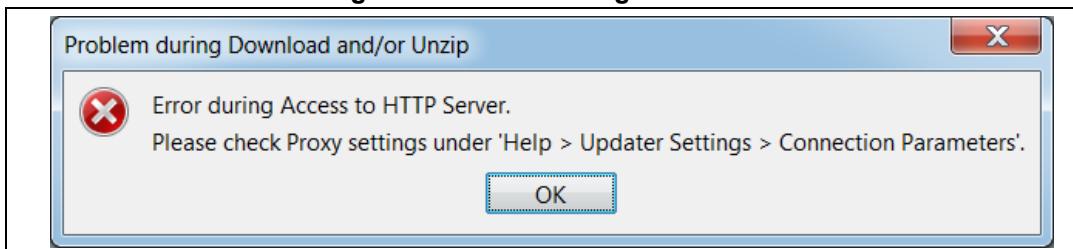
Figure 231. Missing firmware package warning message



2. STM32CubeMX offers to download the relevant firmware package or to go on. Click **Download** to obtain a complete project, that is a project ready to be used in the selected IDE.  
By clicking **Continue**, only *Inc* and *Src* folders will be created, holding STM32CubeMX generated initialization files. The necessary firmware and middleware libraries will have to be copied manually to obtain a complete project.

If the download fails, an error message is displayed.

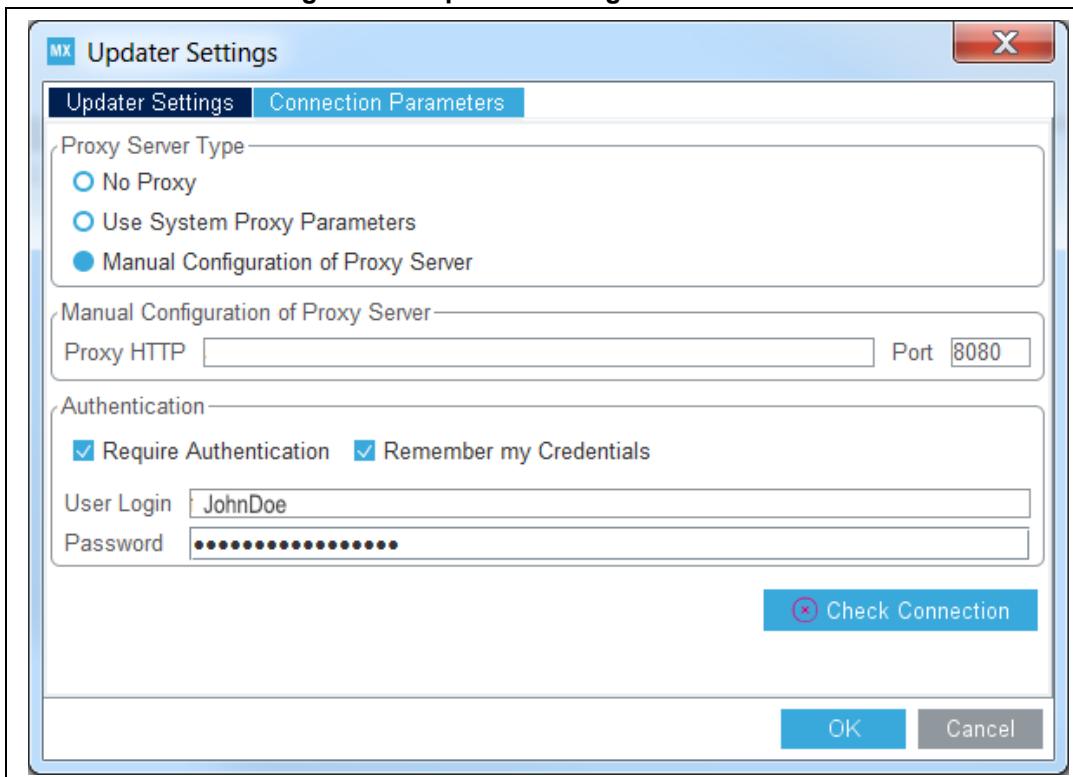
**Figure 232. Error during download**



To solve this issue, execute the next two steps. Skip them otherwise.

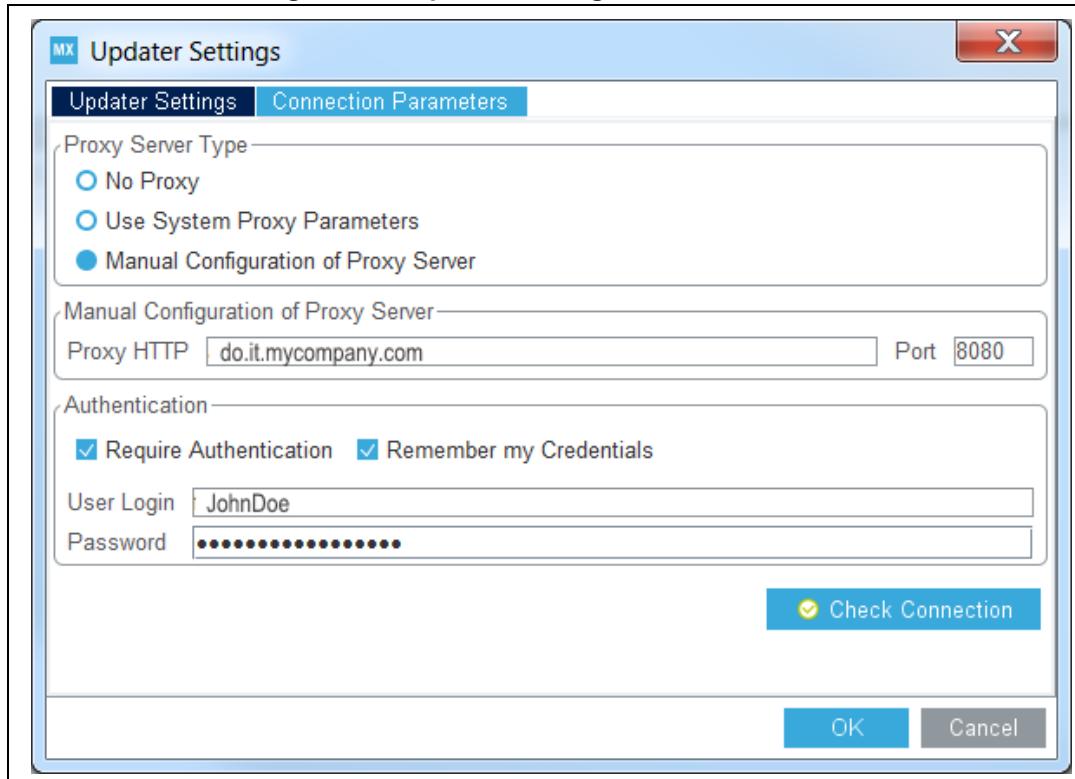
3. Select **Help > Updater settings menu** and adjust the connection parameters to match your network configuration.

**Figure 233. Updater settings for download**



4. Click **Check connection**. The check mark turns green once the connection is established.

Figure 234. Updater settings with connection



- Once the connection is functional, click **GENERATE CODE** to generate the C code. The C code generation process starts and progress is displayed (see next figures).

Figure 235. Downloading the firmware package

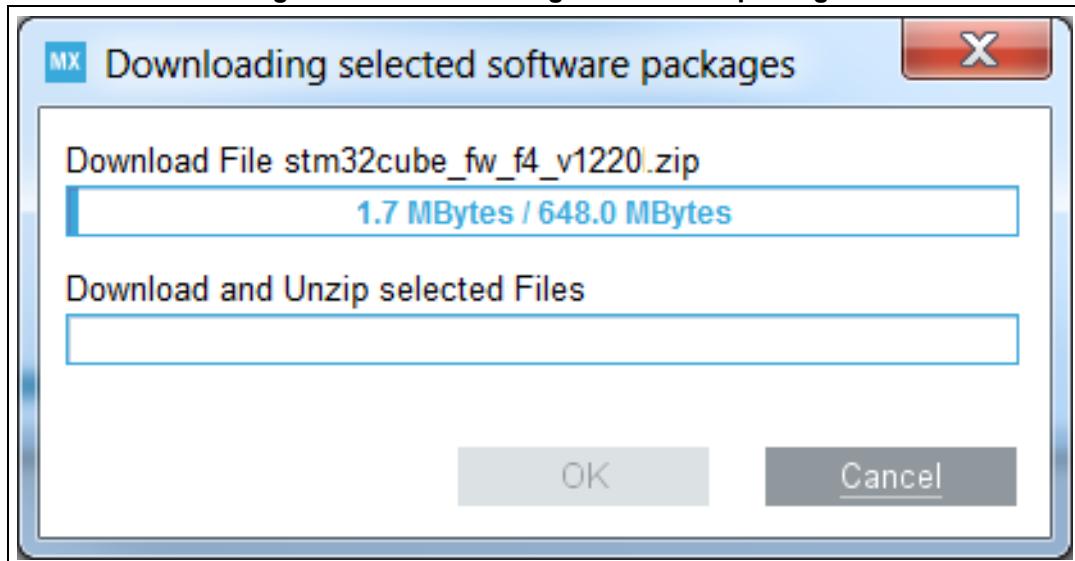
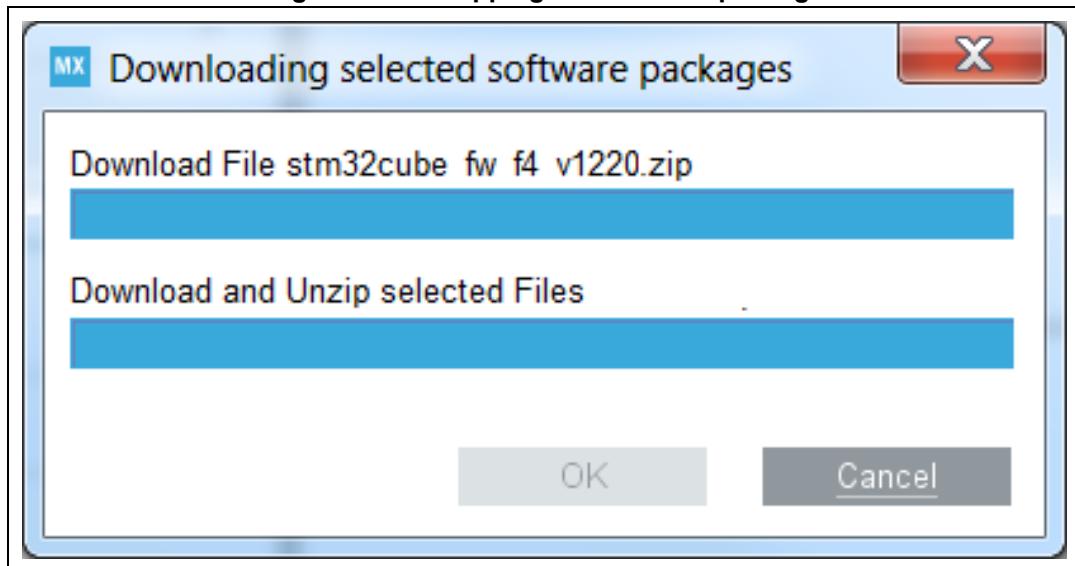
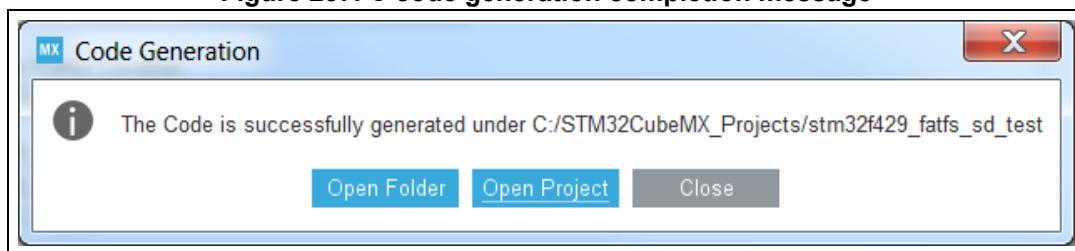


Figure 236. Unzipping the firmware package



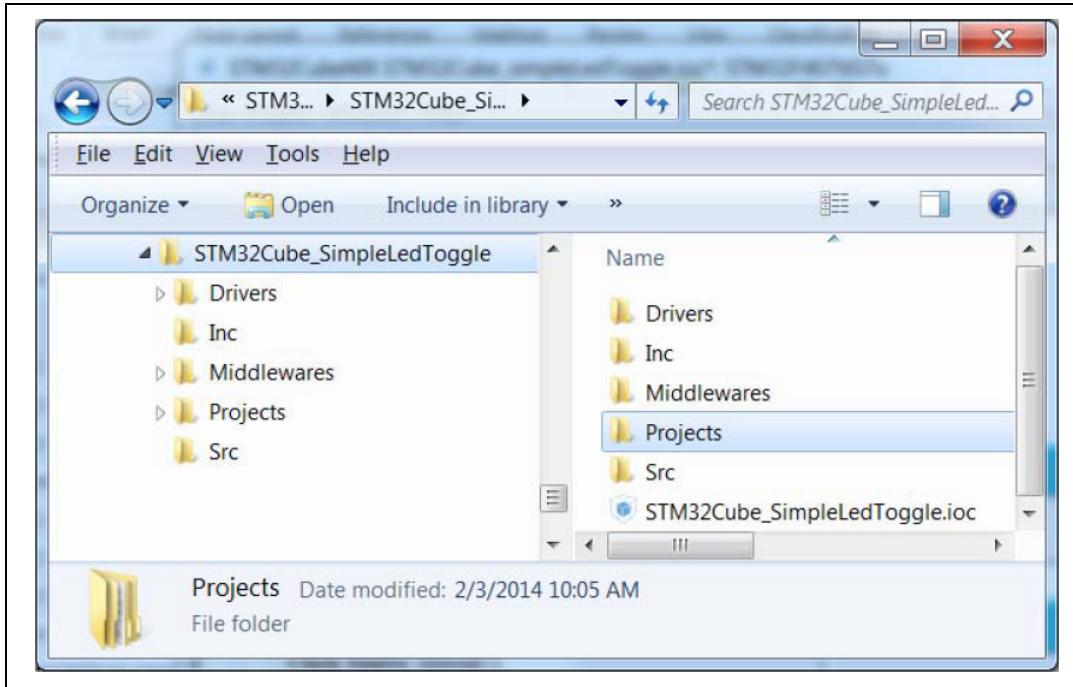
- Finally, a confirmation message is displayed to indicate that the C code generation has been successful.

Figure 237. C code generation completion message



7. Click **Open Folder** to display the generated project contents or click **Open Project** to open the project directly in your IDE. Then proceed with [Section 11.8](#).

**Figure 238. C code generation output folder**



The generated project contains:

- The STM32CubeMX .ioc project file located in the root folder. It contains the project user configuration and settings generated through STM32CubeMX user interface.
- The *Drivers* and *Middlewares* folders hold copies of the firmware package files relevant for the user configuration.
- The *Projects* folder contains IDE specific folders with all the files required for the project development and debug within the IDE.
- The *Inc* and *Src* folders contain STM32CubeMX generated files for middleware, peripheral and GPIO initialization, including the main.c file. The STM32CubeMX generated files contain user-dedicated sections allowing to insert user-defined C code.

**Caution:** C code written within the user sections is preserved at next C code generation, while C code written outside these sections is overwritten.

User C code will be lost if user sections are moved or if user sections delimiters are renamed.

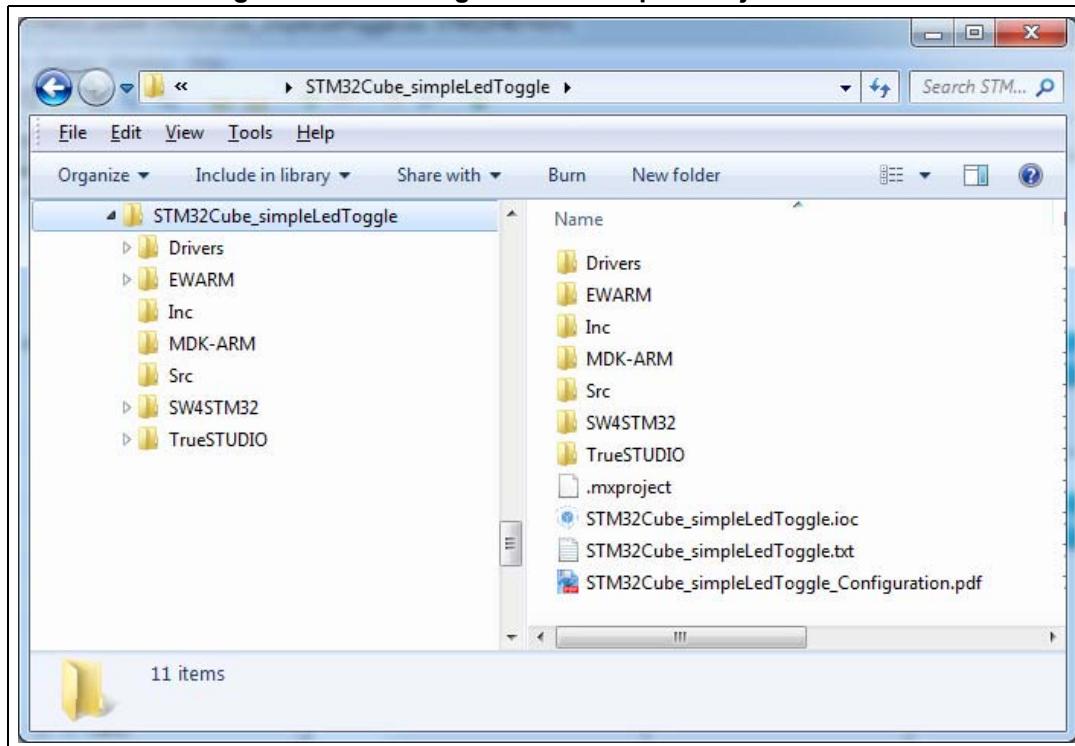
## 11.8 Building and updating the C code project

This example explains how to use the generated initialization C code and complete the project, within IAR™ EWARM toolchain, to have the LED blink according to the TIM3 frequency.

A folder is available for the toolchains selected for C code generation: the project can be generated for more than one toolchain by choosing a different toolchain from the **Project Manager** menu and clicking Generate code once again.

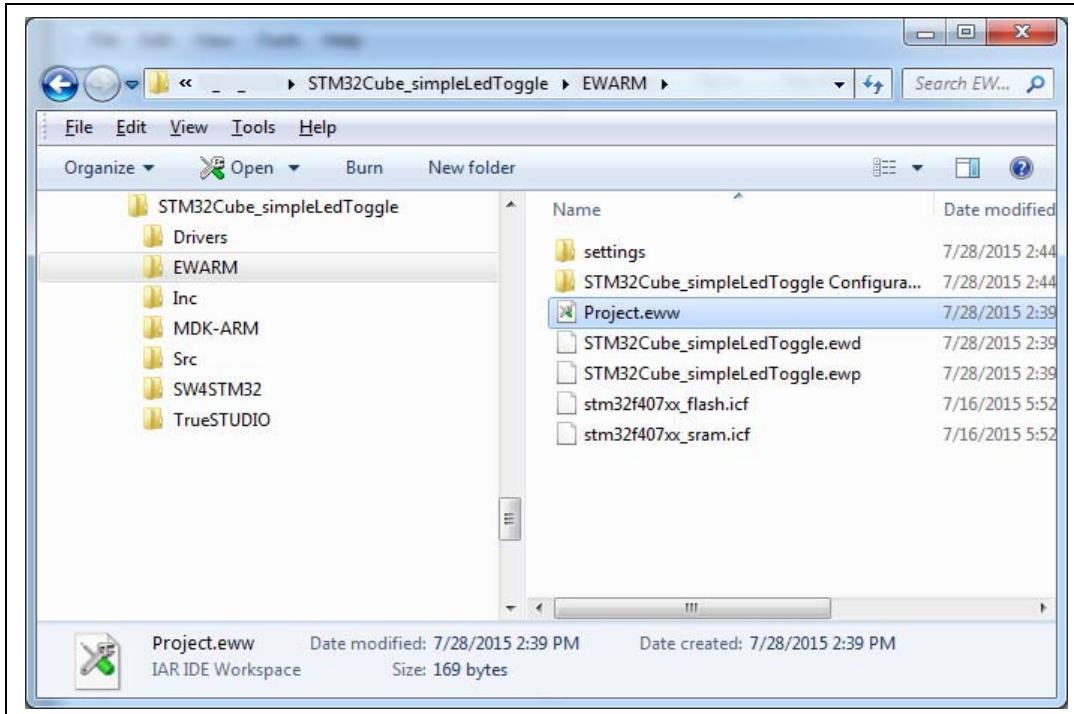
1. Open the project directly in the IDE toolchain by clicking **Open Project** from the dialog window or by double-clicking the relevant IDE file available in the toolchain folder under STM32CubeMX generated project directory (see [Figure 237](#)).

**Figure 239. C code generation output: Projects folder**



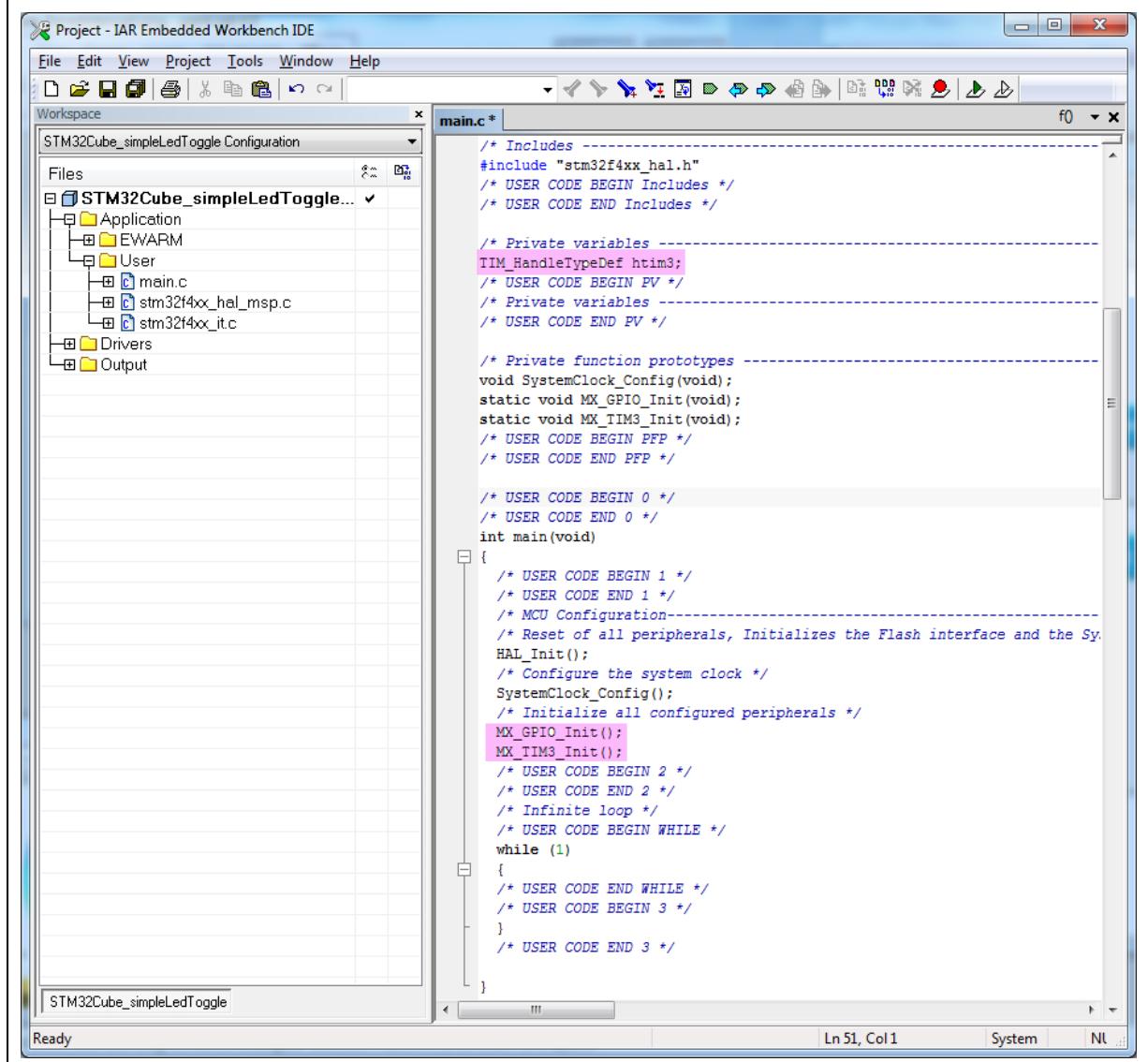
2. As an example, select .eww file to load the project in the IAR™ EWARM IDE.

**Figure 240. C code generation for EWARM**



3. Select the main.c file to open in editor.

**Figure 241. STM32CubeMX generated project open in IAR™ IDE**

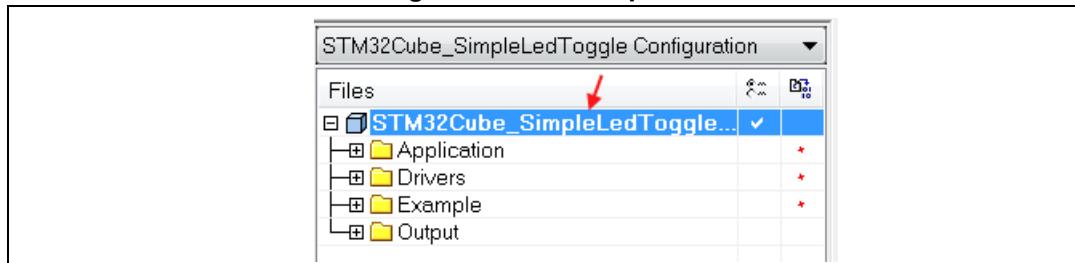


The htim3 structure handler, system clock, GPIO and TIM3 initialization functions are defined. The initialization functions are called in the main.c. For now the user C code sections are empty.

## Tutorial 1: From pinout to project C code generation using an MCU of the STM32F4 Series

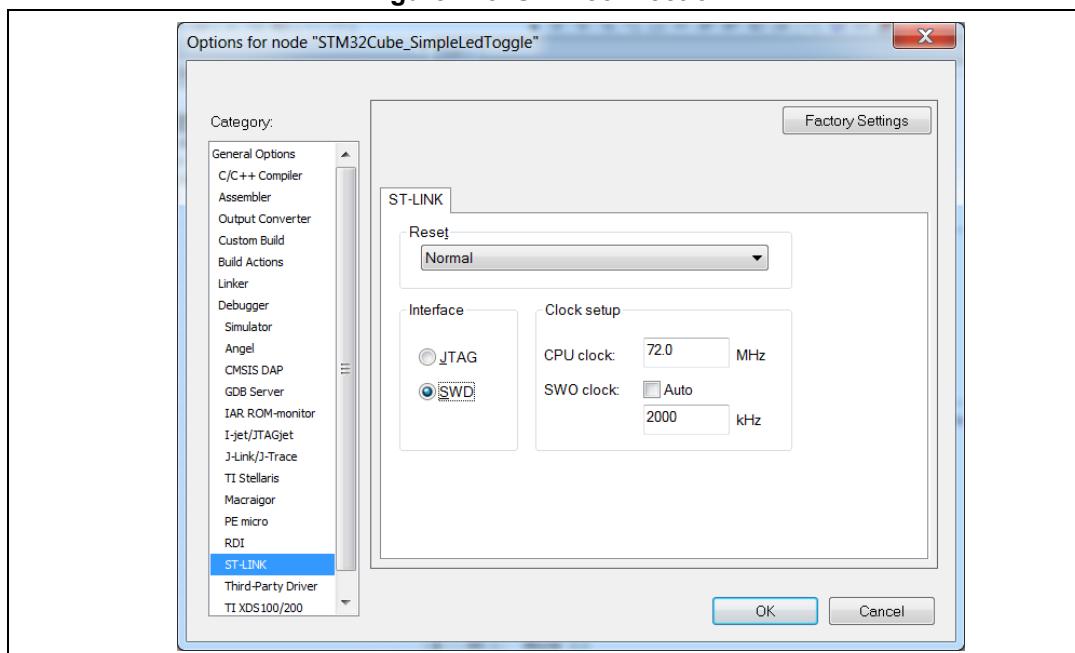
4. In the IAR™ IDE, right-click the project name and select **Options**.

Figure 242. IAR™ options



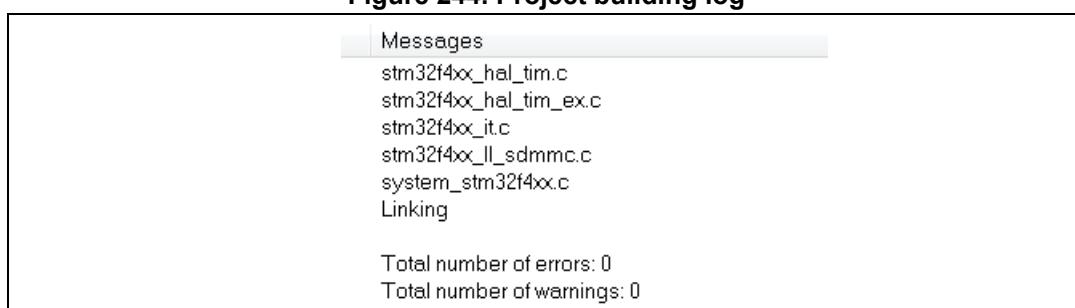
5. Click the ST-LINK category and make sure SWD is selected to communicate with the STM32F4DISCOVERY board. Click **OK**.

Figure 243. SWD connection



6. Select **Project > Rebuild all**. Check if the project building has succeeded.

Figure 244. Project building log



7. Add user C code in the dedicated user sections **only**.

*Note:* The main while(1) loop is placed in a user section.

For example:

- a) Edit the main.c file.
- b) To start timer 3, update User Section 2 with the following C code:

Figure 245. User Section 2

```
HAL_Init();
/* Configure the system clock */
SystemClock_Config();
/* Initialize all configured peripherals */
MX_GPIO_Init();
MX_TIM3_Init();

/* USER CODE BEGIN 2 */
HAL_TIM_Base_Start_IT(&htim3);
/* USER CODE END 2 */

/* Infinite loop */
/* USER CODE BEGIN WHILE */
while (1)
{
```

- c) Then, add the following C code in User Section 4:

Figure 246. User Section 4

```
/* USER CODE BEGIN 4 */

void HAL_TIM_PeriodElapsedCallback(TIM_HandleTypeDef *htim)
{
    if ( htim->Instance == htim3.Instance )
    {
        HAL_GPIO_TogglePin(GPIOB, GPIO_PIN_12);
    }
}
/* USER CODE END 4 */
```

This C code implements the weak callback function defined in the HAL timer driver (stm32f4xx\_hal\_tim.h) to toggle the GPIO pin driving the green LED when the timer counter period has elapsed.

8. Rebuild and program your board using . Make sure the SWD ST-LINK option is checked as a Project options otherwise board programming will fail.
9. Launch the program using . The green LED on the STM32F4DISCOVERY board will blink every second.
10. To change the MCU configuration, go back to STM32CubeMX user interface, implement the changes and regenerate the C code. The project will be updated, preserving the C code in the user sections if  Keep User Code when re-generating option in Project Manager's Code Generator tab is enabled.

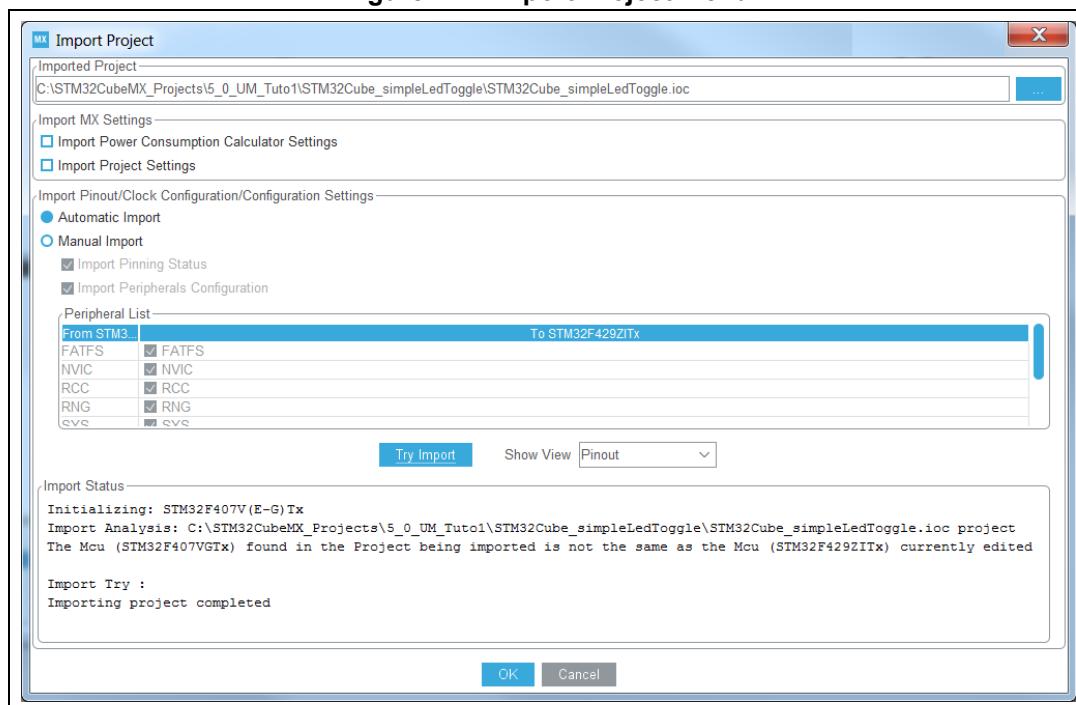
## 11.9 Switching to another MCU

STM32CubeMX allows loading a project configuration on an MCU of the same Series.

Proceed as follows:

1. Select **File > New Project**.
2. Select an MCU belonging to the same Series. As an example, you can select the STM32F429ZITx that is the core MCU of the 32F429IDISCOVERY board.
3. Select **File > Import project**. In the **Import project** window, browse to the .ioc file to load. A message warns you that the currently selected MCU (STM32F429ZITx) differs from the one specified in the .ioc file (STM32F407VGTx). Several import options are proposed (see *Figure 247*).
4. Click the **Try Import** button and check the import status to verify if the import has been successful.
5. Click **OK** to really import the project. An output tab is then displayed to report the import results.
6. The green LED on 32F429IDISCOVERY board is connected to PG13: CTRL+ right click **PD12** and drag and drop it on PG13.
7. From **Project Manager** project tab configure the new project name and folder location. Click **Generate icon** to save the project and generate the code.
8. Select **Open the project** from the dialog window, update the user sections with the user code, making sure to update the GPIO settings for PG13. Build the project and flash the board. Launch the program and check that LED blinks once per second.

**Figure 247. Import Project menu**



## 12 Tutorial 2 - Example of FatFs on an SD card using STM32429I-EVAL evaluation board

The tutorial consists in creating and writing to a file on the STM32429I-EVAL1 SD card using the FatFs file system middleware.

To generate a project and run tutorial 2, follow the sequence below:

1. Launch STM32CubeMX.
2. Select **File > New Project**. The Project window opens.
3. Click the **Board Selector Tab** to display the list of ST boards.
4. Select **EvalBoard** as type of Board and **STM32F4** as Series to filter down the list.
5. Answer Yes to Initialize all peripherals with their default mode so that the code is generated only for the peripherals used by the application.
6. Select the STM32429I-EVAL board and click **OK**. Answer No in the dialog box asking to initialize all peripherals to their default modes (see [Figure 248](#)). The **Pinout** view is loaded, matching the MCU pinout configuration on the evaluation board (see [Figure 249](#)).

**Figure 248. Board peripheral initialization dialog box**

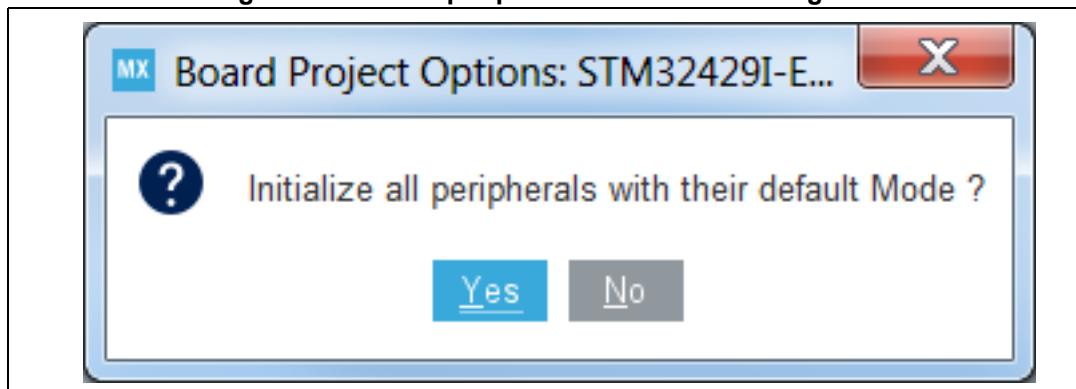
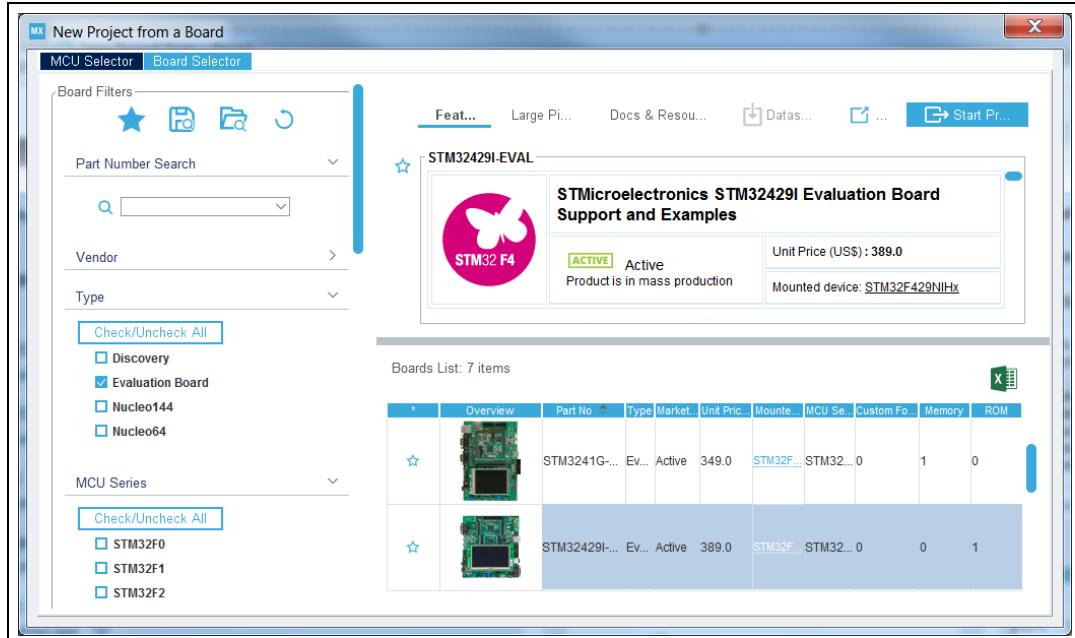
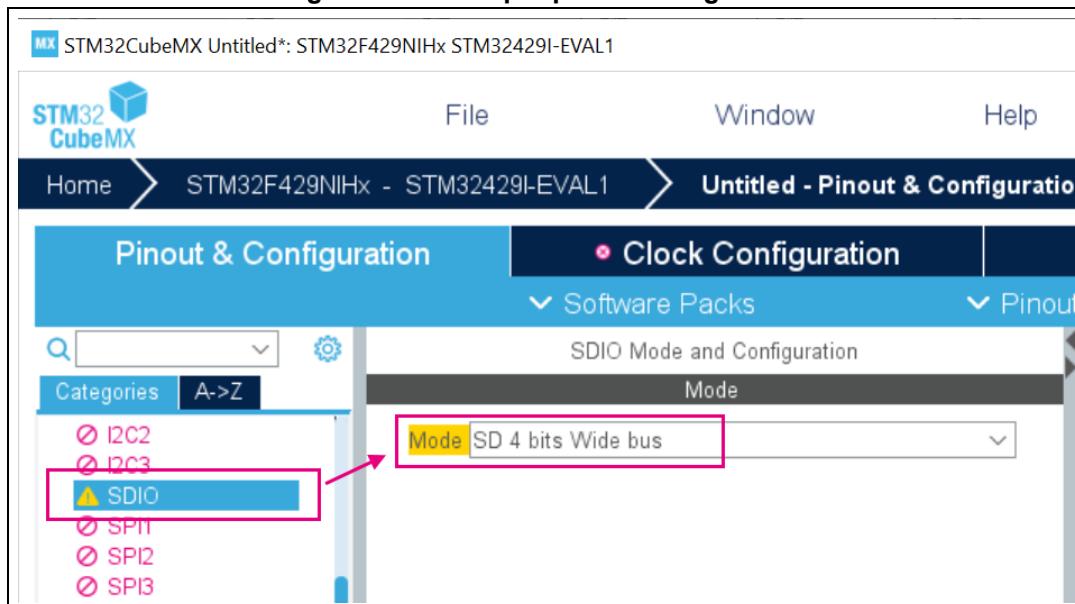


Figure 249. Board selection



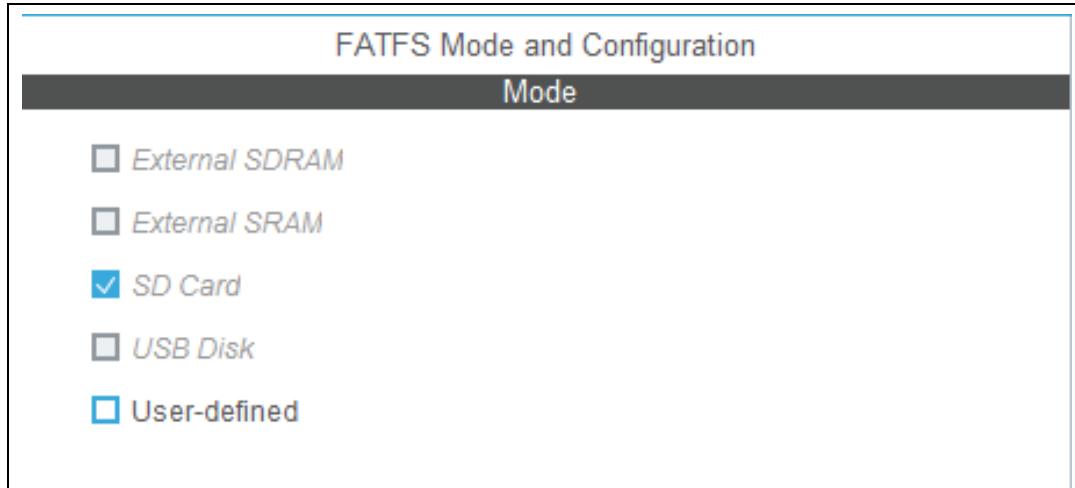
7. From the Peripheral tree on the left, expand the SDIO peripheral and select “SD 4 bits wide bus” (see [Figure 250](#)). In the configuration panel, from the DMA settings tab, add SDIO\_RX and SDIO\_TX DMA requests.
8. Finally, go back to the peripheral tree panel, select NVIC and enable the SDIO global interrupt from the configuration panel.

Figure 250. SDIO peripheral configuration



9. Under the Middlewares category, check SD card as FatFs mode (see [Figure 251](#)).

**Figure 251. FatFs mode configuration**



From the Pinout view on the right, enable, as GPIO input, a pin to be used for the SDIO detection.

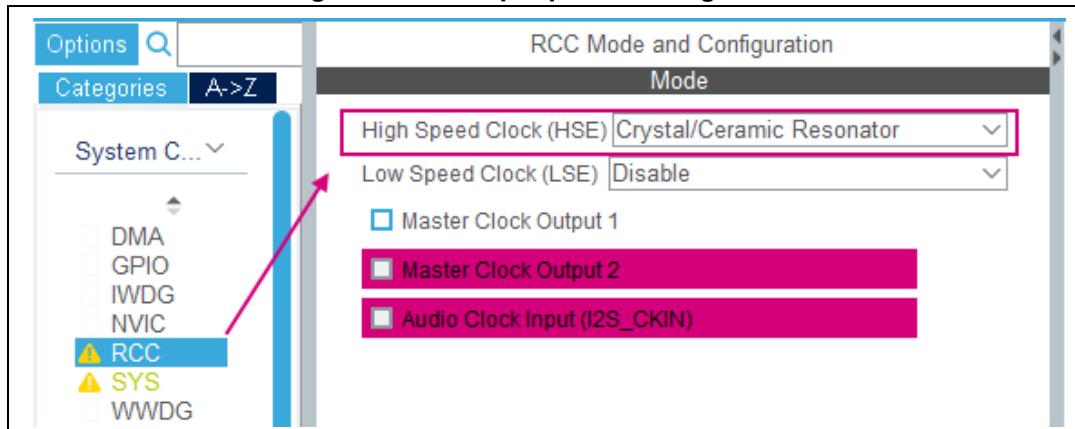
In the configuration panel below the mode panel, go to the platform settings tab and configure the SD\_detection using the pin previously enabled.

Finally, go to FatFs "Advanced settings tab" and enable "Use DMA template".

10. Configure the clocks as follows:

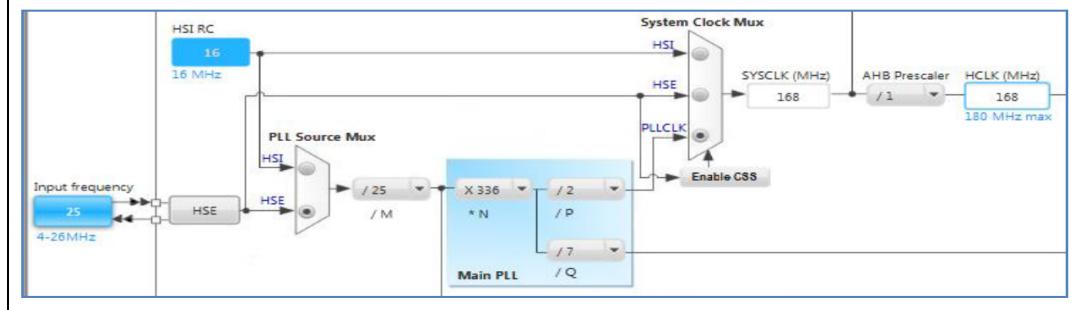
- a) Select the RCC peripheral from the Pinout view (see [Figure 252](#)).

**Figure 252. RCC peripheral configuration**



- b) Configure the clock tree from the clock tab (see [Figure 253](#)).

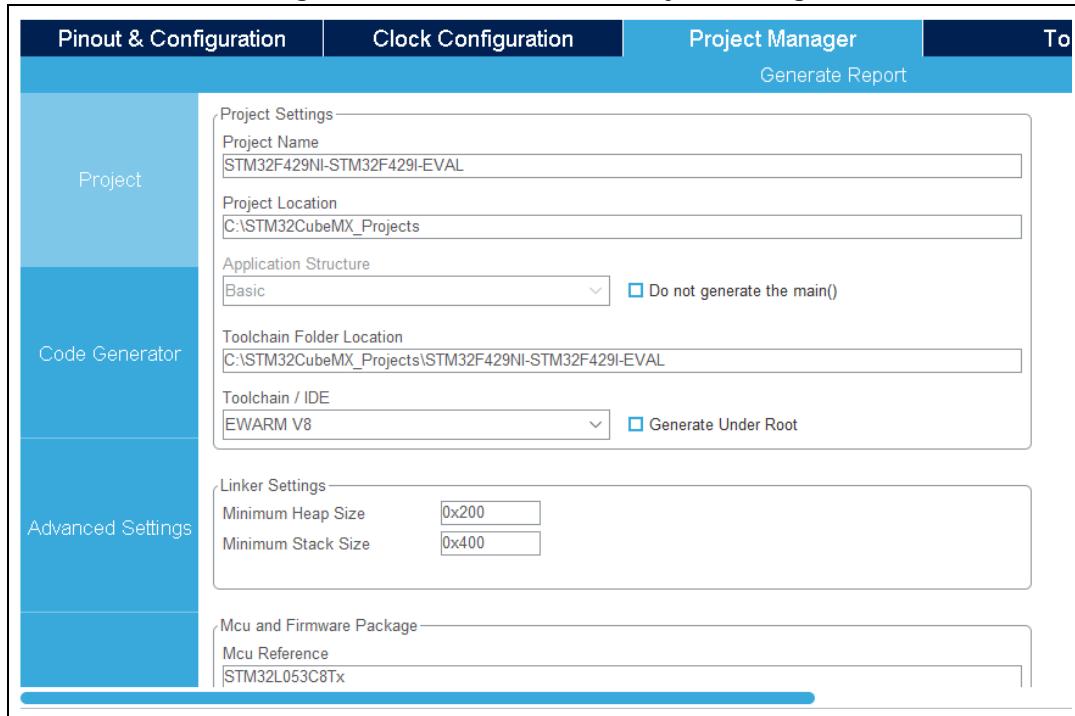
**Figure 253. Clock tree view**



11. In the **Project** tab, specify the project name and destination folder. Then, select the EWARM IDE toolchain.

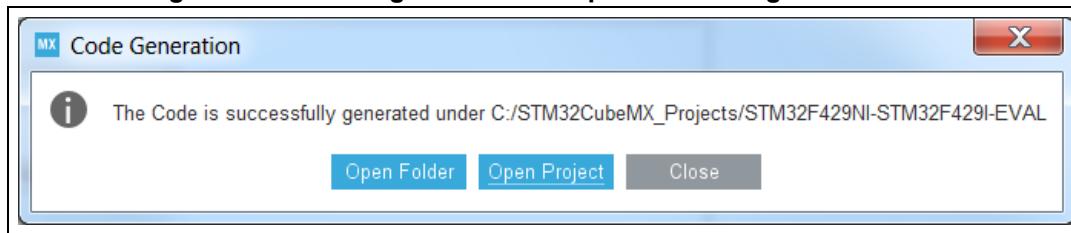
Note that project heap and stack size can be adjusted to the minimum required for the FATFS application.

**Figure 254. FATFS tutorial - Project settings**



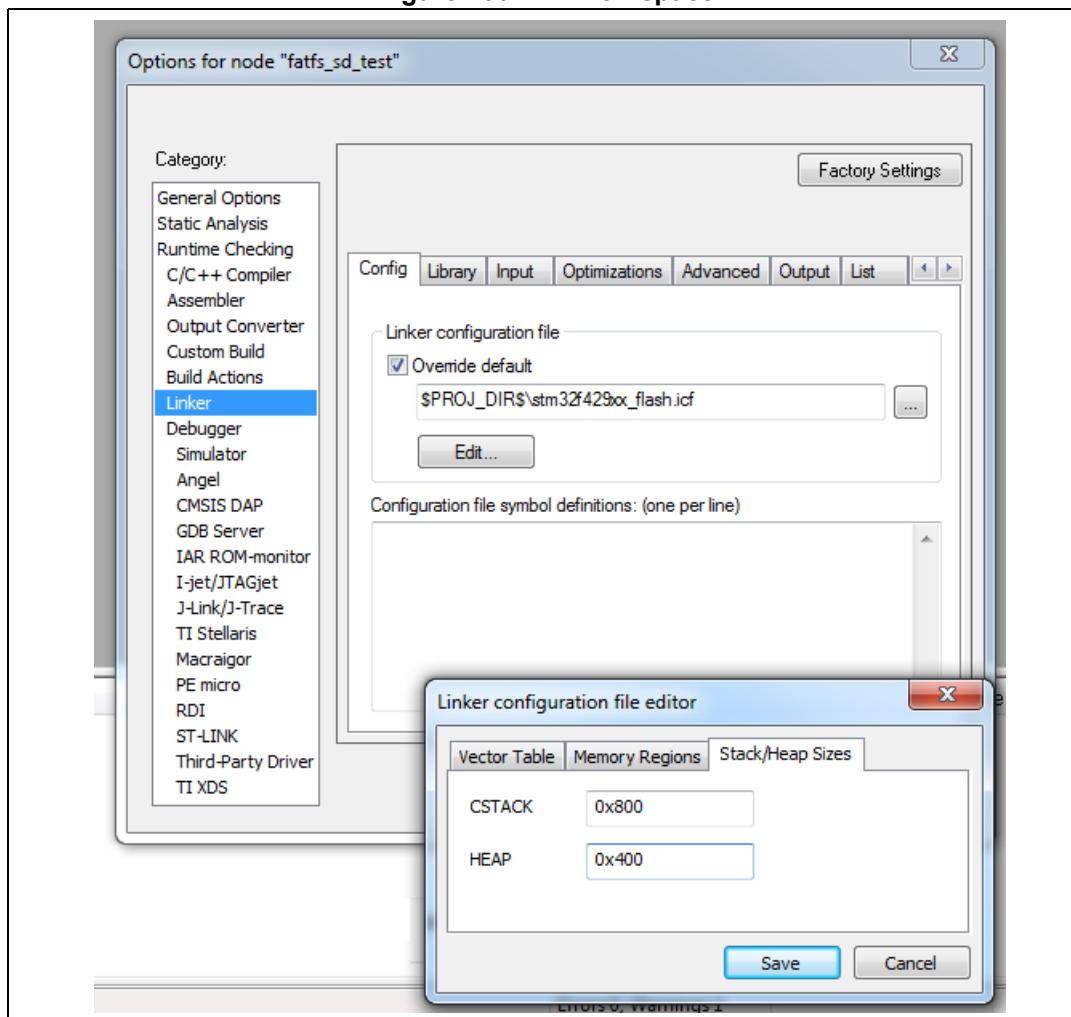
12. Click **Ok**. Then, on the toolbar menu, click **GENERATE CODE** to generate the project.  
 13. Upon code generation completion, click **Open Project** in the **Code Generation** dialog window (see [Figure 255](#)). This opens the project directly in the IDE.

Figure 255. C code generation completion message



14. In the IDE, check that heap and stack sizes are sufficient: right click the project name and select **Options**, then select **Linker**. Check **Override default** to use the icf file from STM32CubeMX generated project folder. if not already done through CubeMX User interface (under Linker Settings from Project Manager's project tab), adjust the heap and stack sizes (see [Figure 256](#)).

Figure 256. IDE workspace



Note:

When using the MDK-Arm toolchain, go to the Application/MDK-ARM folder and double-click the startup\_xx.s file to edit and adjust the heap and stack sizes there.

15. Go to the Application/User folder. Double-click the main.c file and edit it.
  16. The tutorial consists in creating and writing to a file on the evaluation board SD card using the FatFs file system middleware:
    - a) At startup all LEDs are OFF.
    - b) The red LED is turned ON to indicate that an error occurred (e.g. FatFs initialization, file read/write access errors).
    - c) The orange LED is turned ON to indicate that the FatFs link has been successfully mounted on the SD driver.
    - d) The blue LED is turned ON to indicate that the file has been successfully written to the SD card.
    - e) The green LED is turned ON to indicate that the file has been successfully read from file the SD card.
  17. For use case implementation, update main.c with the following code:
    - a) Insert main.c private variables in a dedicated user code section:

```

/* USER CODE BEGIN PV */
/* Private variables -----*/
FATFS SDFatFs; /* File system object for SD card logical drive */
FIL MyFile; /* File object */
const char wtext[] = "Hello World!";
const uint8_t image1_bmp[] = {
0x42,0xd,0x36,0x84,0x03,0x00,0x00,0x00,0x00,0x00,0x36,0x00,0x00,0x00,
0x28,0x00,0x00,0x00,0x40,0x01,0x00,0x00,0xf0,0x00,0x00,0x00,0x01,0x00,
0x18,0x00,0x00,0x00,0x00,0x00,0x84,0x03,0x00,0x00,0x00,0x00,0x00,0x00,
0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x29,0x74,
0x51,0xe,0x63,0x30,0x04,0x4c,0x1d,0x0f,0x56,0x25,0x11,0x79,0x41,0x1f,
0x85,0x6f,0x25,0x79,0x7e,0x27,0x72,0x72,0x0b,0x50,0x43,0x00,0x44,0x15,
0x00,0x4b,0x0f,0x00,0x4a,0x15,0x07,0x50,0x16,0x03,0x54,0x22,0x23,0x70,
0x65,0x30,0x82,0x6d,0x0f,0x6c,0x3e,0x22,0x80,0x5d,0x23,0x8b,0x5b,0x26};
/* USER CODE END PV */

b) Insert main functional local variables:
int main(void)
{
    /* USER CODE BEGIN 1 */
    FRESULT res; /* FatFs function common result code */
    uint32_t byteswritten, bytesread; /* File write/read counts */
    char rtext[256]; /* File read buffer */
    /* USER CODE END 1 */

    /* MCU Configuration-----*/
    /* Reset of all peripherals, Initializes the Flash interface and the
Systick. */
    HAL_Init();
    c) Insert user code in the main function, after initialization calls and before the while
loop, to perform actual read/write from/to the SD card:
int main(void)
{

```

```

...
MX_FATFS_Init();

/* USER CODE BEGIN 2 */
/*##-0- Turn all LEDs off(red, green, orange and blue) */
HAL_GPIO_WritePin(GPIOG, (GPIO_PIN_10 | GPIO_PIN_6 | GPIO_PIN_7 |
GPIO_PIN_12), GPIO_PIN_SET);
/*##-1- FatFS: Link the SD disk I/O driver #####*/
if(retSD == 0){
    /* success: set the orange LED on */
    HAL_GPIO_WritePin(GPIOG, GPIO_PIN_7, GPIO_PIN_RESET);
/*##-2- Register the file system object to the FatFs module ####*/
    if(f_mount(&SDFatFs, (TCHAR const*)SDPath, 0) != FR_OK){
        /* FatFs Initialization Error : set the red LED on */
        HAL_GPIO_WritePin(GPIOG, GPIO_PIN_10, GPIO_PIN_RESET);
        while(1);
    } else {
/*##-3- Create a FAT file system (format) on the logical drive#*/
        /* WARNING: Formatting the uSD card will delete all content on the
device */
        if(f_mkfs((TCHAR const*)SDPath, FM_ANY, 0, buffer, sizeof(buffer)) !=
FR_OK){
            /* FatFs Format Error : set the red LED on */
            HAL_GPIO_WritePin(GPIOG, GPIO_PIN_10, GPIO_PIN_RESET);
            while(1);
        } else {
/*##-4- Create & Open a new text file object with write access#*/
            if(f_open(&MyFile, "Hello.txt", FA_CREATE_ALWAYS | FA_WRITE) != FR_OK){
                /* 'Hello.txt' file Open for write Error : set the red LED on */
                HAL_GPIO_WritePin(GPIOG, GPIO_PIN_10, GPIO_PIN_RESET);
                while(1);
            } else {
/*##-5- Write data to the text file ####*/
                res = f_write(&MyFile, wtext, sizeof(wtext), (void
*)&byteswritten);
                if((byteswritten == 0) || (res != FR_OK)){
                    /* 'Hello.txt' file Write or EOF Error : set the red LED on */
                    HAL_GPIO_WritePin(GPIOG, GPIO_PIN_10, GPIO_PIN_RESET);
                    while(1);
                } else {
/*##-6- Successful open/write : set the blue LED on */
                    HAL_GPIO_WritePin(GPIOG, GPIO_PIN_12, GPIO_PIN_RESET);
                    f_close(&MyFile);
/*##-7- Open the text file object with read access #*/
                    if(f_open(&MyFile, "Hello.txt", FA_READ) != FR_OK){
                        /* 'Hello.txt' file Open for read Error : set the red LED on */
                        HAL_GPIO_WritePin(GPIOG, GPIO_PIN_10, GPIO_PIN_RESET);
                        while(1);
                    } else {
/*##-8- Read data from the text file ####*/

```

```
res = f_read(&MyFile, rtext, sizeof(wtext), &bytesread);
if((strcmp(rtext,wtext)!=0) || (res != FR_OK)){
/* 'Hello.txt' file Read or EOF Error : set the red LED on */
    HAL_GPIO_WritePin(GPIOG, GPIO_PIN_10, GPIO_PIN_RESET);
    while(1);
} else {
/* Successful read : set the green LED On */
    HAL_GPIO_WritePin(GPIOG, GPIO_PIN_6, GPIO_PIN_RESET);
/*##-9- Close the open text file #####*/
    f_close(&MyFile);
}}}}}
/*##-10- Unlink the micro SD disk I/O driver ####*/
FATFS_UnLinkDriver(SDPath);

/* USER CODE END 2 */

/* Infinite loop */
/* USER CODE BEGIN WHILE */
while (1)
```

## 13 Tutorial 3 - Using the Power Consumption Calculator to optimize the embedded application consumption and more

### 13.1 Tutorial overview

This tutorial focuses on STM32CubeMX Power Consumption Calculator (Power Consumption Calculator) feature and its benefits to evaluate the impacts of power-saving techniques on a given application sequence.

The key considerations to reduce a given application power consumption are:

- Reducing the operating voltage
- Reducing the time spent in energy consuming modes

It is up to the developer to select a configuration that gives the best compromise between low-power consumption and performance.

- Maximizing the time spent in non-active and low-power modes
- Using the optimal clock configuration

The core should always operate at relatively good speed, since reducing the operating frequency can increase energy consumption if the microcontroller has to remain for a long time in an active operating mode to perform a given operation.

- Enabling only the peripherals relevant for the current application state and clock-gating the others
- When relevant, using the peripherals with low-power features (e.g. waking up the microcontroller with the I2C)
- Minimizing the number of state transitions
- Optimizing memory accesses during code execution
  - Prefer code execution from RAM to Flash memory
  - When relevant, consider aligning CPU frequency with Flash memory operating frequency for zero wait states.

The following tutorial shows how the STM32CubeMX Power Consumption Calculator feature can help to tune an application to minimize its power consumption and extend the battery life.

Note:

*The Power Consumption Calculator does not account for I/O dynamic current consumption and external board components that can also affect current consumption. For this purpose, an “additional consumption” field is provided for the user to specify such consumption value.*

## 13.2 Application example description

The application is designed using the NUCLEO-L476RG board based on a STM32L476RGTx device and supplied by a 2.4 V battery.

The main purpose of this application is to perform ADC measurements and transfer the conversion results over UART. It uses:

- Multiple low-power modes: Low-power run, Low-power sleep, Sleep, Stop and Standby
- Multiple peripherals: USART, DMA, Timer, COMP, DAC and RTC
  - The RTC is used to run a calendar and to wake up the CPU from Standby when a specified time has elapsed.
  - The DMA transfers ADC measurements from ADC to memory
  - The USART is used in conjunction with the DMA to send/receive data via the virtual COM port and to wake up the CPU from Stop mode.

The process to optimize such complex application is to start describing first a functional only sequence then to introduce, on a step by step basis, the low-power features provided by the STM32L476RG microcontroller.

## 13.3 Using the Power Consumption Calculator

### 13.3.1 Creating a power sequence

Follow the steps below to create the sequence (see [Figure 257](#)):

1. Launch STM32CubeMX.
2. Click **new project** and select the Nucleo-L476RG board from the **Board** tab.
3. Click the **Power Consumption Calculator** tab to select the Power Consumption Calculator view. A first sequence is then created as a reference.
4. Adapt it to minimize the overall current consumption. To do this:
  - a) Select 2.4 V  $V_{DD}$  power supply. This value can be adjusted on a step by step basis (see [Figure 258](#)).
  - b) Select the Li-MnO<sub>2</sub> (CR2032) battery. This step is optional. The battery type can be changed later on (see [Figure 258](#)).

Figure 257. Power Consumption Calculation example

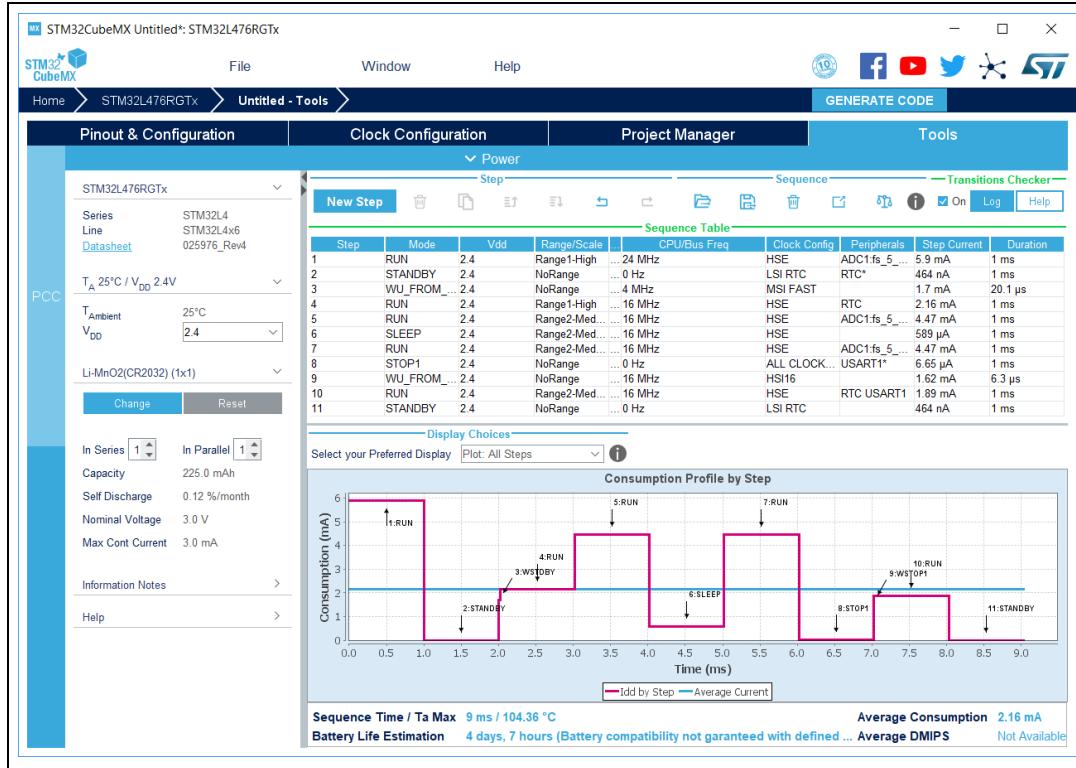
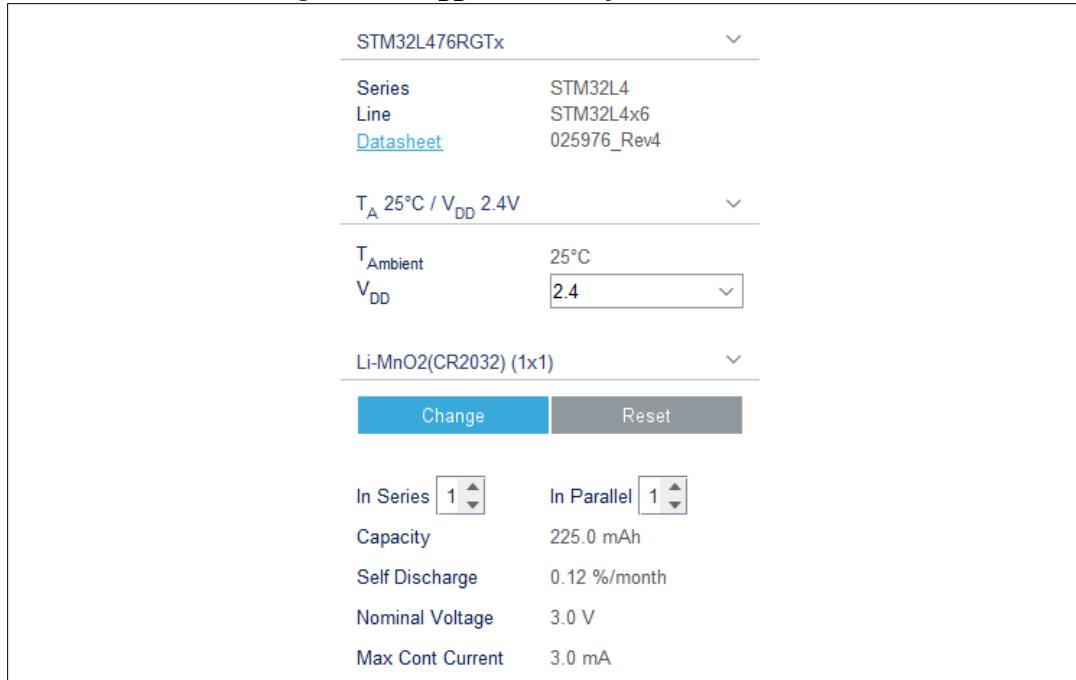


Figure 258. V<sub>DD</sub> and battery selection menu



5. Enable the **Transition checker** to ensure the sequence is valid (see [Figure 258](#)). This option allows verifying that the sequence respects the allowed transitions implemented within the STM32L476RG.
6. Click the **Add** button to add steps that match the sequence described in [Figure 258](#).
  - By default the steps last 1 ms each, except for the wakeup transitions that are preset using the transition times specified in the product datasheet (see [Figure 259](#)).
  - Some peripherals for which consumption is unavailable or negligible are highlighted with '\*' (see [Figure 259](#)).

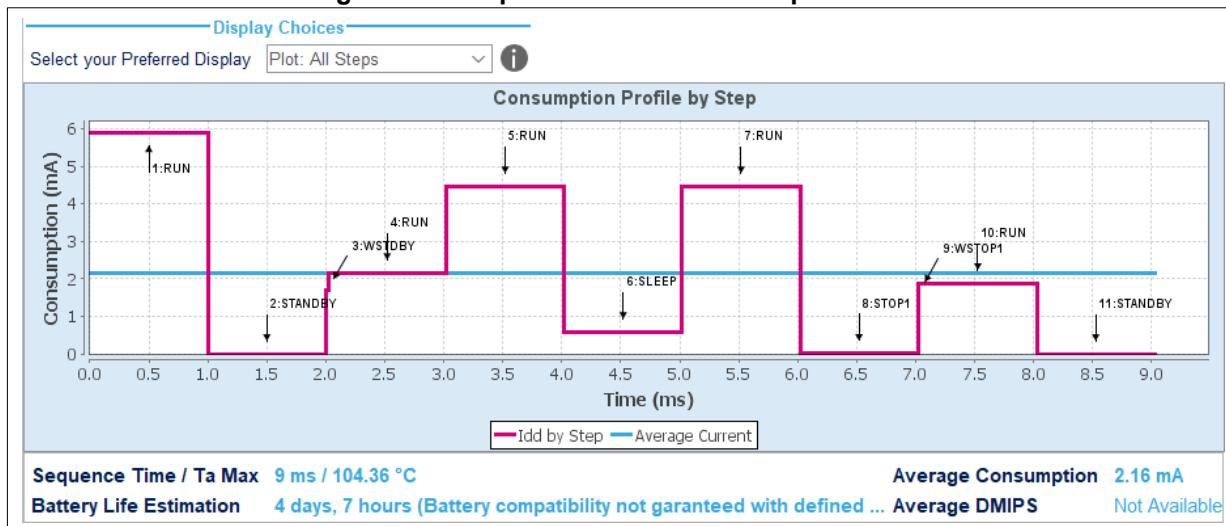
**Figure 259. Sequence table**

Sequence Table									
Step	Mode	Vdd	Range/Scale	CPU/Bus Freq	Clock Config	Peripherals	Step Current	Duration	
1	RUN	2.4	Range1-High	... 24 MHz	HSE	ADC1:fs_5_...	5.9 mA	1 ms	
2	STANDBY	2.4	NoRange	... 0 Hz	LSI RTC	RTC*	464 nA	1 ms	
3	WU_FROM_...	2.4	NoRange	... 4 MHz	MSI FAST		1.7 mA	20.1 µs	
4	RUN	2.4	Range1-High	... 16 MHz	HSE	RTC	2.16 mA	1 ms	
5	RUN	2.4	Range2-Med...	... 16 MHz	HSE	ADC1:fs_5_...	4.47 mA	1 ms	
6	SLEEP	2.4	Range2-Med...	... 16 MHz	HSE		589 µA	1 ms	
7	RUN	2.4	Range2-Med...	... 16 MHz	HSE	ADC1:fs_5_...	4.47 mA	1 ms	
8	STOP1	2.4	NoRange	... 0 Hz	ALL CLOCK...	USART1*	6.65 µA	1 ms	
9	WU_FROM_...	2.4	NoRange	... 16 MHz	HSI16		1.62 mA	6.3 µs	
10	RUN	2.4	Range2-Med...	... 16 MHz	HSE	RTC USART1	1.89 mA	1 ms	
11	STANDBY	2.4	NoRange	... 0 Hz	LSI RTC		464 nA	1 ms	

7. Click the **Save** button to save the sequence as SequenceOne.

The application consumption profile is generated. It shows that the overall sequence consumes an average of 2.01 mA for 9 ms, and the battery lifetime is only 4 days (see [Figure 260](#)).

**Figure 260. sequence results before optimization**



### 13.3.2 Optimizing application power consumption

Let us now take several actions to optimize the overall consumption and the battery lifetime. These actions are performed on step 1, 4, 5, 6, 7, 8 and 10.

The next figures show on the left the original step and on the right the step updated with several optimization actions.

### Step 1 (Run)

- Findings

All peripherals are enabled although the application requires only the RTC.

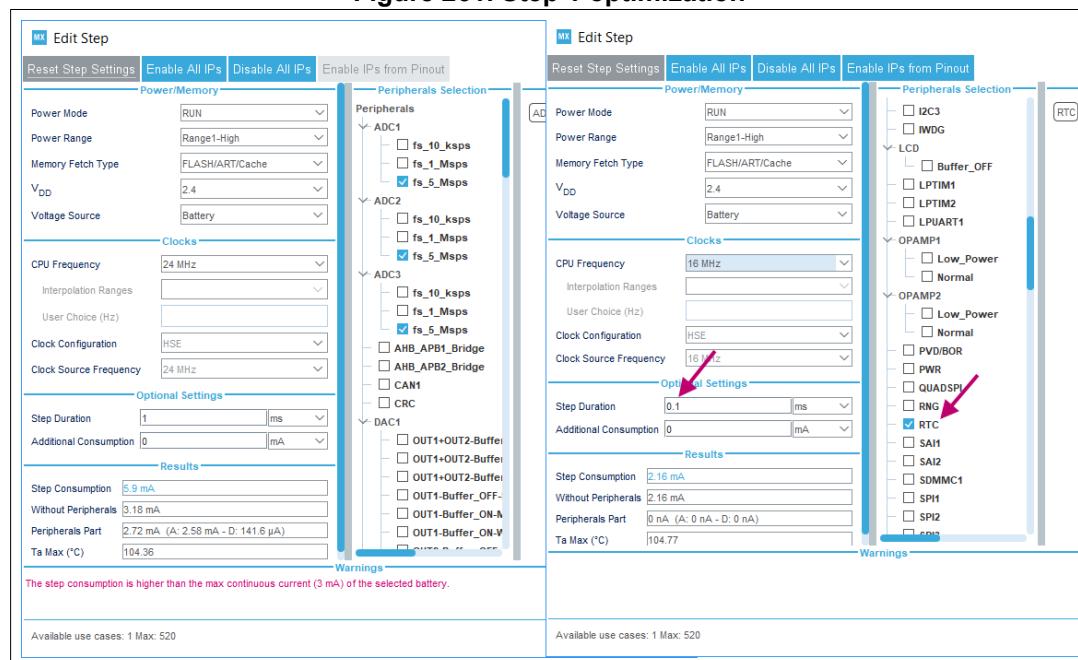
- Actions

- Lower the operating frequency.
- Enable solely the RTC peripheral.
- To reduce the average current consumption, reduce the time spent in this mode.

- Results

The current is reduced from 9.05 mA to 2.16 mA (see [Figure 261](#)).

**Figure 261. Step 1 optimization**



### Step 4 (Run, RTC)

- Action

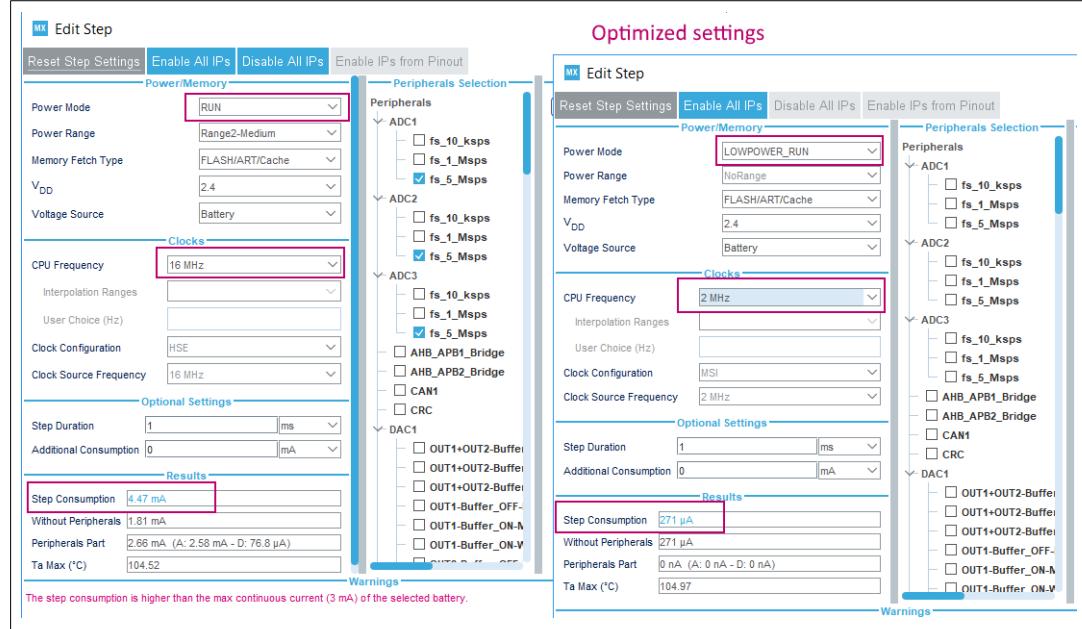
Reduce the time spent in this mode to 0.1 ms.

## Step 5 (Run, ADC, DMA, RTC)

- Actions
  - Change to Low-power run mode.
  - Lower the operating frequency.
- Results

The current consumption is reduced from 6.17 mA to 271 µA (see [Figure 262](#)).

**Figure 262. Step 5 optimization**

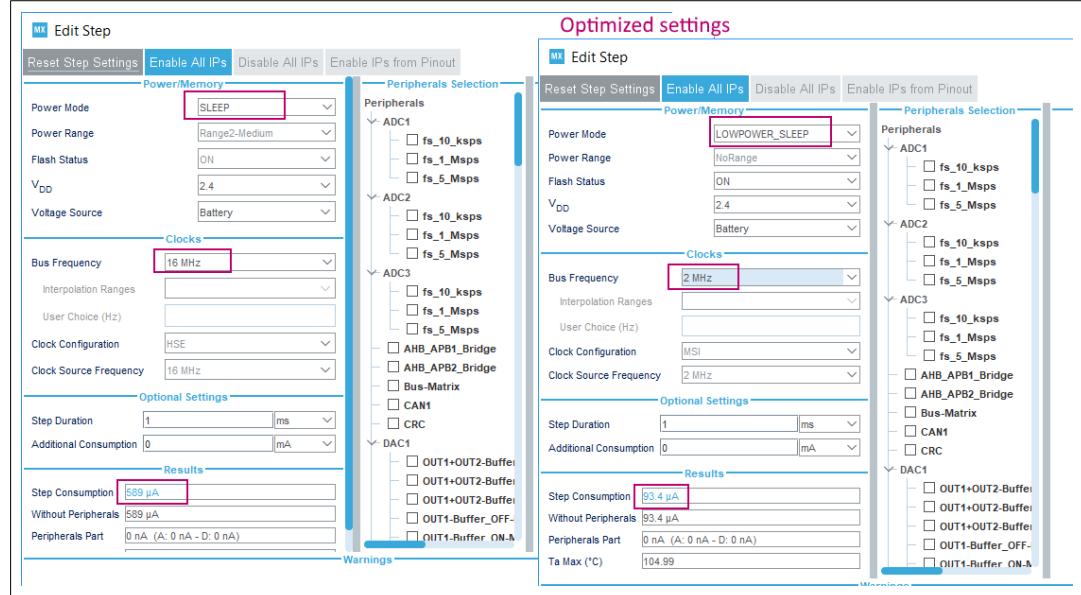


## Step 6 (Sleep, DMA, ADC,RTC)

- Actions
  - Switch to Lower-power sleep mode (BAM mode)
  - Reduce the operating frequency to 2 MHz.
- Results

The current consumption is reduced from 703 µA to 93 µA (see [Figure 263](#)).

**Figure 263. Step 6 optimization**

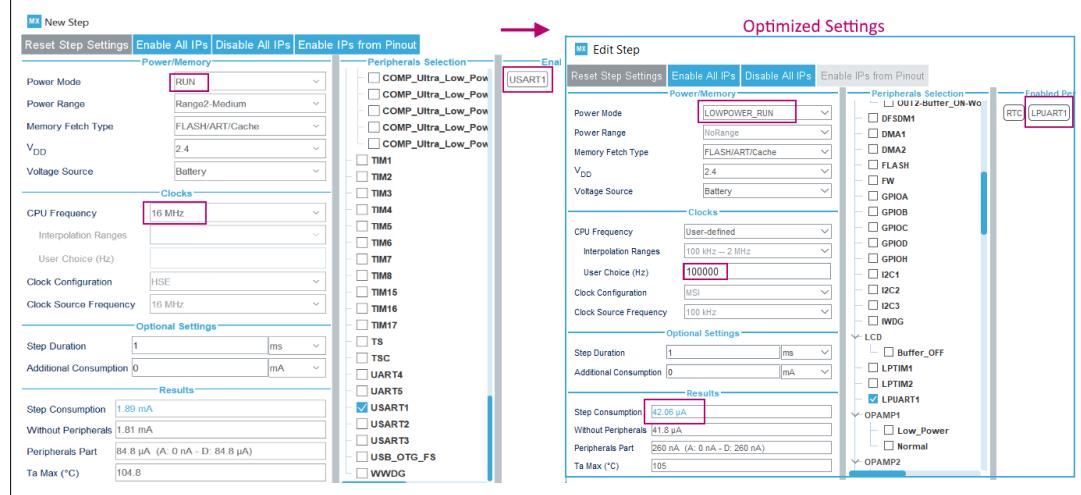


### Step 7 (Run, DMA, RTC, USART)

- Actions
  - Switch to Lower-power run mode.
  - Use the power-efficient LPUART peripheral.
  - Reduce the operating frequency to 1 MHz using the interpolation feature.
- Results

The current consumption is reduced from 1.92  $\mu$ A to 42  $\mu$ A (see [Figure 264](#)).

**Figure 264. Step 7 optimization**

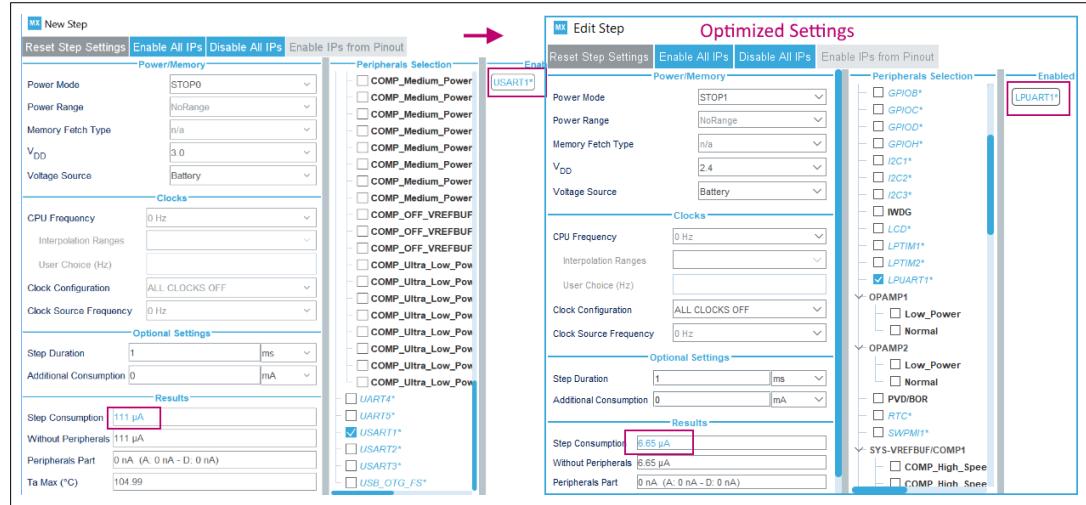


### Step 8 (Stop 0, USART)

- Actions
  - Switch to Stop1 low-power mode.
  - Use the power-efficient LPUART peripheral.
- Results
 

The current consumption is reduced (see [Figure 265](#)).

**Figure 265. Step 8 optimization**



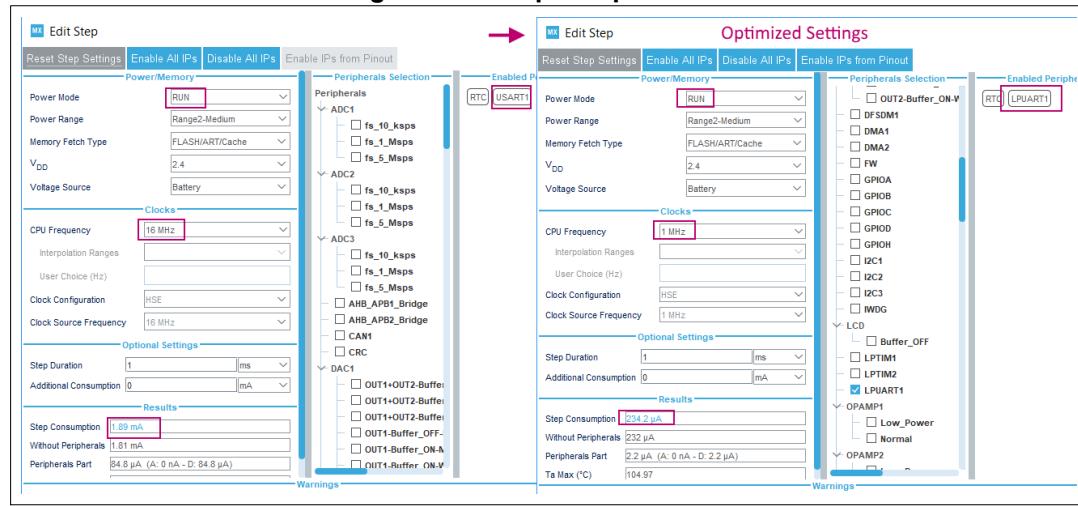
### Step 10 (RTC, USART)

- Actions
  - Use the power-efficient LPUART peripheral.
  - Reduce the operating frequency to 1 MHz.
- Results
 

The current consumption is reduced from 1.89 mA to 234 µA (see [Figure 266](#)).

The example given in [Figure 267](#) shows an average current consumption reduction of 155 µA.

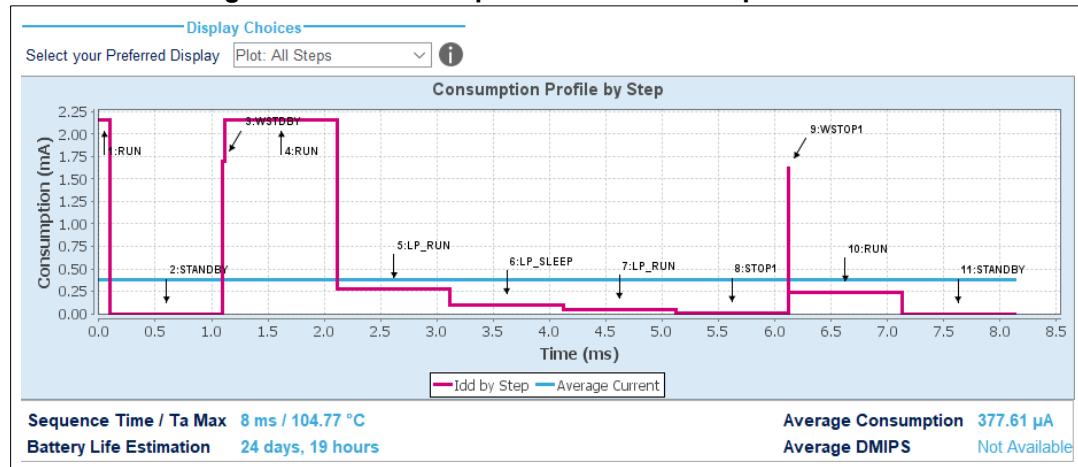
**Figure 266. Step 10 optimization**



See [Figure 267](#) for the sequence overall results: 7 ms duration, about 2 month battery life, and an average current consumption of 165.25 µA.

Use the **compare** button to compare the current results to the original ones saved as SequenceOne.pcs.

**Figure 267. Power sequence results after optimizations**



## 14 Tutorial 4 - Example of UART communications with an STM32L053xx Nucleo board

This tutorial aims at demonstrating how to use STM32CubeMX to create a UART serial communication application for a NUCLEO-L053R8 board.

A Windows PC is required for the example. The ST-Link USB connector is used both for serial data communications, and firmware downloading and debugging on the MCU. A Type-A to mini-B USB cable must be connected between the board and the computer. The USART2 peripheral uses PA2 and PA3 pins, which are wired to the ST-Link connector. In addition, USART2 is selected to communicate with the PC via the ST-Link Virtual COM Port. A serial communication client, such as Tera Term, needs to be installed on the PC to display the messages received from the board over the virtual communication Port.

### 14.1 Tutorial overview

Tutorial 4 will take you through the following steps:

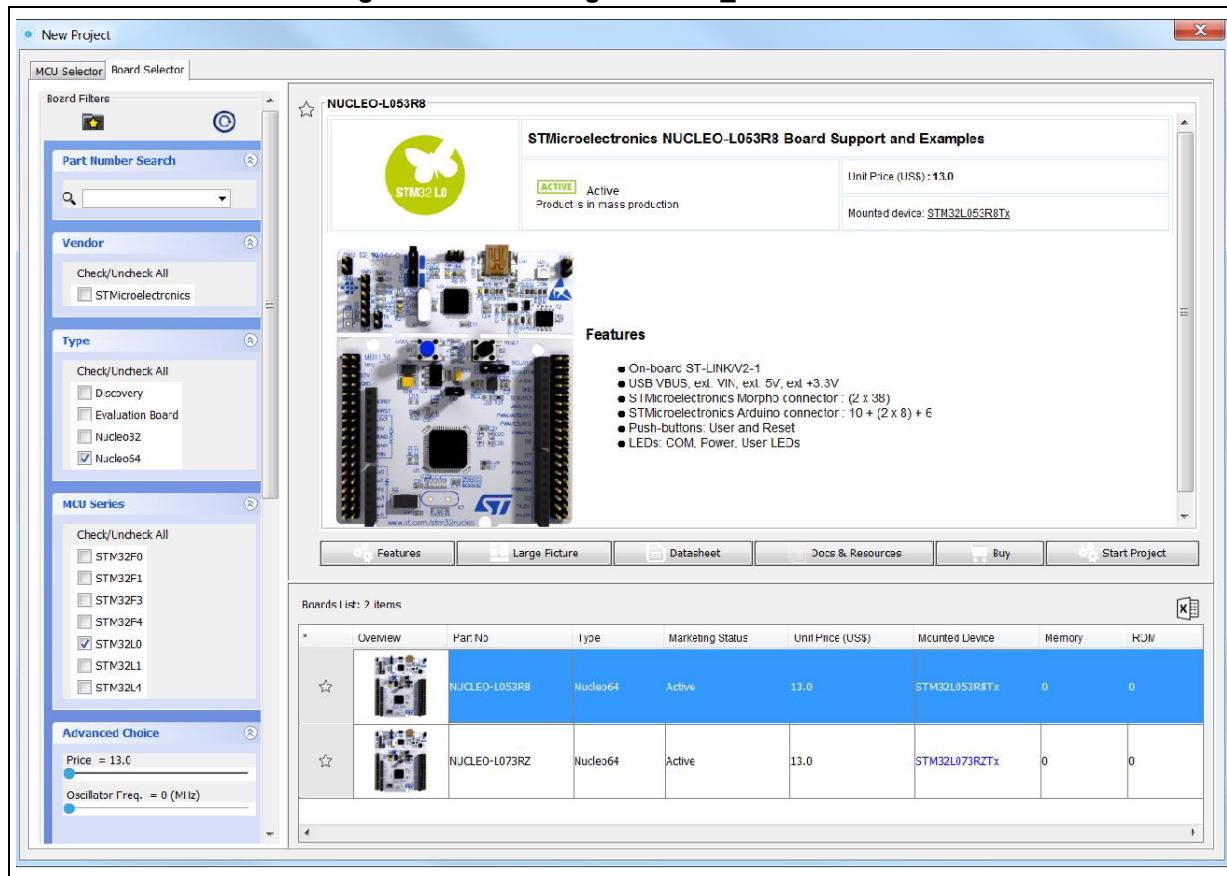
1. Selection of the NUCLEO-L053R8 board from the **New Project** menu.
2. Selection of the required features (debug, USART, timer) from the **Pinout** view: peripheral operating modes as well as assignment of relevant signals on pins.
3. Configuration of the MCU clock tree from the **Clock Configuration** view.
4. Configuration of the peripheral parameters from the **Configuration** view
5. Configuration of the project settings in the **Project Manager** menu and generation of the project (initialization code only).
6. Project update with the user application code corresponding to the USART communication example.
7. Compilation, and execution of the project on the board.
8. Configuration of Tera Term software as serial communication client on the PC.
9. The results are displayed on the PC.

### 14.2 Creating a new STM32CubeMX project and selecting the Nucleo board

To do this, follow the sequence below:

1. Select **File > New project** from the main menu bar. This opens the **New Project** window.
2. Go to the **Board selector** tab and filter on STM32L0 Series.
3. Select NUCLEO-L053R8 and click **OK** to load the board within the STM32CubeMX user interface (see [Figure 268](#)).

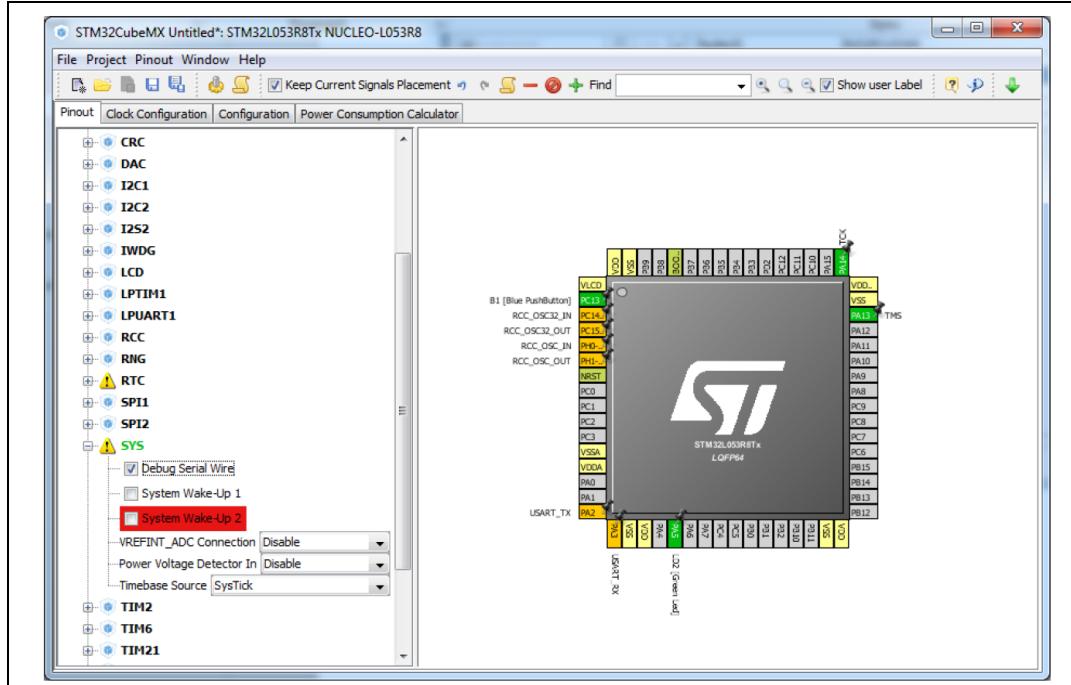
Figure 268. Selecting NUCLEO\_L053R8 board



## 14.3 Selecting the features from the Pinout view

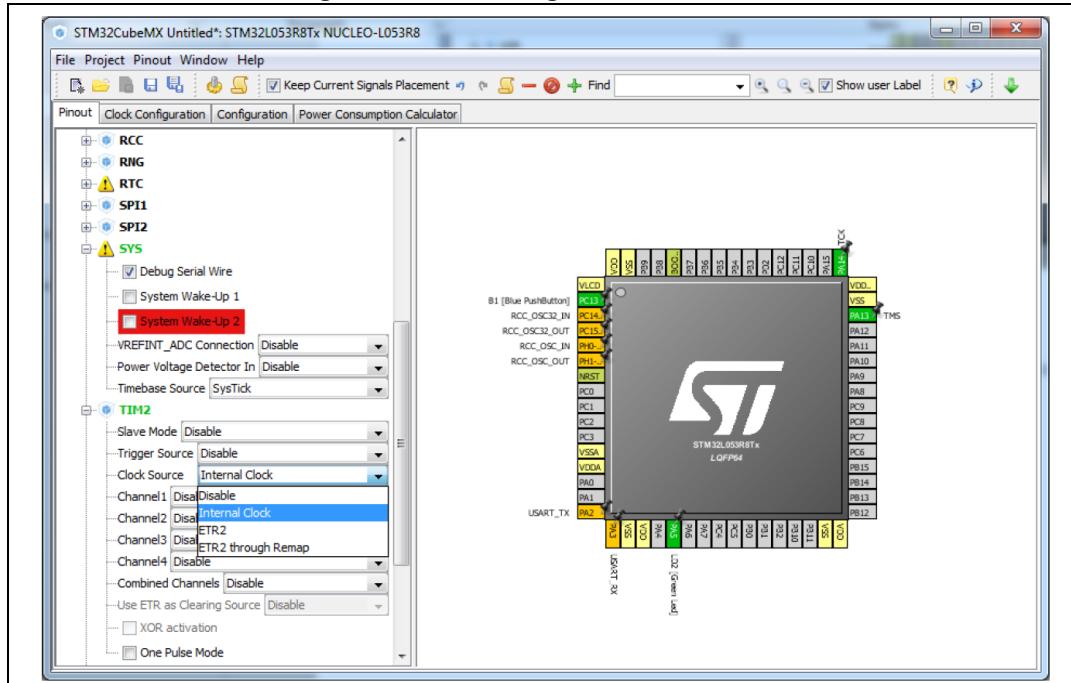
1. Select Debug Serial Wire under SYS (see [Figure 269](#)).

**Figure 269. Selecting debug pins**



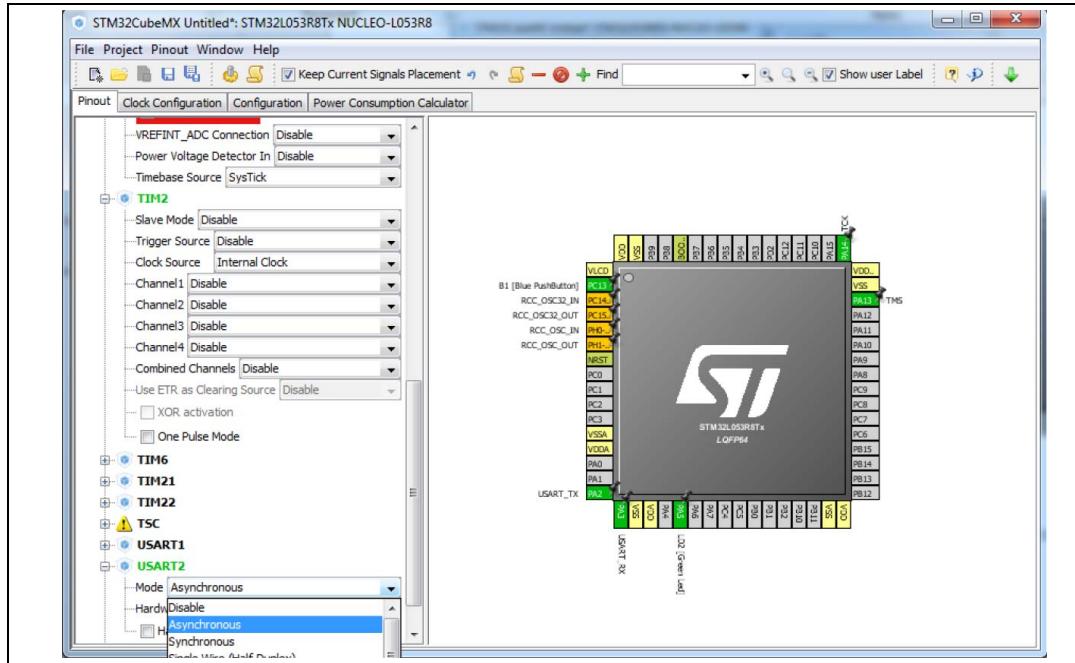
2. Select Internal Clock as clock source under TIM2 peripheral (see [Figure 270](#)).

**Figure 270. Selecting TIM2 clock source**



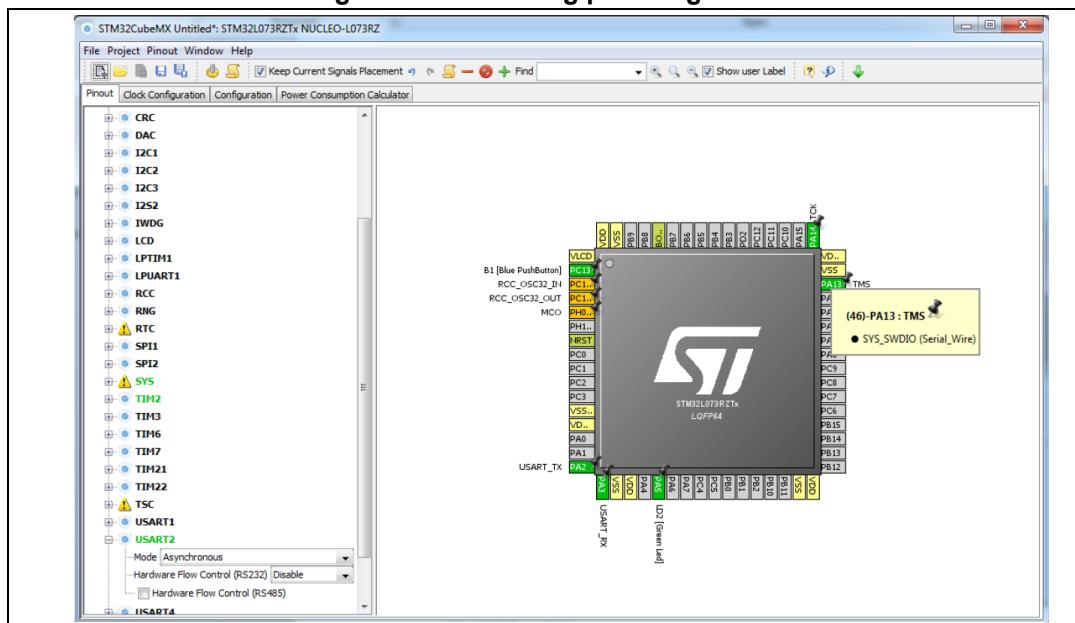
3. Select the Asynchronous mode for the USART2 peripheral (see [Figure 271](#)).

**Figure 271. Selecting asynchronous mode for USART2**



4. Check that the signals are properly assigned on pins (see [Figure 272](#)):
- SYS\_SWDIO on PA13
  - TCK on PA14
  - USART\_RX on PA2
  - USART\_TX on PA3

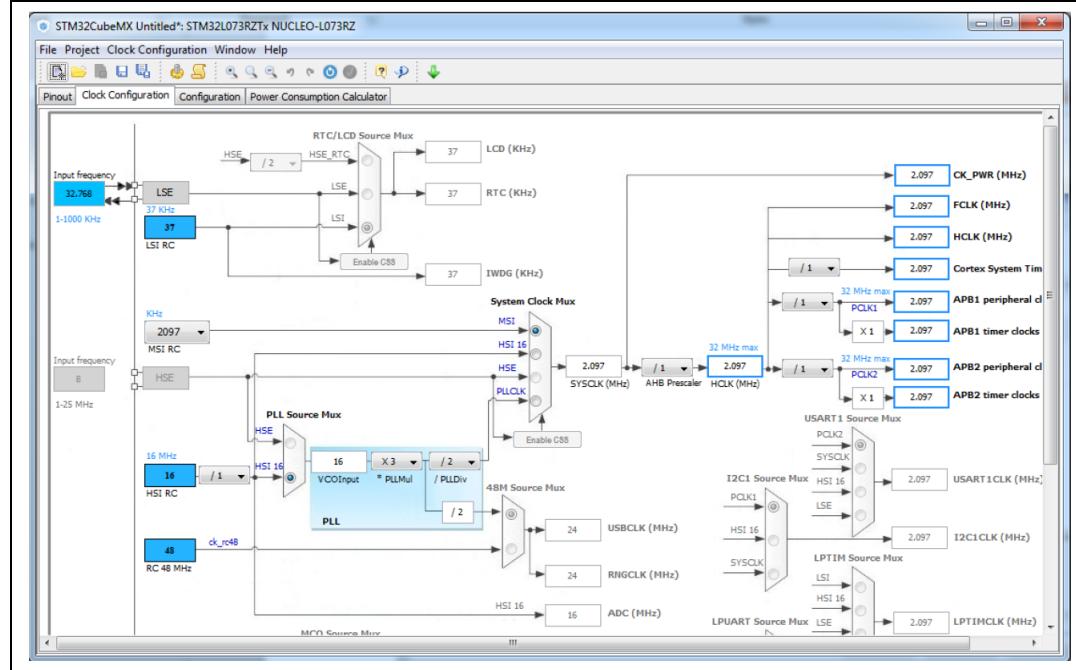
**Figure 272. Checking pin assignment**



## 14.4 Configuring the MCU clock tree from the Clock Configuration view

1. Go to the **Clock Configuration** tab and leave the configuration untouched, in order to use the MSI as input clock and an HCLK of 2.097 MHz (see [Figure 273](#)).

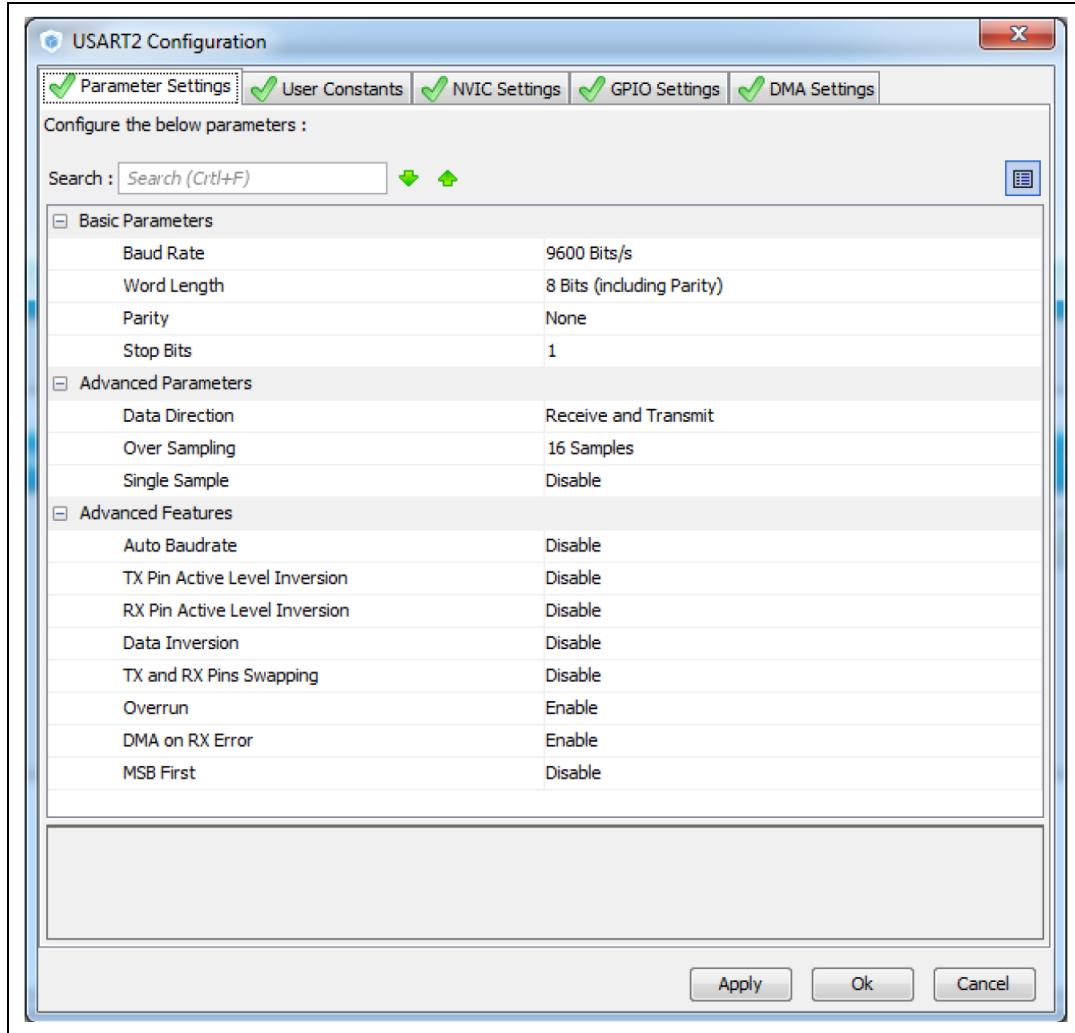
**Figure 273. Configuring the MCU clock tree**



## 14.5 Configuring the peripheral parameters from the Configuration view

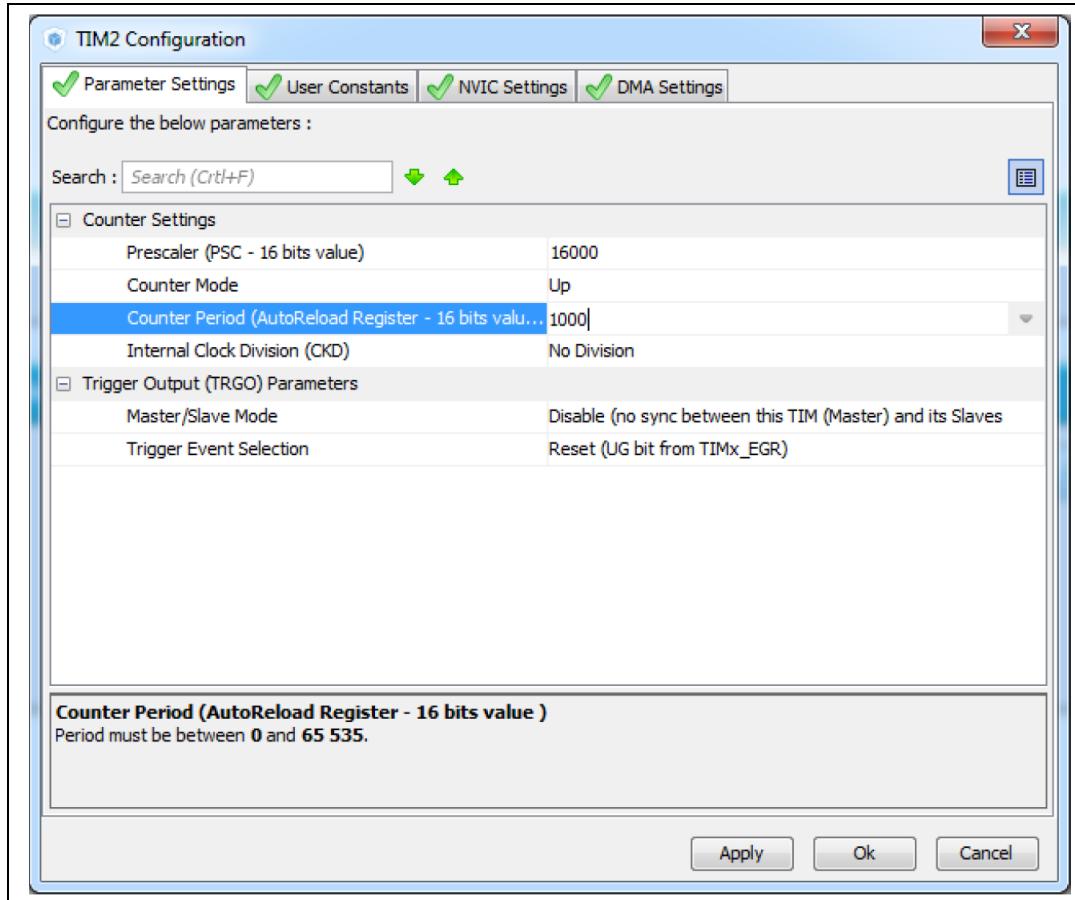
1. From the **Configuration** tab, click **USART2** to open the peripheral **Parameter Settings** window and set the baud rate to 9600. Make sure the Data direction is set to "Receive and Transmit" (see [Figure 274](#)).
2. Click **OK** to apply the changes and close the window.

**Figure 274. Configuring USART2 parameters**



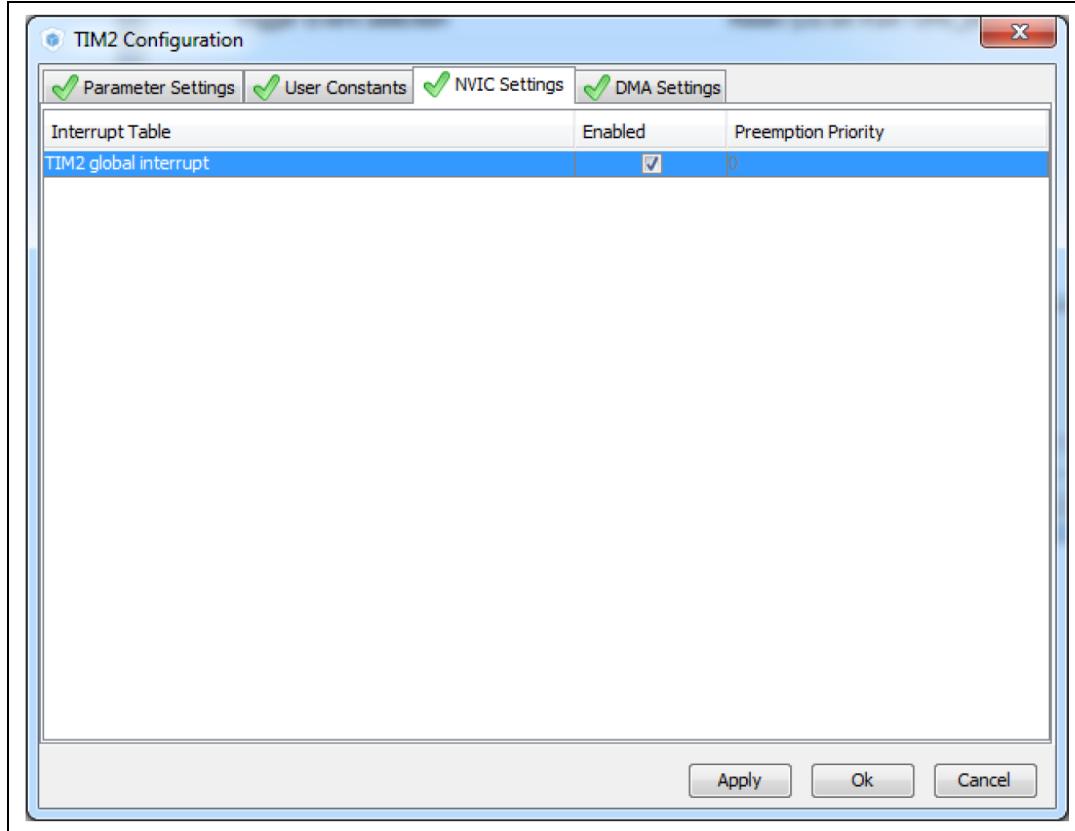
3. Click **TIM2** and change the prescaler to 16000, the Word Length to 8 bits and the Counter Period to 1000 (see [Figure 275](#)).

**Figure 275. Configuring TIM2 parameters**



4. Enable TIM2 global interrupt from the **NVIC Settings** tab (see *Figure 276*).

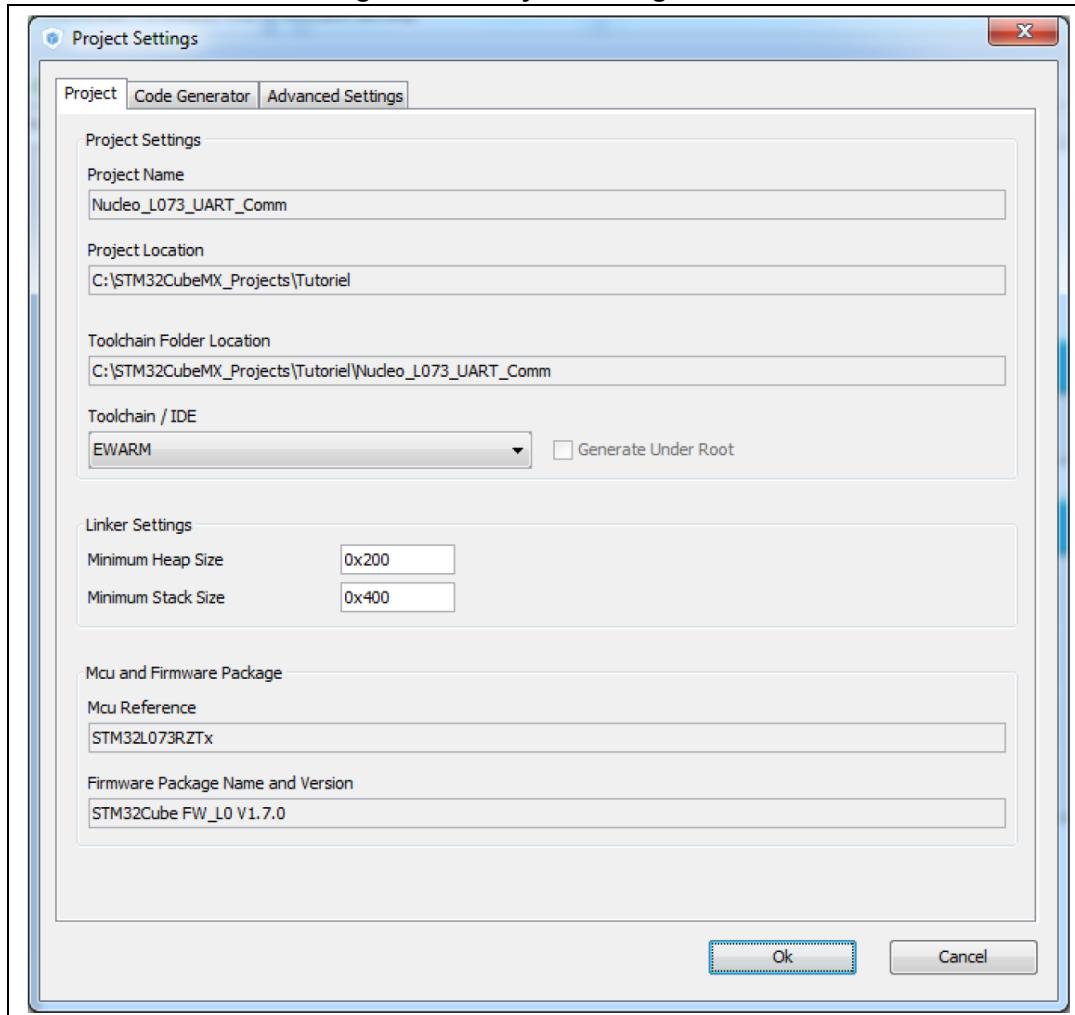
**Figure 276. Enabling TIM2 interrupt**



## 14.6 Configuring the project settings and generating the project

1. In the **Project Settings** menu, specify the project name, destination folder, and select the EWARM IDE toolchain (see *Figure 277*).

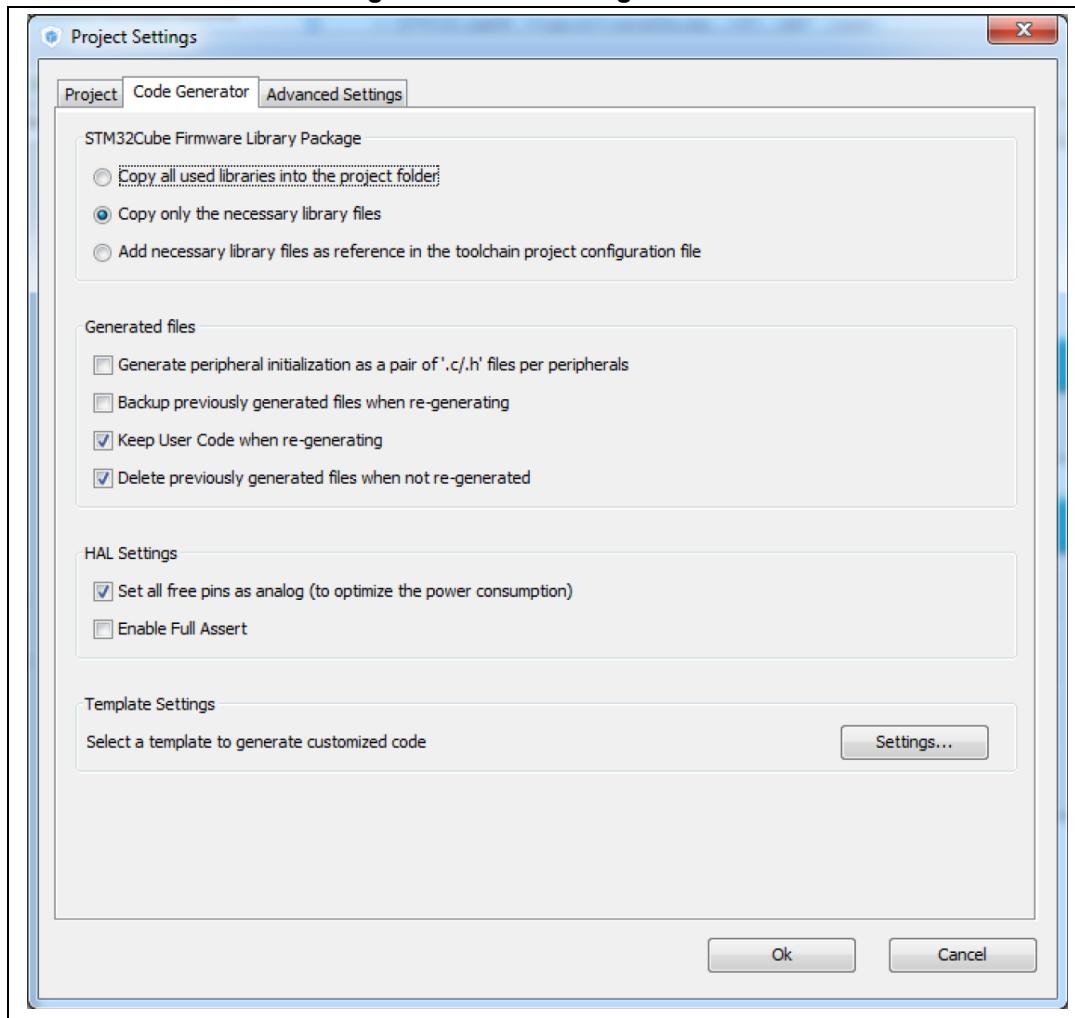
Figure 277. Project Settings menu



If the firmware package version is not already available on the user PC, a progress window opens to show the firmware package download progress.

2. In the **Code Generator** tab, configure the code to be generated as shown in [Figure 278](#), and click **OK** to generate the code.

**Figure 278. Generating the code**



## 14.7 Updating the project with the user application code

Add the user code as follows:

```
/* USER CODE BEGIN 0 */  
#include "stdio.h"  
#include "string.h"  
/* Buffer used for transmission and number of transmissions */  
char aTxBuffer[1024];  
int nbtime=1;  
/* USER CODE END 0 */
```

Within the main function, start the timer event generation function as follows:

```
/* USER CODE BEGIN 2 */
```

```
/* Start Timer event generation */
HAL_TIM_Base_Start_IT(&htim2);
/* USER CODE END 2 */

/* USER CODE BEGIN 4 */
void HAL_TIM_PeriodElapsedCallback(TIM_HandleTypeDef *htim){
    sprintf(aTxBuffer,"STM32CubeMX rocks %d times \t", ++nbtime);
    HAL_UART_Transmit(&huart2,(uint8_t *) aTxBuffer, strlen(aTxBuffer), 5000);
}
/* USER CODE END 4 */
```

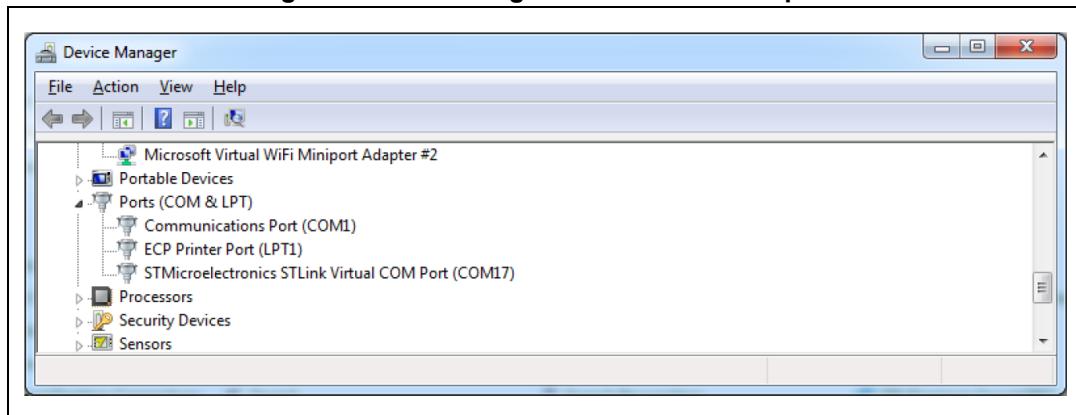
## 14.8 Compiling and running the project

1. Compile the project within your favorite IDE.
2. Download it to the board.
3. Run the program.

## 14.9 Configuring Tera Term software as serial communication client on the PC

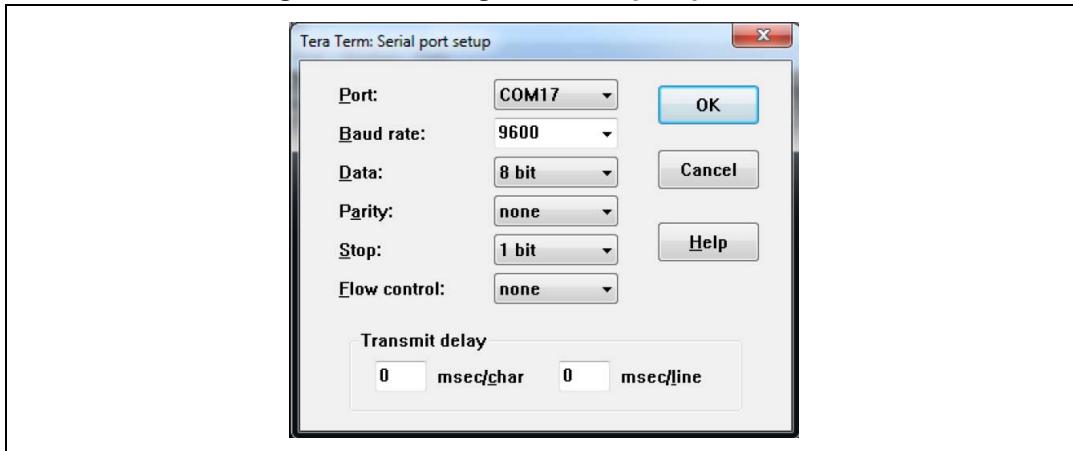
1. On the computer, check the virtual communication port used by ST Microelectronics from the Device Manager window (see [Figure 279](#)).

Figure 279. Checking the communication port



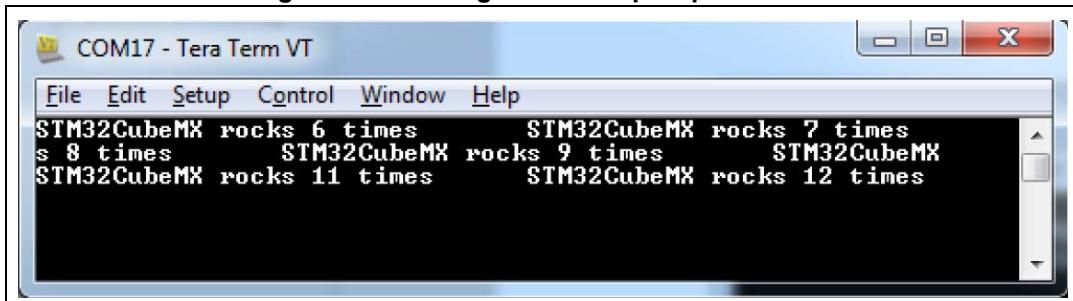
2. To configure Tera Term to listen to the relevant virtual communication port, adjust the parameters to match the USART2 parameter configuration on the MCU (see [Figure 280](#)).

**Figure 280. Setting Tera Term port parameters**



3. The Tera Term window displays a message coming from the board at a period of a few seconds (see [Figure 281](#)).

**Figure 281. Setting Tera Term port parameters**



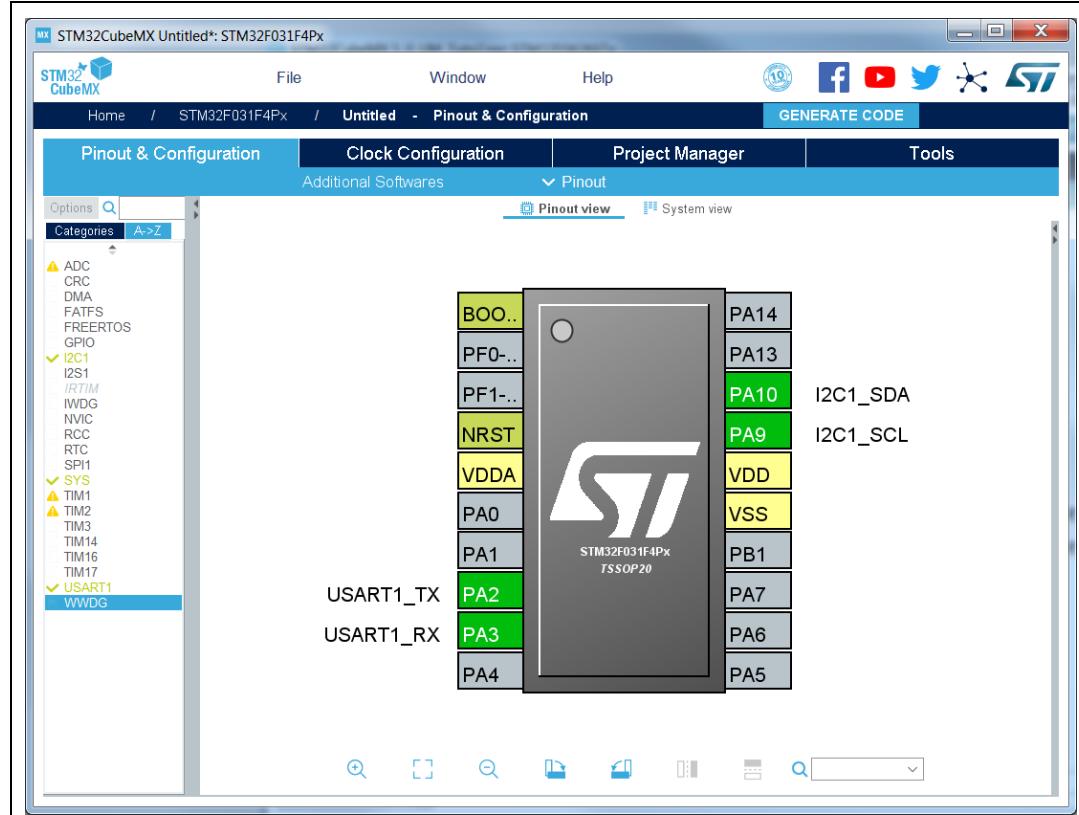
## 15 Tutorial 5: Exporting current project configuration to a compatible MCU

When **List pinout compatible MCUs** is selected from the **Pinout** menu, STM32CubeMX retrieves the list of the MCUs which are compatible with the current project configuration, and offers to export the current configuration to the newly selected compatible MCU.

This tutorial shows how to display the list of compatible MCUs and export your current project configuration to a compatible MCU:

1. Load an existing project, or create and save a new project:

**Figure 282. Existing or new project pinout**



2. Go to the **Pinout** menu and select **List Pinout Compatible MCUs**. The **Pinout compatible** window pops up (see [Figure 283](#) and [Figure 284](#)).

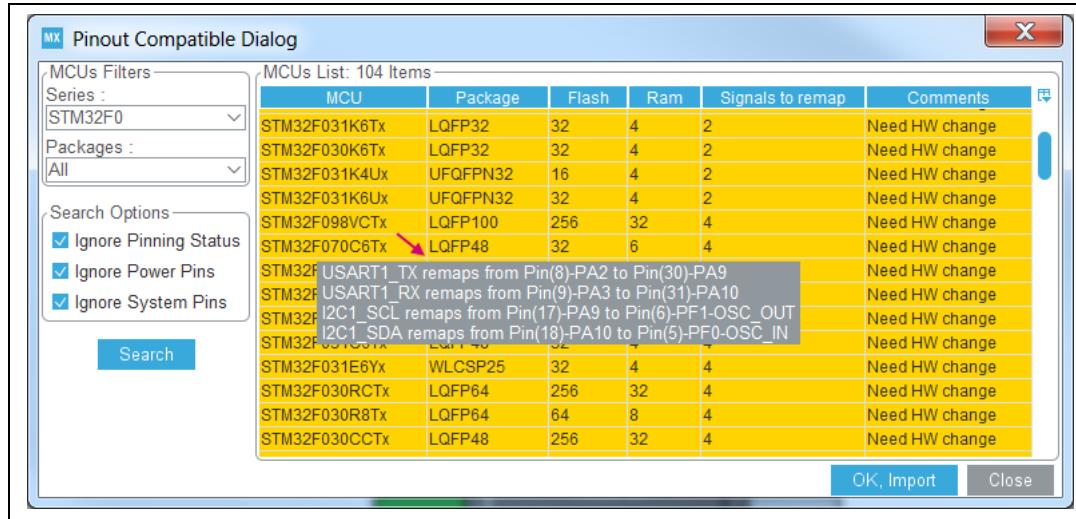
If needed, modify the search criteria and the filter options and restart the search process by clicking the **Search** button.

The color shading and the *Comments* column indicate the level of matching:

- Exact match: the MCU is fully compatible with the current project (see [Figure 284](#) for an example).
- Partial match with hardware compatibility: the hardware compatibility can be ensured but some pin names could not be preserved. Hover the mouse over the desired MCU to display an explanatory tooltip (see [Figure 283](#) for an example).

- Partial match without hardware compatibility: not all signals can be assigned to the exact same pin location and a remapping will be required. Hover the mouse over the desired MCU to display an explanatory tooltip (see [Figure 284](#) for an example).

**Figure 283. List of pinout compatible MCUs - Partial match with hardware compatibility**



**MCUs Filters**

MCU	Package	Flash	Ram	Signals to remap	Comments
STM32F031K6Tx	LQFP32	32	4	2	Need HW change
STM32F030K6Tx	LQFP32	32	4	2	Need HW change
STM32F031K4Ux	UFQFPN32	16	4	2	Need HW change
STM32F031K6Ux	UFQFPN32	32	4	2	Need HW change
STM32F098VCTx	LQFP100	256	32	4	Need HW change
STM32F070C6Tx	LQFP48	32	6	4	Need HW change
STM32F USART1_TX	remaps from Pin(8)-PA2 to Pin(30)-PA9				Need HW change
STM32F USART1_RX	remaps from Pin(9)-PA3 to Pin(31)-PA10				Need HW change
STM32F I2C1_SCL	remaps from Pin(17)-PA9 to Pin(6)-PF1-OSC_OUT				Need HW change
STM32F I2C1_SDA	remaps from Pin(18)-PA10 to Pin(5)-PF0-OSC_IN				Need HW change
STM32F031C6Yx	LQFP48	32	4	4	Need HW change
STM32F031E6Yx	WLCS25	32	4	4	Need HW change
STM32F030RCTx	LQFP64	256	32	4	Need HW change
STM32F030R8Tx	LQFP64	64	8	4	Need HW change
STM32F030CCTx	LQFP48	256	32	4	Need HW change

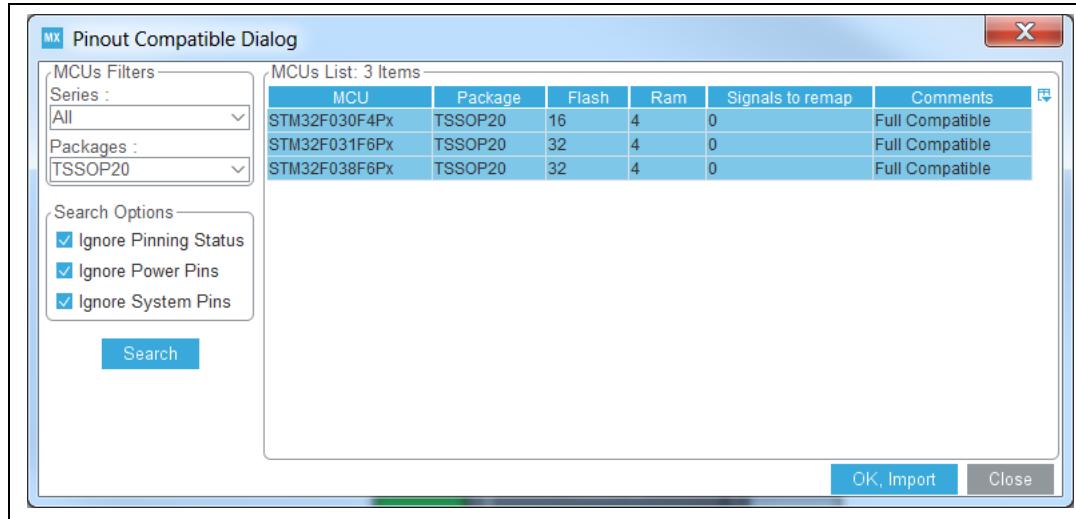
**Search Options**

Ignore Pinning Status  
 Ignore Power Pins  
 Ignore System Pins

**Search**

**OK, Import** **Close**

**Figure 284. List of Pinout compatible MCUs - Exact and partial match**



**MCUs Filters**

MCU	Package	Flash	Ram	Signals to remap	Comments
STM32F030F4Px	TSSOP20	16	4	0	Full Compatible
STM32F031F6Px	TSSOP20	32	4	0	Full Compatible
STM32F038F6Px	TSSOP20	32	4	0	Full Compatible

**Search Options**

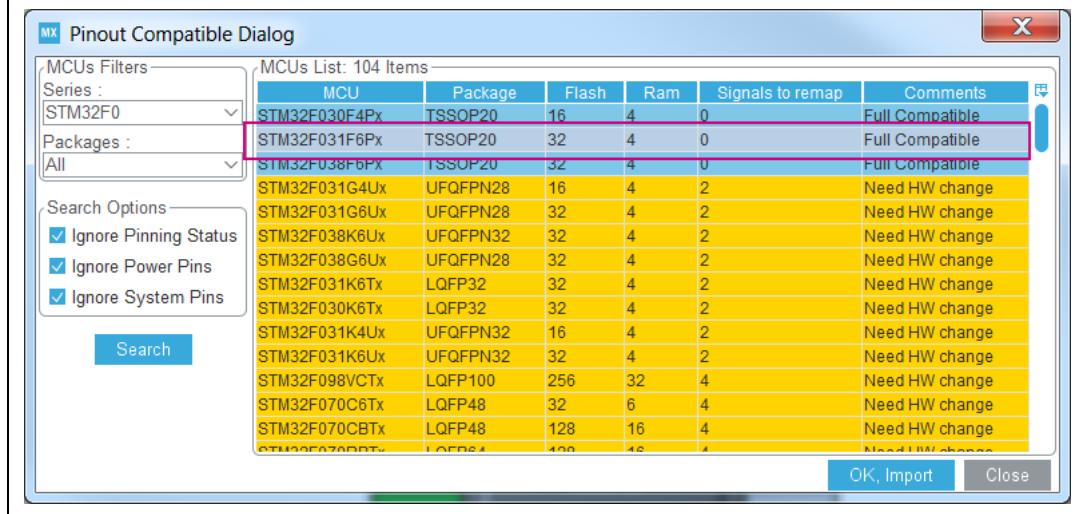
Ignore Pinning Status  
 Ignore Power Pins  
 Ignore System Pins

**Search**

**OK, Import** **Close**

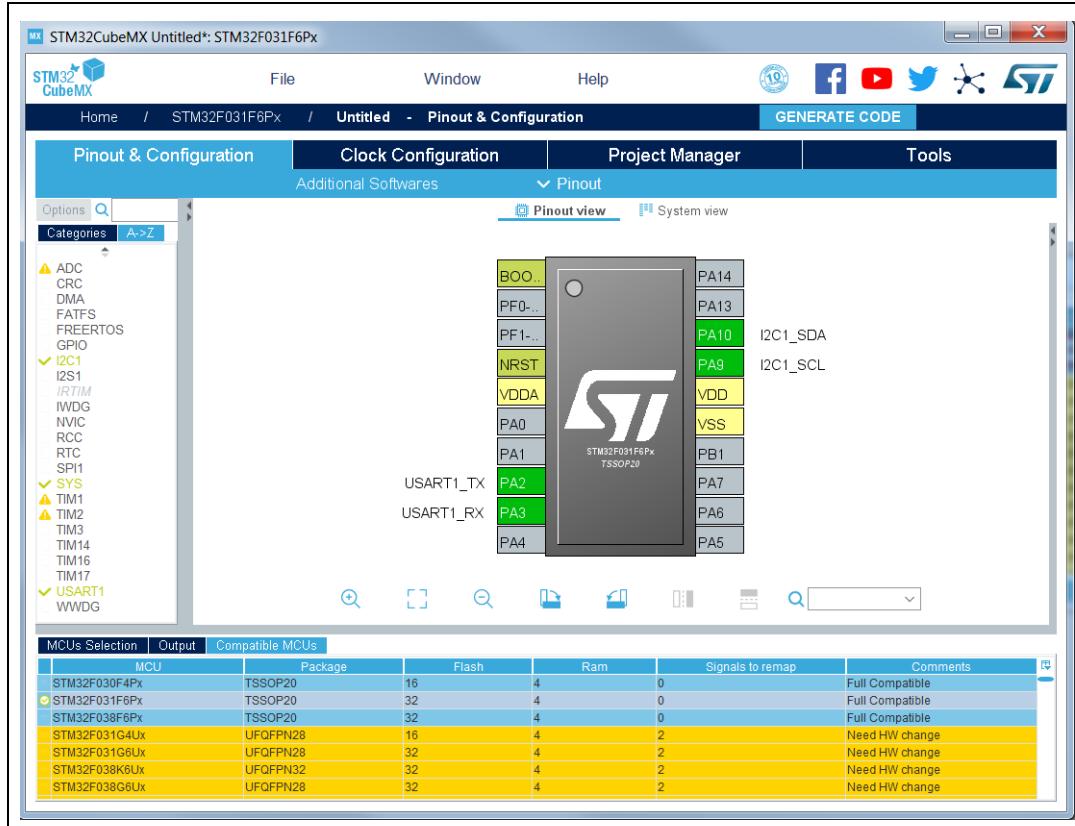
3. Then, select an MCU to import the current configuration to, and click **OK, Import**:

**Figure 285. Selecting a compatible MCU and importing the configuration**



The configuration is now available for the selected MCU:

**Figure 286. Configuration imported to the selected compatible MCU**



4. To see the list of compatible MCUs at any time, select **Outputs** under the **Window** menu.  
To load the current configuration to another compatible MCU, double-click the list of compatible MCUs.
5. To remove some constraints on the search criteria, several solutions are possible:
  - Select the **Ignore Pinning Status** checkbox to ignore pin status (locked pins).
  - Select the **Ignore Power Pins** checkbox not to take into account the power pins.
  - Select the **Ignore System Pins** not take into account the system pins. Hover the mouse over the checkbox to display a tooltip that lists the system pins available on the current MCU.

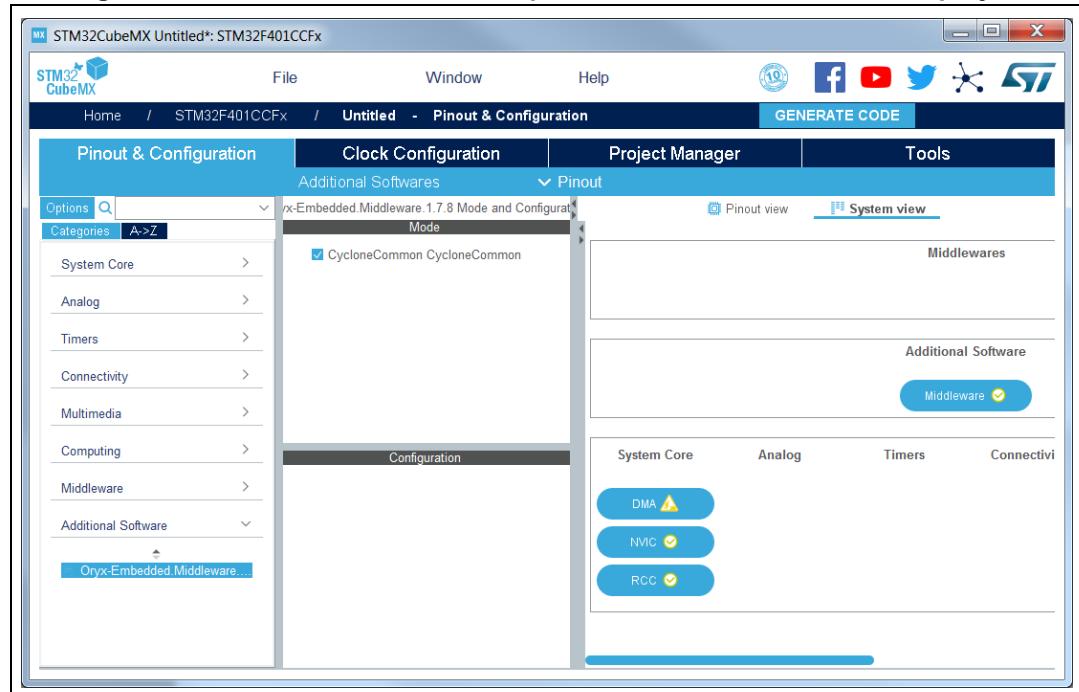
## 16 Tutorial 6 – Adding embedded software packs to user projects

In this tutorial, the Oryx-Embedded.Middleware.1.7.8. pack is taken as an example to demonstrate how to add pack software components to STM32CubeMX projects. The use of this package shall not be understood as an STMicroelectronics recommendation.

To add embedded software packs to your project, proceed as follows:

1. Install Oryx-Embedded.Middleware.1.7.8.pack using the .pdsc file available from <http://www.oryx-embedded.com> (see [Section 3.4.4: Installing embedded software packs](#)).
2. Select **New project**.
3. Select STM32F01CCFx from the **MCU selector**.
4. Select **Additional Software** from the **Pinout & Configuration** view to open the additional software component window and choose the following software components: Compiler Support, RTOS Port/None and Date Time Helper Routines from the CycloneCommon bundle (see [Section 4.13: Additional software component selection window](#)).
5. Click **OK** to display the selected components on the tree view and click the checkbox to enable the software components for the current project (see [Figure 287](#)).

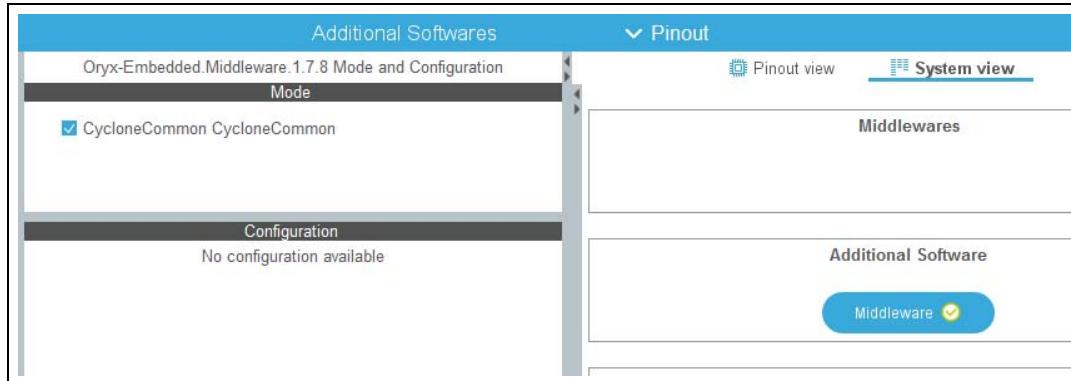
**Figure 287. Additional software components enabled for the current project**



The pack name highlighted in green indicates that all conditions for the selected software components resolve to true. If at least one condition is not resolved, the pack name is highlighted in orange.

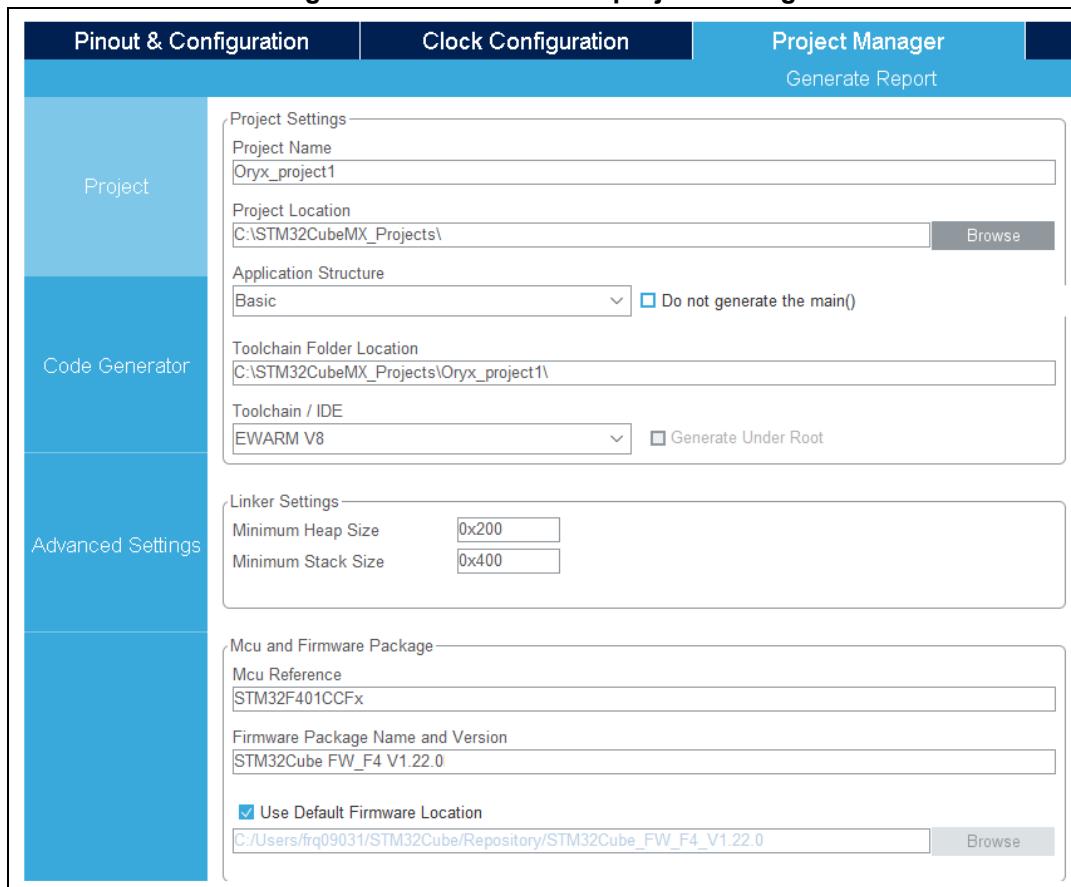
6. Check that no parameters can be configured in the **Configuration** tab (see [Figure 288](#)).

**Figure 288. Pack software components - no configurable parameters**



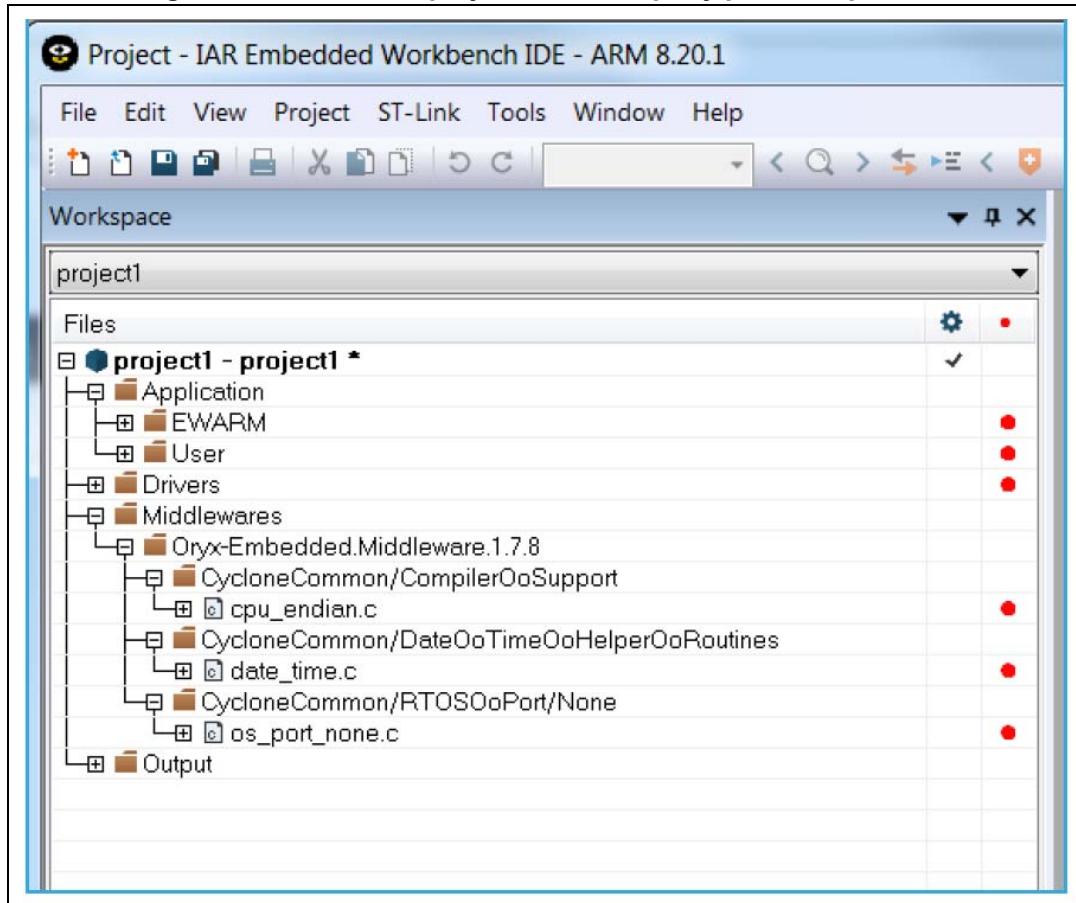
7. Select the **Project manager** project tab to specify project parameters (see [Figure 289](#)), and choose IAR™ EWARM as IDE.

**Figure 289. Pack tutorial - project settings**



8. Generate your project by clicking **GENERATE CODE**. Accept to download the STM32CubeF4 MCU package if it is not present in STM32Cube repository.
9. Click **Open project**. The Oryx software components are displayed in the generated project (see *Figure 290*).

**Figure 290. Generated project with third party pack components**



## 17 Tutorial 7 – Using the X-Cube-BLE1 software pack

This tutorial demonstrates how to achieve a functional project using the X-Cube-BLE1 software pack.

Below the prerequisites to run this tutorial:

- Hardware: NUCLEO-L053R8, X-NUCLEO-IDB05A1 and mini-USB cable (see [Figure 291](#))
- Tools: STM32CubeMX, IDE (Atollic® or any other toolchain supported by STM32CubeMX)
- Embedded software package: STM32CubeL0 (version 1.10.0 or higher), X-Cube-BLE1 1.1.0 (see [Figure 292](#)).
- Mobile application (see [Figure 293](#)): STMicroelectronics BlueNRG application for iOS® or Android™

**Figure 291. Hardware prerequisites**

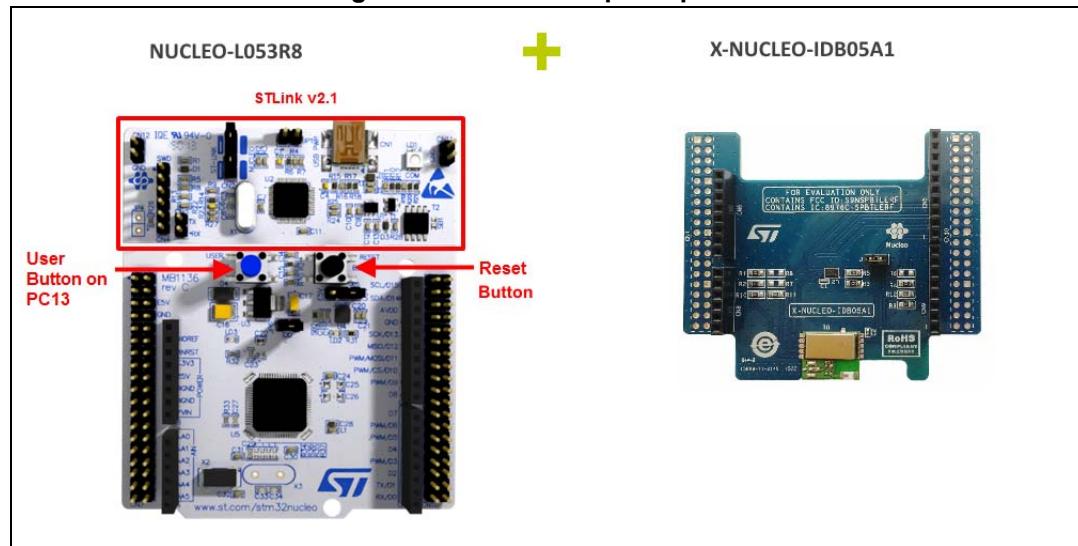


Figure 292. Embedded software packages

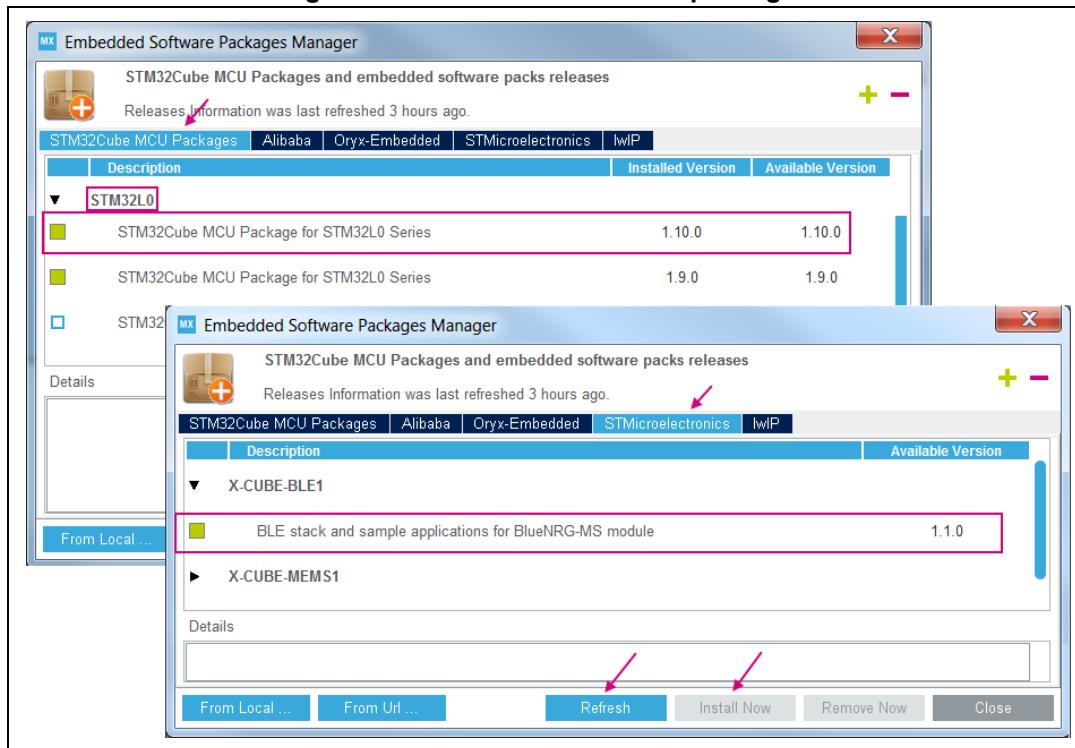
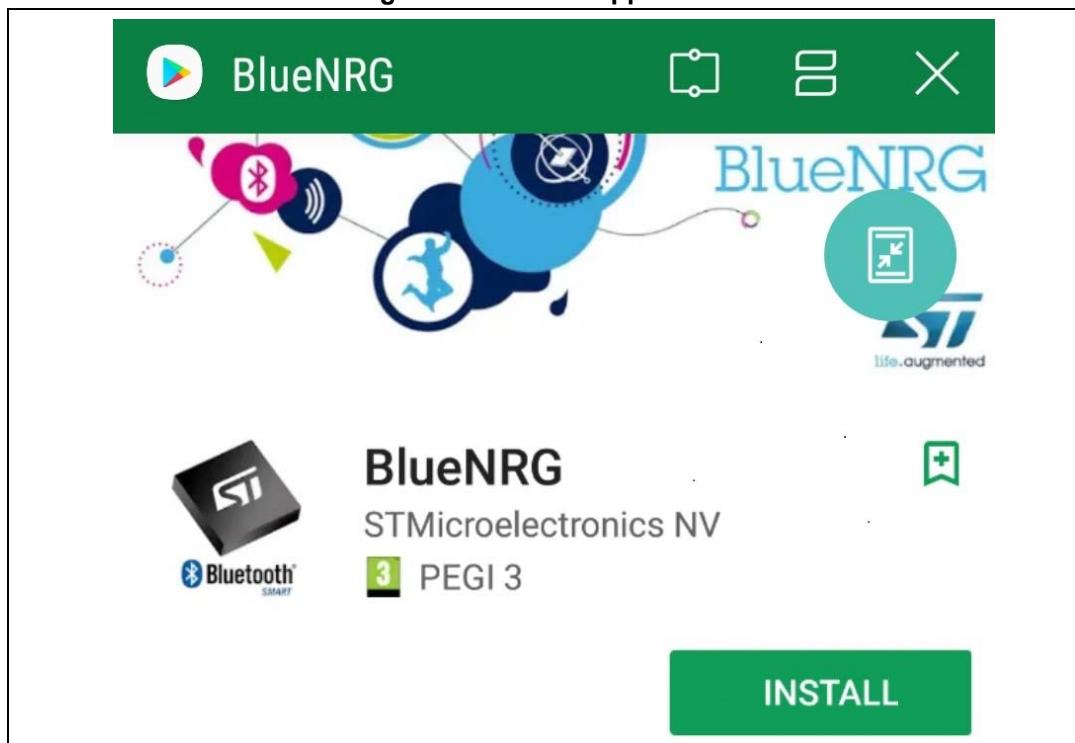


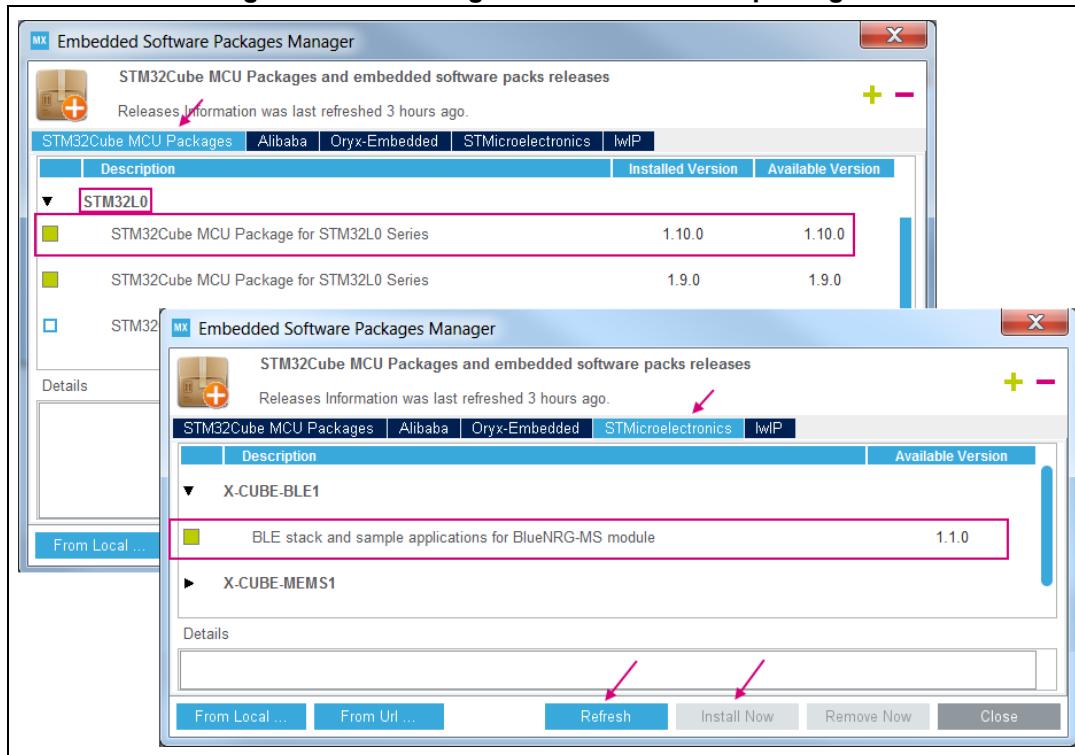
Figure 293. Mobile application



Proceed as follows to install and run the tutorial:

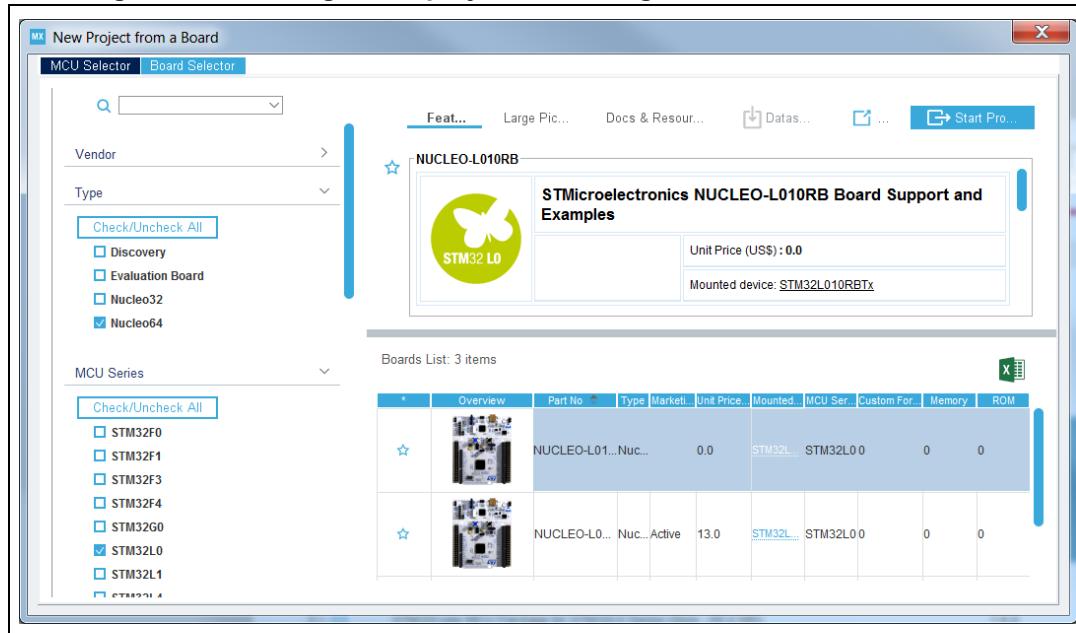
1. Check STM32CubeMX Internet connection:
  - a) Select the **Help > Updater settings** menu to open the updater window.
  - b) Verify in the **Connection** tab that the Internet connection is configured and up.
2. Install the required embedded software packages (see [Figure 294](#)):
  - a) Select the **Help > Manage Embedded software packages** menu to open the **embedded software package manager** window.
  - b) Click the **Refresh** button to refresh the list with the latest available package versions.
  - c) Select the **STM32Cube MCU Package** tab and check that the STM32CubeL0 firmware package version 1.10.0 or higher is installed (the checkbox must be green). Otherwise select the checkbox and click **Install now**.
  - d) Select the **STMicroelectronics** tab and check that the X-Cube-BLE1 software pack version 1.0.0 is installed (checkbox must be green). Otherwise, select the checkbox and click **Install now**.

**Figure 294. Installing Embedded software packages**

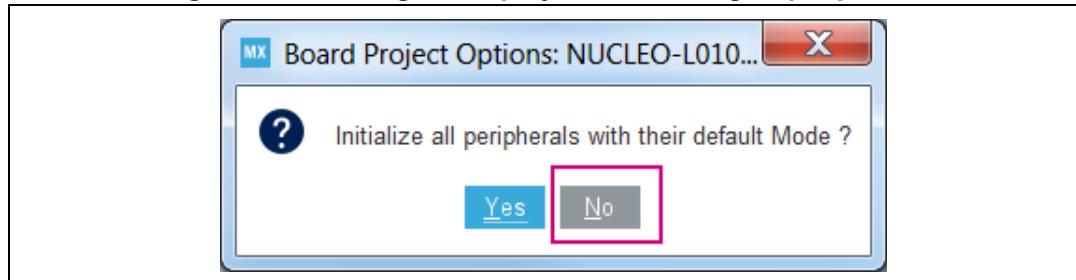


3. Start a new project:
  - a) Select **New Project** to open the new project window.
  - b) Select the **Board selector** tab.
  - c) Select Nucleo64 as board type and STM32L0 as MCU Series.
  - d) Select the NUCLEO-L053R8 from the resulting board list (see [Figure 295](#)).
  - e) Answer **No** when prompted to initialize all peripherals in their default mode (see [Figure 296](#)).

**Figure 295. Starting a new project - selecting the NUCLEO-L053R8 board**



**Figure 296. Starting a new project - initializing all peripherals**



4. Add X-Cube-BLE1 components to the project:
  - a) Click **Additional Software** from **Pinout & Configuration** view to open the **Additional Software component Selection** window.
  - b) Select the relevant components (see [Figure 297](#))  
The Application group comes with a list of applications: the C files implement the application loop, that is the *Process()* function. From the Application group, select the **SensorDemo** application.  
Select the **Controller** and **Utils** components  
Select the **Basic** variant for the **HCI\_TL** component. The Basic variant provides the STMicroelectronics implementation of the HCI\_TL API while the template option requires the user to implement his own code.  
Select the **UserBoard** variant as **HCI\_TL\_INTERFACE** component. Using the UserBoard option generates the <boardname>\_bus.c file, that is nucleo\_l053r8\_bus.c for this tutorial, while the template option generates the custom\_bus.c file and requires the user to provide his own implementation.  
Refer to the X-Cube-BLE1 pack documentation for more details on software components.

- c) Click **OK** to apply the selection to the project and close the window. The left panel **Additional Software** section is updated accordingly.

**Figure 297. Selecting X-Cube-BLE1 components**

The screenshot shows a software interface for selecting X-Cube components. On the left, there's a tree view under 'Packs' with several nodes expanded, including 'Exposed APIs', 'Wireless BlueNRG-MS', and 'Device X-NUCLEO-IDB05A1'. To the right is a table with columns for 'Pack / Bundle / Component', 'Version', and 'Selection'. The 'Selection' column contains dropdown menus with checkboxes. Three pink arrows point to these dropdowns: one to the 'Controller' dropdown (which has a checked box), one to the 'UserBoard' dropdown (which also has a checked box), and one to the 'SensorDemo' dropdown. The table rows are:

Pack / Bundle / Component	Version	Selection
STMICROELECTRONICS.X-CUBE-BLE1	5.0.0	
> Exposed APIs		
> Wireless BlueNRG-MS	4.4.0	
Controller		<input checked="" type="checkbox"/>
HCI_TL		<input type="checkbox"/>
HCI_TL_INTERFACE		<input type="checkbox"/>
Utils		<input checked="" type="checkbox"/>
> Device X-NUCLEO-IDB05A1	5.0.0	
Application		<input type="checkbox"/>

5. Enable peripherals and GPIOs from the **Pinout** tab (see [Figure 298](#)):
- Configure **USART2** in **Asynchronous** mode.
  - Configure **SPI1** in **Full-duplex master** mode.
  - Left-click the following pins and configure them for the required GPIO settings:  
**PA0**: GPIO\_EXTI0  
**PA1**: GPIO\_Output  
**PA8**: GPIO\_Output
  - Enable **Debug Serial Wire** under **SYS** peripheral.

Figure 298. Configuring peripherals and GPIOs



6. Configure the peripherals from the **Configuration** tab:
  - a) Click the **NVIC** button under the **System** section to open the **NVIC configuration** window. Enable EXTI line 0 and line 1 interrupts and click **OK** (see [Figure 299](#)).
  - b) Click the **SPI** button under the **Connectivity** section to open the **SPI configuration** window. Check that the data size is set to 8 bits and the prescaler value to 16 so that HCLK divided by the prescaler value is less or equal to 8 MHz.
  - c) Click **USART2** under the **Connectivity** section to open the **Configuration** window and check the following parameter settings:

**Under Parameter Settings:**

Baud rate: 115200 bits/s

Word length: 8 bits (including parity)

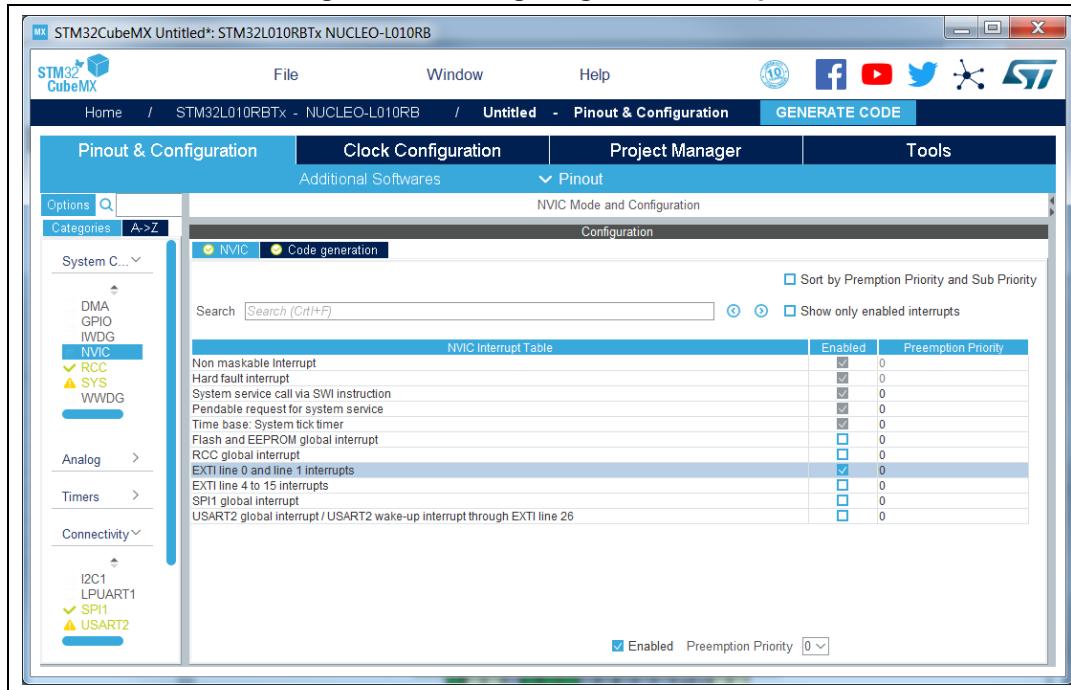
Parity: none

Stop bits: 1

**Under GPIO Settings:**

User labels: USART\_RX and USART\_TX

Figure 299. Configuring NVIC interrupts



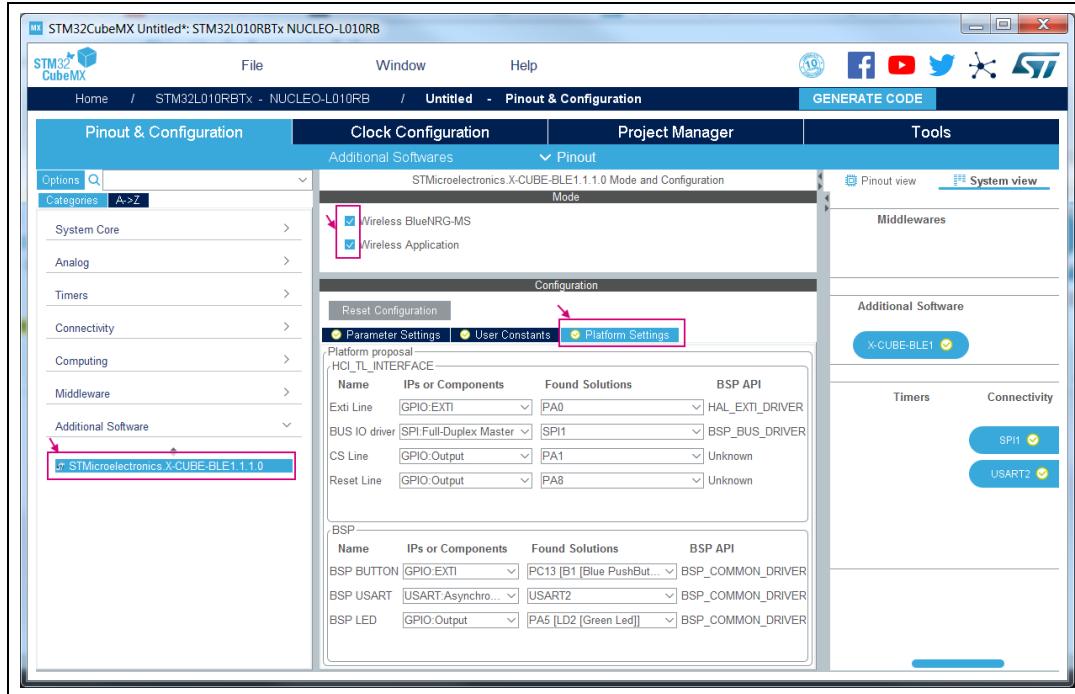
7. Enable and configure X-Cube-BLE1 pack components from the **Pinout & Configuration** view:
  - a) Click the pack items from the left panel to show the mode and configuration tabs.
  - b) Click the check boxes from the Mode panel to enable X-Cube-BLE1, the configuration panel appears showing the parameters to configure. An orange triangle indicates that some parameters are not configured. It turns into a green check mark once all parameters are correctly configured (see [Figure 300](#)).
  - c) Leave the Parameter Settings Tab unchanged.
  - d) Go the Platform settings tab, configure the connection with the hardware resources as indicated in [Figure 300](#) and [Table 23](#).

Table 23. Connection with hardware resources

Name	IPs or components	Found solutions
BUS IO driver	SPI in Full-duplex master mode	SPI1
EXTI Line	GPIO:EXTI	PA0
CS Line	GPIO:output	PA1
Reset Line	GPIO:output	PA8
BSP LED	GPIO:output	PA5
BSP Button	GPIO:EXTI	PC13
BSP USART	USART in Asynchronous mode	USART2

Check that the icon turns to . Click **OK** to close the **Configuration** window.

Figure 300. Enabling X-Cube-BLE1



8. Generate the SensorDemo project:

- Click **GENERATE CODE** to generate the code. The **Project settings** window opens if the project has not yet been saved.
- Click **GENERATE CODE** to generate the code once the project settings have been properly configured (see [Figure 301](#)). When the generation is complete, a dialog window requests to open the project folder (Open Folder) or to open the project in IDE toolchain (Open Project). Select **Open Project** (see [Figure 302](#)).
- If .cproject files are associated to Atollic® TrueStudio®, TrueStudio® is automatically launched by clicking **Open Project**: from the TrueStudio launch window, create or select an existing workspace (see [Figure 303](#)) and click **OK**. STM32CubeMX generated project appears in the TrueStudio® **Project explorer** panel (see [Figure 304](#)).

Figure 301. Configuring the SensorDemo project

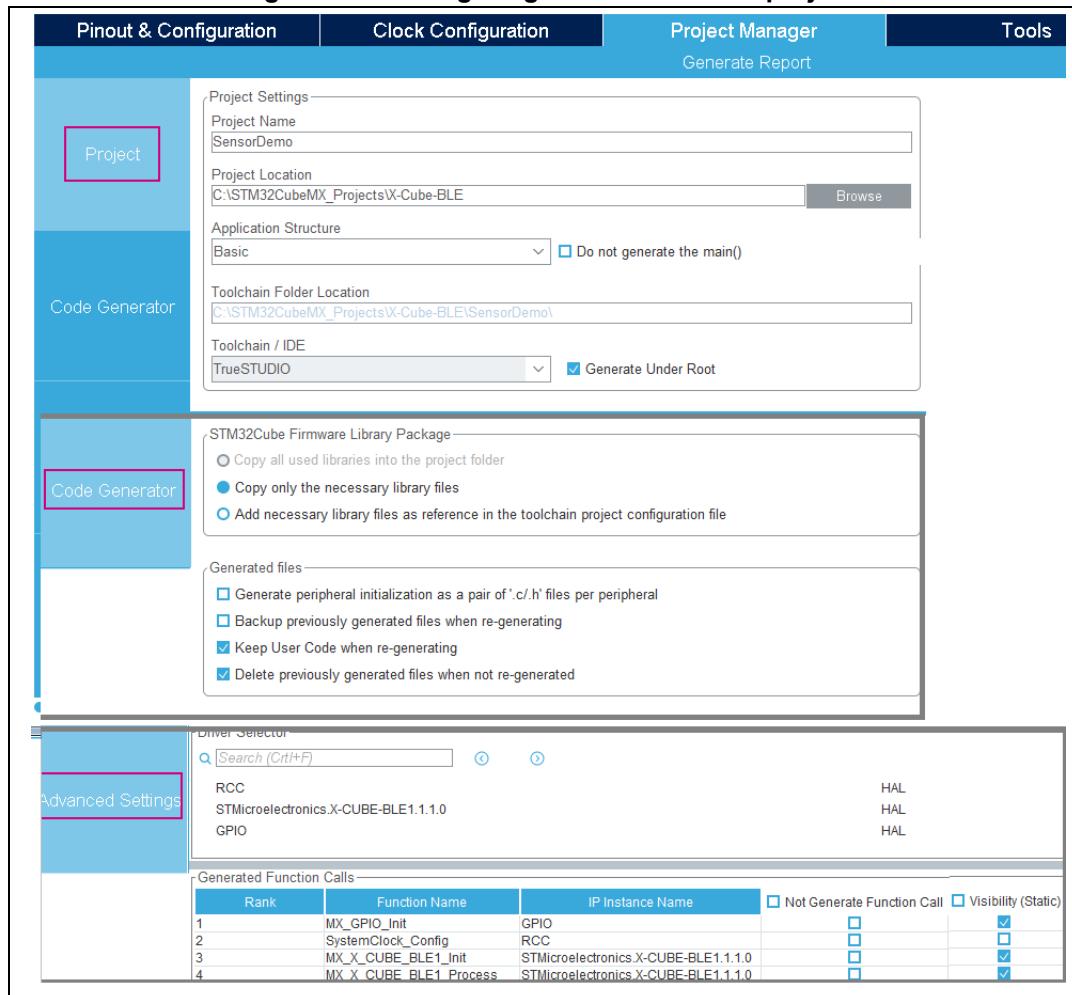
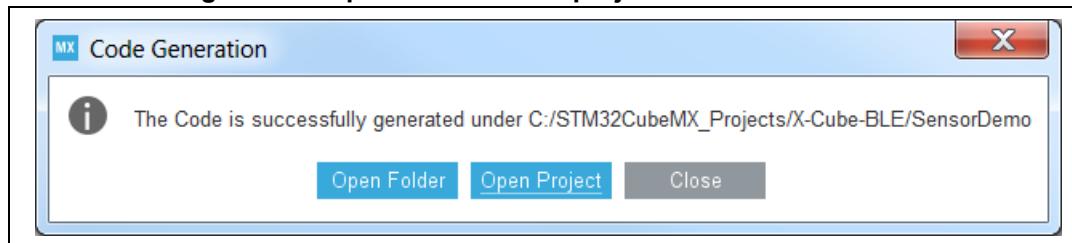
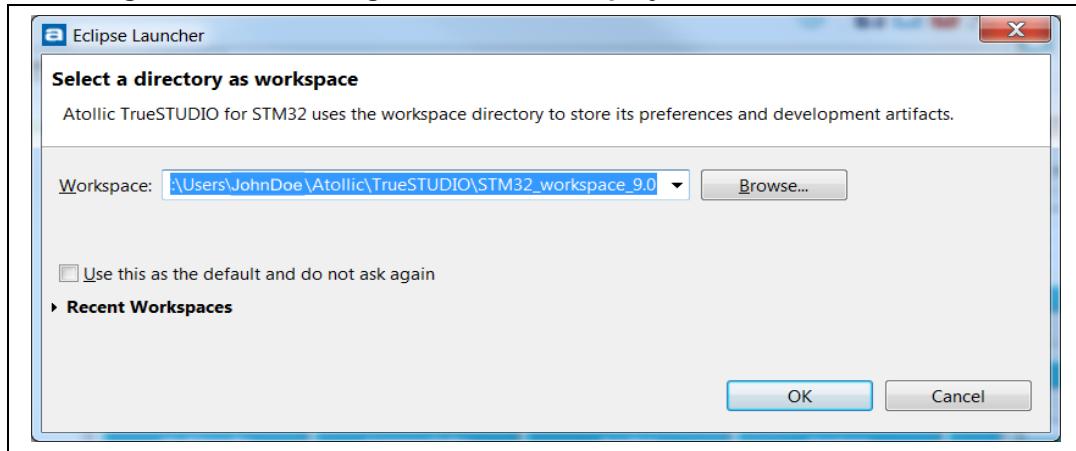
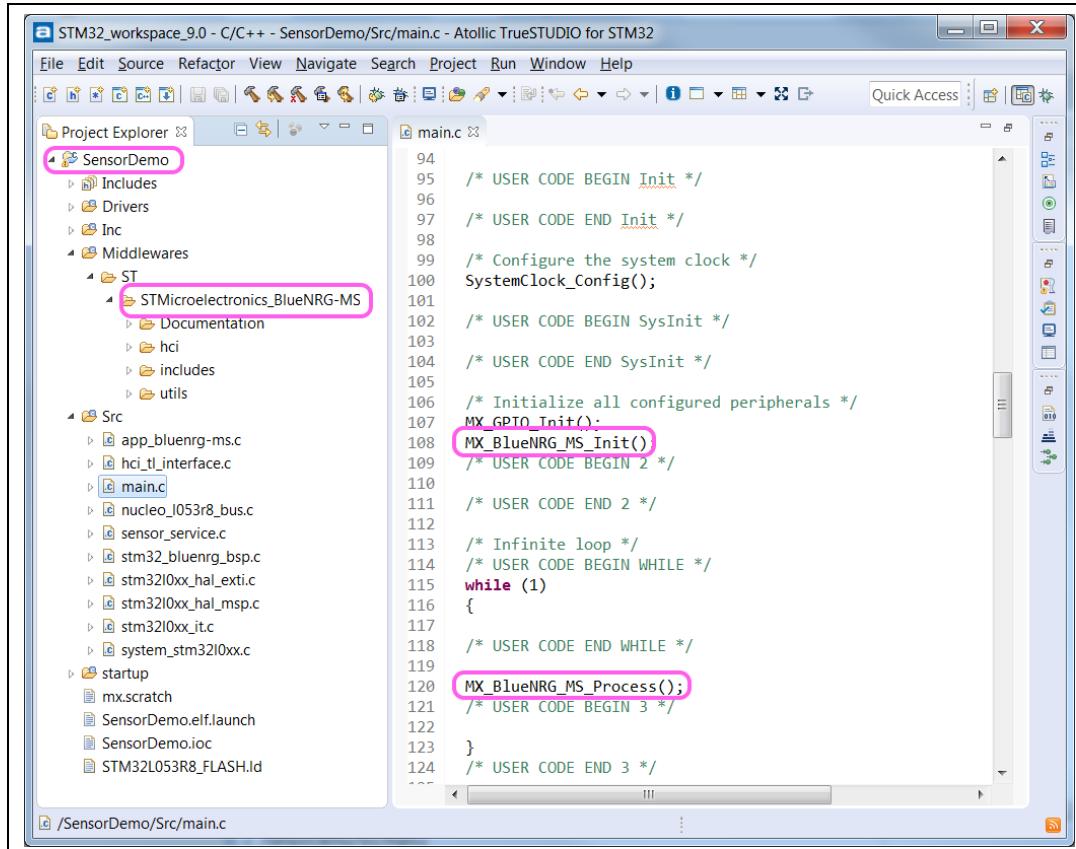


Figure 302. Open SensorDemo project in the IDE toolchain



**Figure 303. Launching the SensorDemo project in Atollic® TrueStudio®****Figure 304. Viewing the SensorDemo project in Atollic® TrueStudio®**

9. Build and Run the SensorDemo application from the Atollic® TrueStudio®:

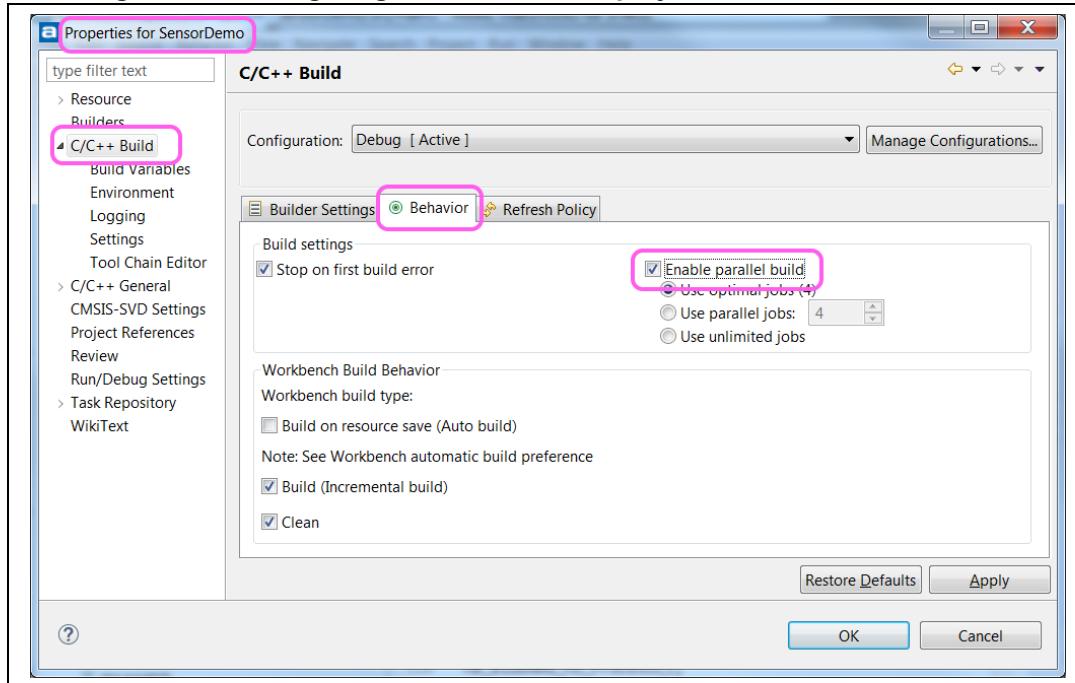
- a) Configure the project properties (see [Figure 305](#))

From the **Project explorer** panel, right-click the project name (SensorDemo) and select **Properties** to open the **Properties** window.

Select **C/C++ Build** and enable parallel build from the **Behavior** tab to speed the build process up.

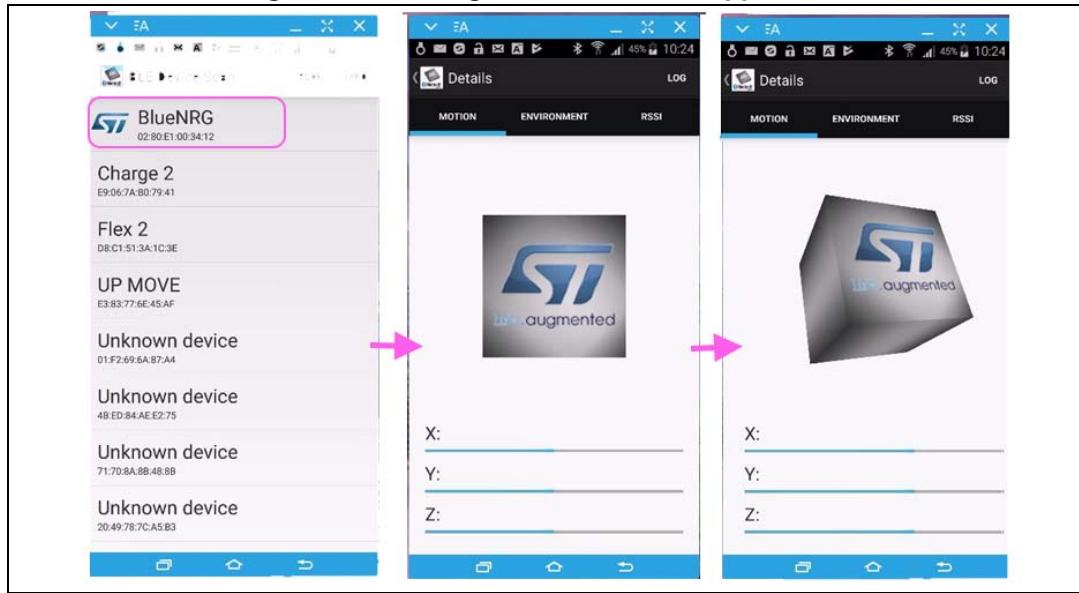
- b) Click the build icon, , to build the project.  
 c) Connect your computer to the Nucleo board ST-link connector via the USB cable.  
 d) Click  from the **Run** menu to run the project on the board.

**Figure 305. Configuring the SensorDemo project in Atollic® TrueStudio®**



10. Test the STM32 SensorDemo application by launching the BlueNRG application on the phone:

- e) Scan for nearby devices.  
 f) Select the BlueNRG device.  
 g) Since there is no MEMs sensing elements on the hardware, press the **Blue Button** to simulate MEMs data: the ST cube rotates by a fixed value each time the button is pressed (see [Figure 306](#)).

**Figure 306. Testing the SensorDemo application**

## 18 FAQ

### 18.1 Since I changed my login to access the Internet, some software packs appear not available.

The workaround is to delete the .stm32cubemx folder from the user directory and re-launch STM32CubeMX. Note that all software packs installed using the “From URL” button must be re-installed.

Select Help > Updater settings:

- Check your repository path on the **Updater Settings** tab.
- If a proxy is used, enter your login and password information on the **Connection Parameters** tab.

### 18.2 On dual-context products why some peripherals or middleware are not available for a given context?

Some peripherals and middleware require another peripheral or middleware to be enabled in the same context.

For example, the LwIP middleware requires the ETH peripheral to be enabled in the same context.

### 18.3 On the Pinout configuration panel, why does STM32CubeMX move some functions when I add a new peripheral mode?

You may have deselected  **Keep Current Signals Placement**. In this case, the tool performs an automatic remapping to optimize your placement.

### 18.4 How can I manually force a function remapping?

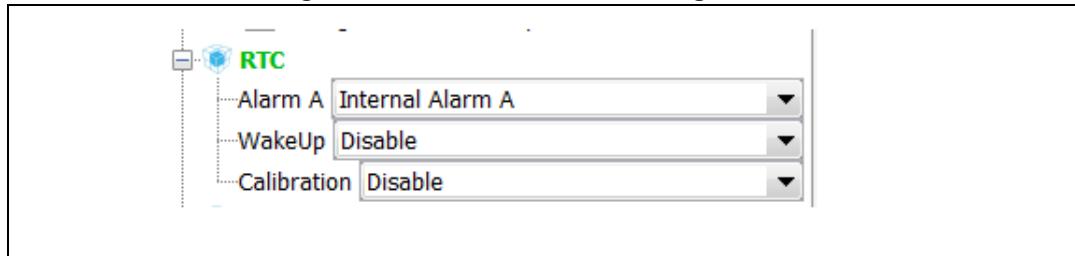
Use the **Manual Remapping** feature.

### 18.5 Why are some pins highlighted in yellow or in light green in the Pinout view? Why cannot I change the function of some pins (when I click some pins, nothing happens)?

These pins are specific pins (such as power supply or BOOT) which are not available as peripheral signals.

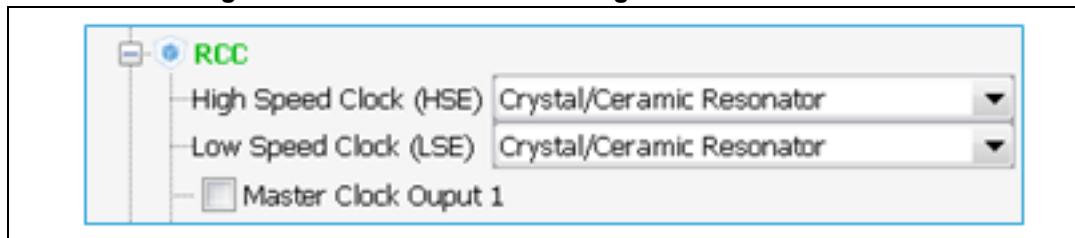
### 18.6 Why does the RTC multiplexer remain inactive on the Clock tree view?

To enable the RTC multiplexer the user must enable the RTC peripheral in the **Pinout** view as indicated below.

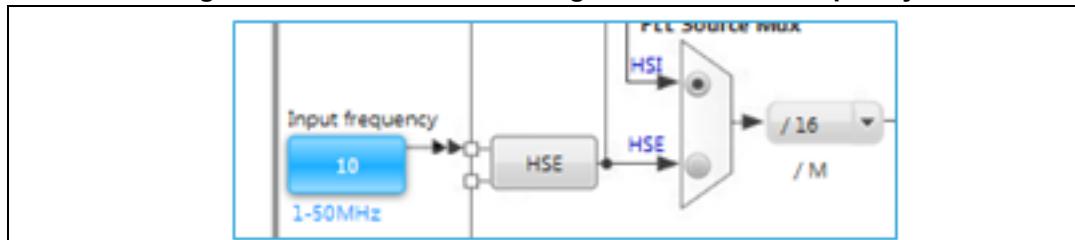
**Figure 307. Pinout view - Enabling the RTC**

## 18.7 How can I select LSE and HSE as clock source and change the frequency?

The LSE and HSE clocks become active once the RCC is configured as such in the Pinout view. See [Figure 308](#) for an example.

**Figure 308. Pinout view - Enabling LSE and HSE clocks**

The clock source frequency can then be edited and the external source selected, see [Figure 309](#).

**Figure 309. Pinout view - Setting LSE/HSE clock frequency**

## 18.8 Why STM32CubeMX does not allow me to configure PC13, PC14, PC15 and PI8 as outputs when one of them is already configured as an output?

STM32CubeMX implements the restriction documented in the reference manuals as a footnote in table Output Voltage characteristics:

*"PC13, PC14, PC15 and PI8 are supplied through the power switch. Since the switch only sinks a limited amount of current (3 mA), the use of GPIOs PC13 to PC15 and PI8 in output mode is limited: the speed should not exceed 2 MHz with a maximum load of 30 pF and these I/Os must not be used as a current source (e.g. to drive a LED)."*

## 18.9 Ethernet configuration: why cannot I specify DP83848 or LAN8742A in some cases?

For most Series, STM32CubeMX adjusts the list of possible PHY component drivers according to the selected Ethernet mode:

- when the Ethernet MII mode is selected the user is able to choose between the DP83848 component driver or a “User Phy”.
- when the Ethernet RMII mode is selected, the user is able to choose between the LAN8742A component driver or a “User Phy”.

When “User Phy” is selected, the user must manually include the component drivers to be used in its project.

Note:

*For STM32H7 Series, the PHY is seen as an external component and is no longer specified under the Ethernet peripheral configuration. The user can select the PHY under LwIP Platform settings tab. However, since the STM32H7 firmware package provides only the driver code for the LAN8742A component that is available on all STM32H7 evaluation and Nucleo boards, STM32CubeMX user interface offers only the choice between "User Phy" and LAN8742.*

*When LAN8742 is selected, the BSP driver code is copied into the generated project.*

## Appendix A STM32CubeMX pin assignment rules

The following pin assignment rules are implemented in STM32CubeMX:

- Rule 1: Block consistency
- Rule 2: Block inter-dependency
- Rule 3: One block = one peripheral mode
- Rule 4: Block remapping (only for STM32F10x)
- Rule 5: Function remapping
- Rule 6: Block shifting (only for STM32F10x)
- Rule 7: Setting or clearing a peripheral mode
- Rule 8: Mapping a function individually (if Keep Current Placement is unchecked)
- Rule 9: GPIO signals mapping

### A.1 Block consistency

When setting a pin signal (provided there is no ambiguity about the corresponding peripheral mode), all the pins/signals required for this mode are mapped and pins are shown in green (otherwise the configured pin is shown in orange).

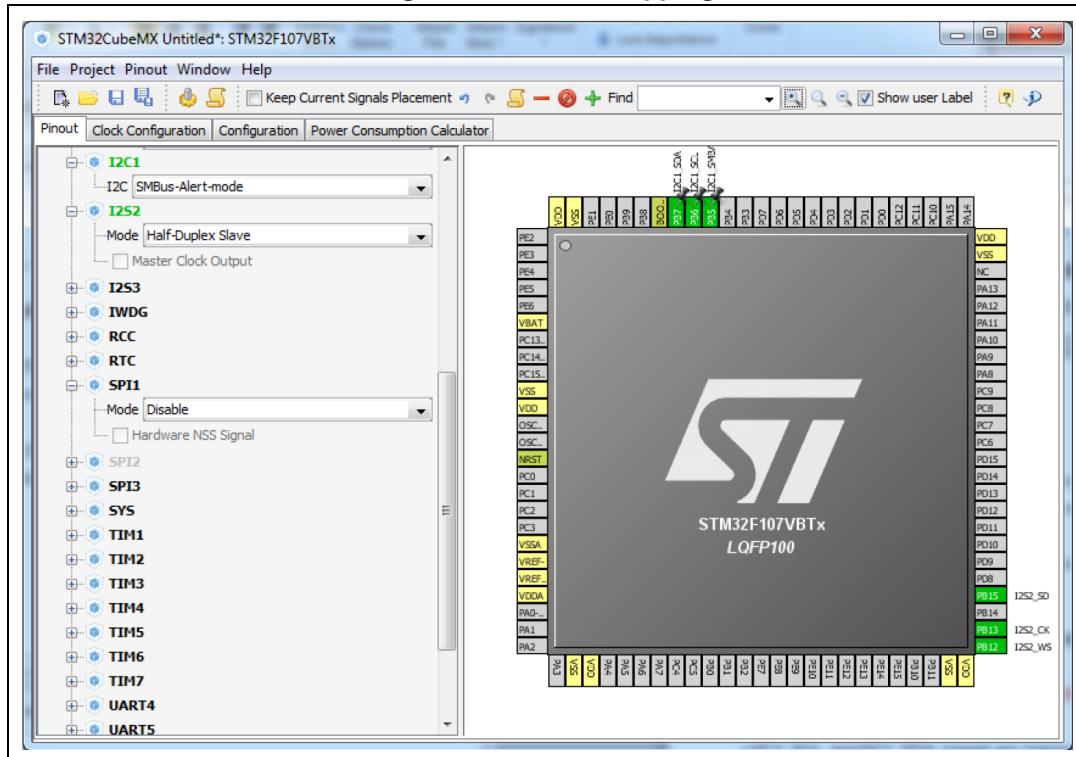
When clearing a pin signal, all the pins/signals required for this mode are unmapped simultaneously and the pins turn back to gray.

#### Example of block mapping with a STM32F107x MCU

If the user assigns I2C1\_SMBA function to PB5, then STM32CubeMX configures pins and modes as follows:

- I2C1\_SCL and I2C1\_SDA signals are mapped to the PB6 and PB7 pins, respectively (see [Figure 310](#)).
- I2C1 peripheral mode is set to SMBus-Alert mode.

Figure 310. Block mapping

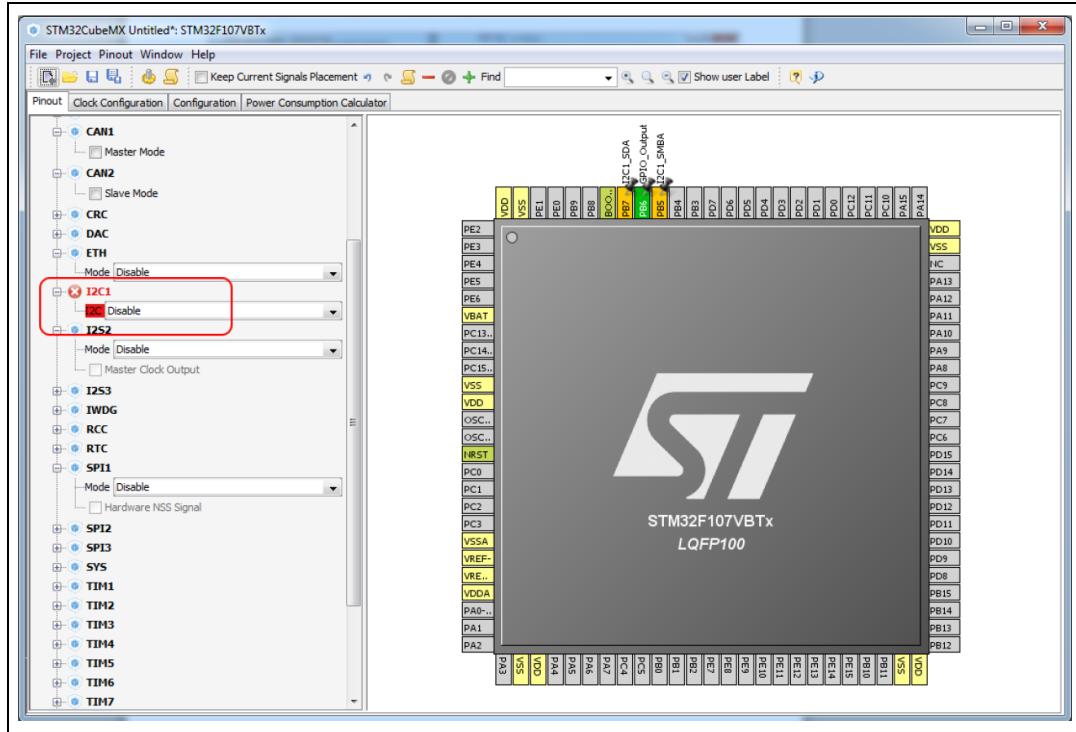


### Example of block remapping with a STM32F107x MCU

If the user assigns GPIO\_Output to PB6, STM32CubeMX automatically disables I2C1 SMBus-Alert peripheral mode from the peripheral tree view and updates the other I2C1 pins (PB5 and PB7) as follows:

- If they are unpinned, the pin configuration is reset (pin grayed out).
- If they are pinned, the peripheral signal assigned to the pins is kept and the pins are highlighted in orange since they no longer match a peripheral mode (see [Figure 311](#)).

**Figure 311. Block remapping**



For STM32CubeMX to find an alternative solution for the I2C peripheral mode, the user will need to unpin I2C1 pins and select the I2C1 mode from the peripheral tree view (see [Figure 312](#) and [Figure 313](#)).

Figure 312. Block remapping - Example 1

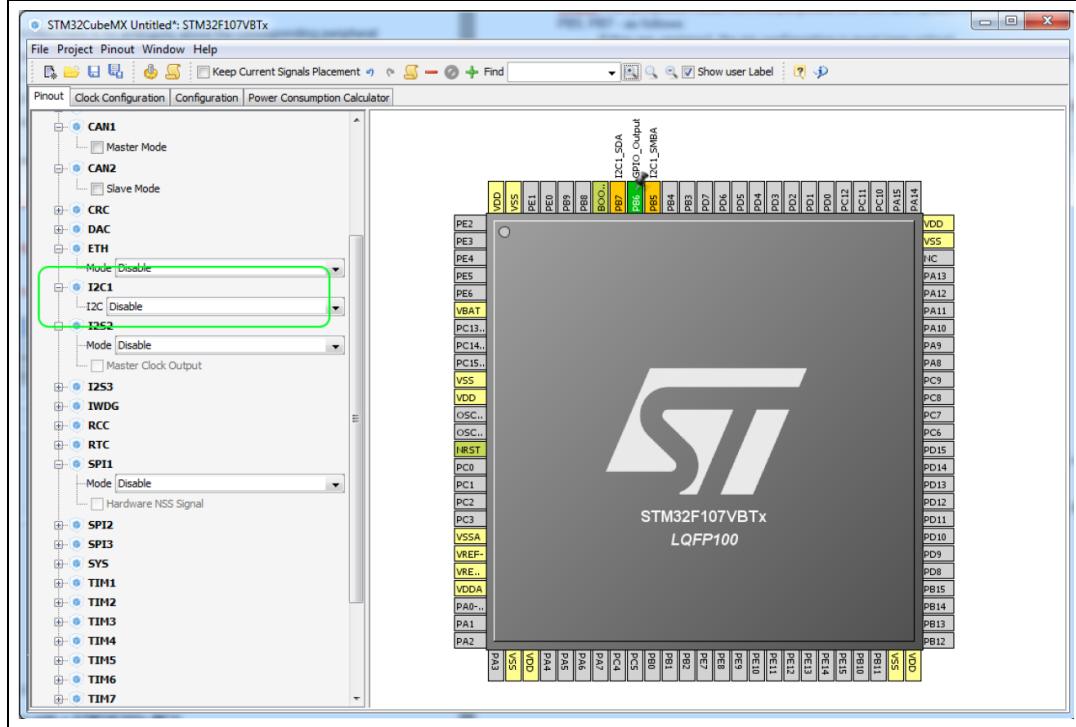
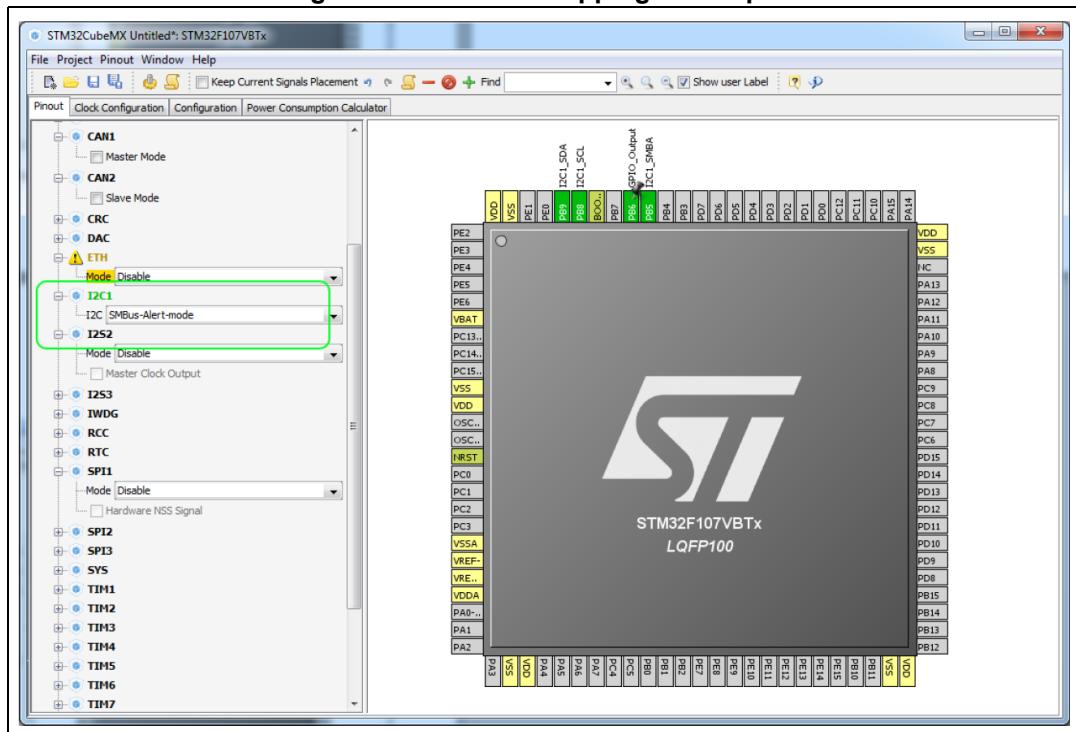


Figure 313. Block remapping - Example 2



## A.2 Block inter-dependency

On the **Pinout** view, the same signal can appear as an alternate function for multiple pins. However it can be mapped only once.

As a consequence, for STM32F1 MCUs, two blocks of pins cannot be selected simultaneously for the same peripheral mode: when a block/signal from a block is selected, the alternate blocks are cleared.

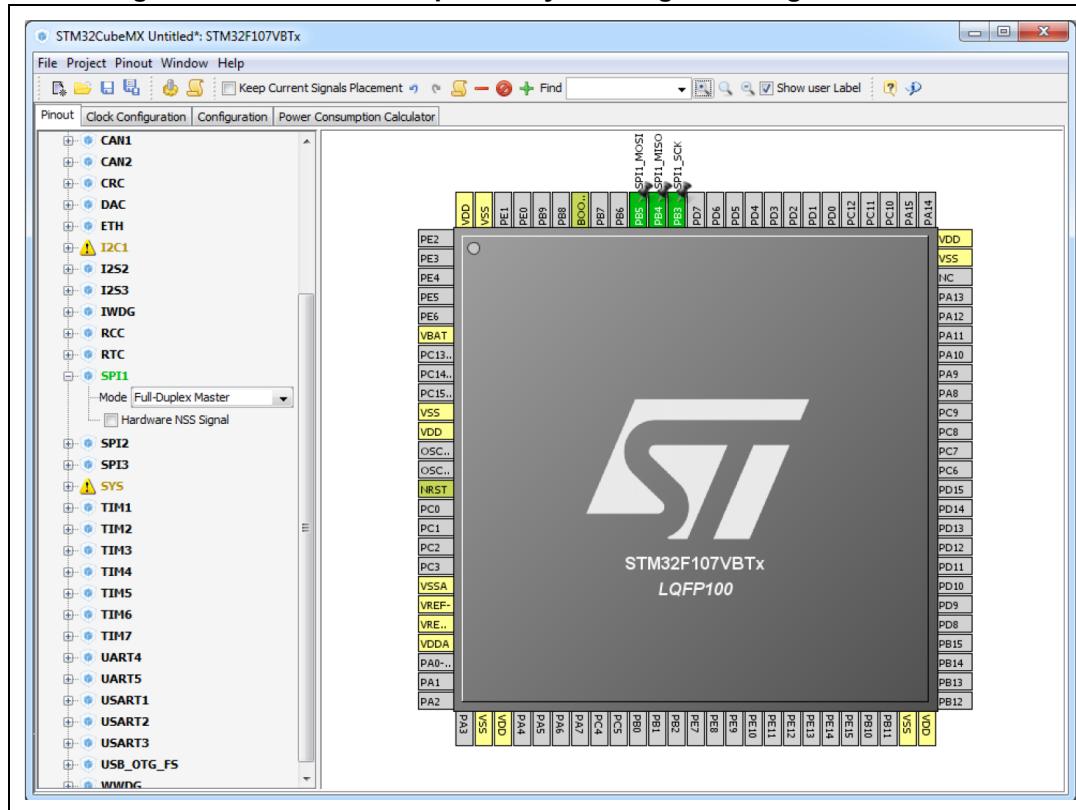
### Example of block remapping of SPI in full-duplex master mode with a STM32F107x MCU

If SPI1 full-duplex master mode is selected from the tree view, by default the corresponding SPI signals are assigned to PB3, PB4 and PB5 pins (see [Figure 314](#)).

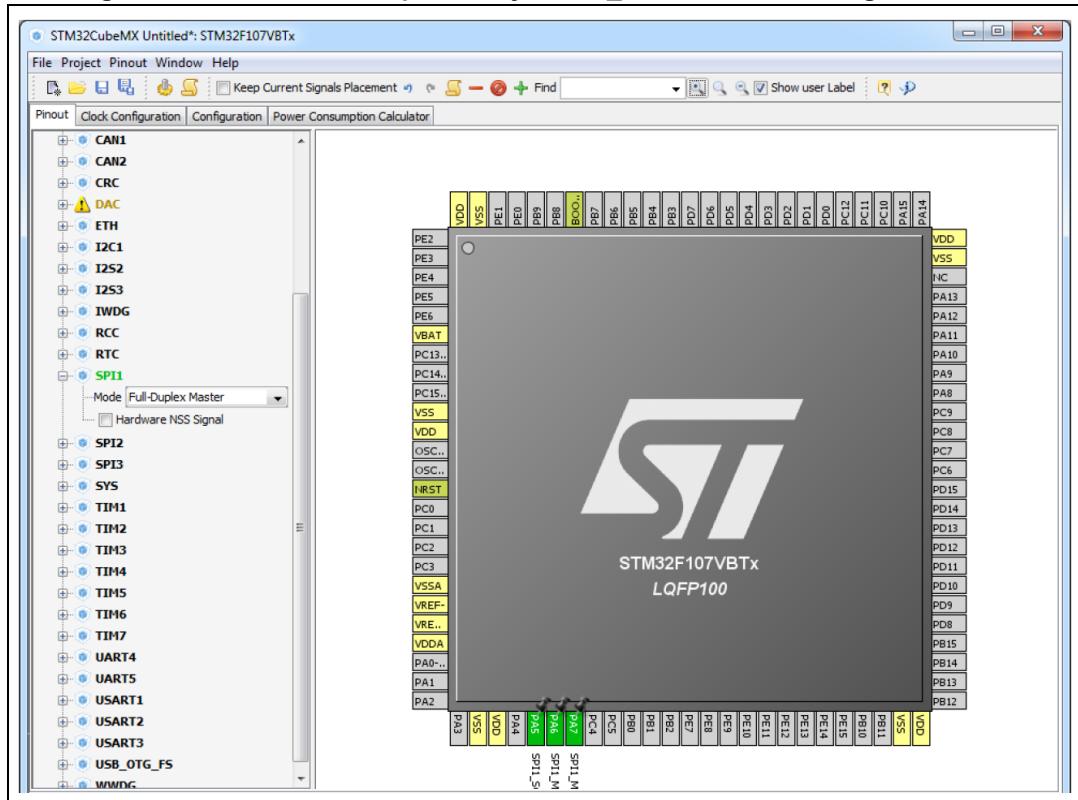
If the user assigns to PA6 the SPI1\_MISO function currently assigned to PB4, STM32CubeMX clears the PB4 pin from the SPI1\_MISO function, as well as all the other pins configured for this block, and moves the corresponding SPI1 functions to the relevant pins in the same block as the PB4 pin (see [Figure 315](#)).

(by pressing CTRL and clicking PB4 to show PA6 alternate function in blue, then drag and drop the signal to pin PA6)

**Figure 314. Block inter-dependency - SPI signals assigned to PB3/4/5**



**Figure 315. Block inter-dependency - SPI1\_MISO function assigned to PA6**



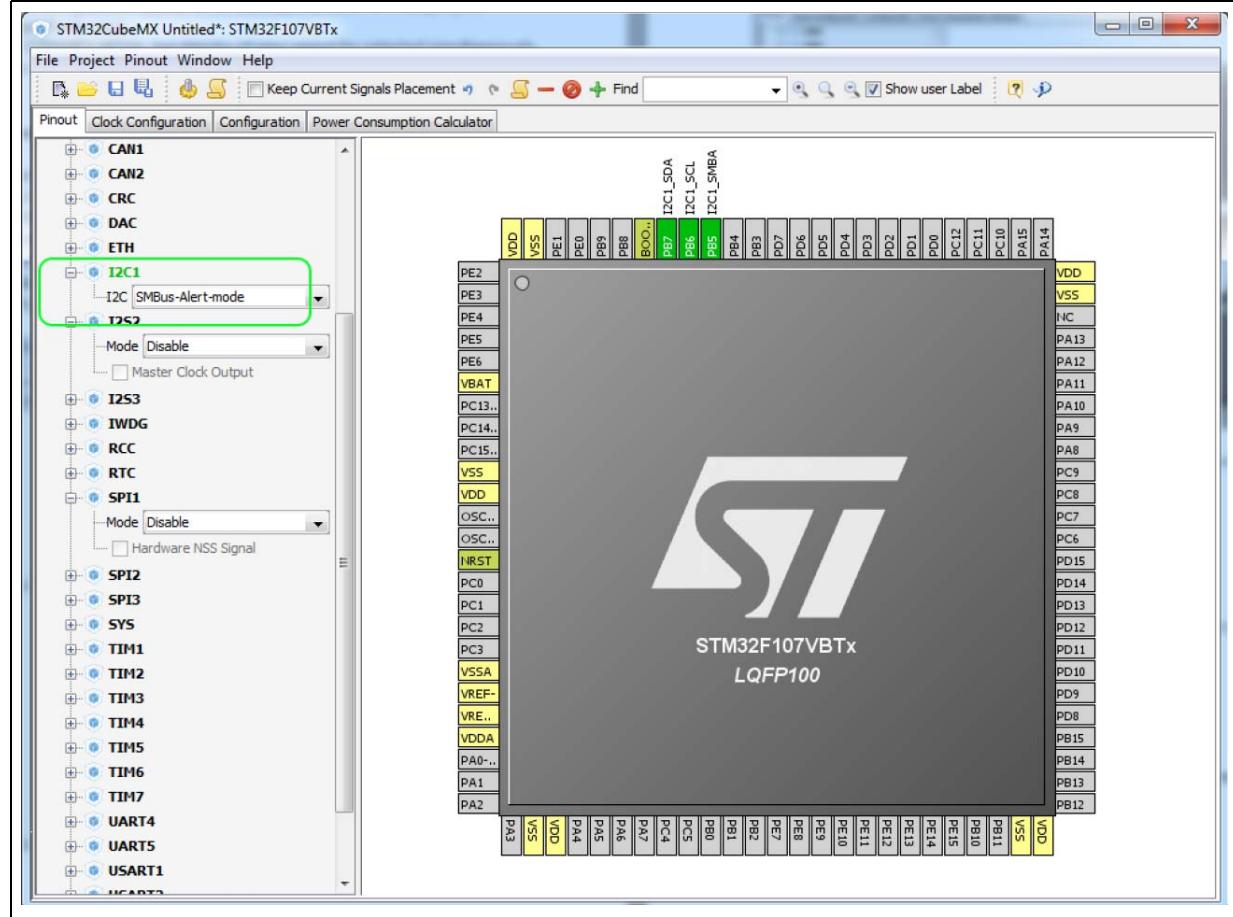
### A.3 One block = one peripheral mode

When a block of pins is fully configured in the **Pinout** view (shown in green), the related peripheral mode is automatically set in the **Peripherals tree**.

#### Example of STM32F107x MCU

Assigning the I2C1\_SMBA function to PB5 automatically configures I2C1 peripheral in SMBus-Alert mode (see Peripheral tree in *Figure 316*).

**Figure 316. One block = one peripheral mode - I2C1\_SMBA function assigned to PB5**



### A.4 Block remapping (STM32F10x only)

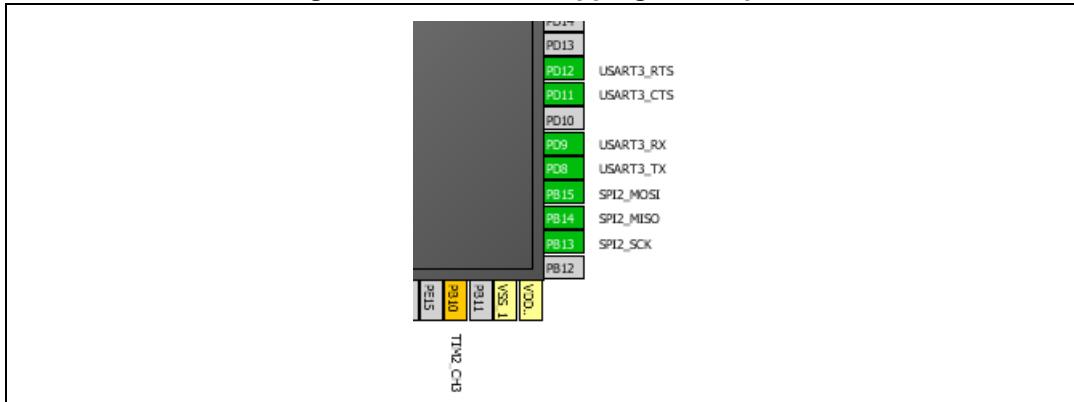
To configure a peripheral mode, STM32CubeMX selects a block of pins and assigns each mode signal to a pin in this block. In doing so, it looks for the first free block to which the mode can be mapped.

When setting a peripheral mode, if at least one pin in the default block is already used, STM32CubeMX tries to find an alternate block. If none can be found, it either selects the functions in a different sequence, or unchecks  **Keep Current Signals Placement**, and remaps all the blocks to find a solution.

### Example

STM32CubeMX remaps USART3 hardware-flow-control mode to the (PD8-PD9-PD11-PD12) block, because PB14 of USART3 default block is already allocated to the SPI2\_MISO function (see [Figure 317](#)).

**Figure 317. Block remapping - Example 2**



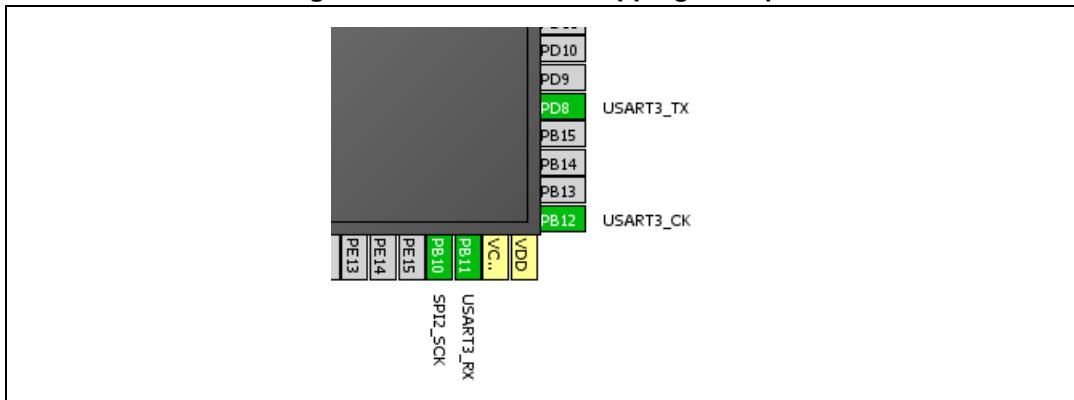
## A.5 Function remapping

To configure a peripheral mode, STM32CubeMX assigns each signal of the mode to a pin. In doing so, it will look for the first free pin the signal can be mapped to.

### Example using STM32F415x

When configuring USART3 for the Synchronous mode, STM32CubeMX discovered that the default PB10 pin for USART3\_TX signal was already used by SPI. It thus remapped it to PD8 (see [Figure 318](#)).

**Figure 318. Function remapping example**



## A.6 Block shifting (only for STM32F10x and when “Keep Current Signals placement” is unchecked)

If a block cannot be mapped and there are no free alternate solutions, STM32CubeMX tries to free the pins by remapping all the peripheral modes impacted by the shared pin.

### Example

With the Keep current signal placement enabled, if USART3 synchronous mode is set first, the Asynchronous default block (PB10-PB11) is mapped and Ethernet becomes unavailable (shown in red) (see [Figure 319](#)).

Unchecking  [Keep Current Signals Placement](#) allows STM32CubeMX shifting blocks around and freeing a block for the Ethernet MII mode. (see [Figure 320](#)).

**Figure 319. Block shifting not applied**

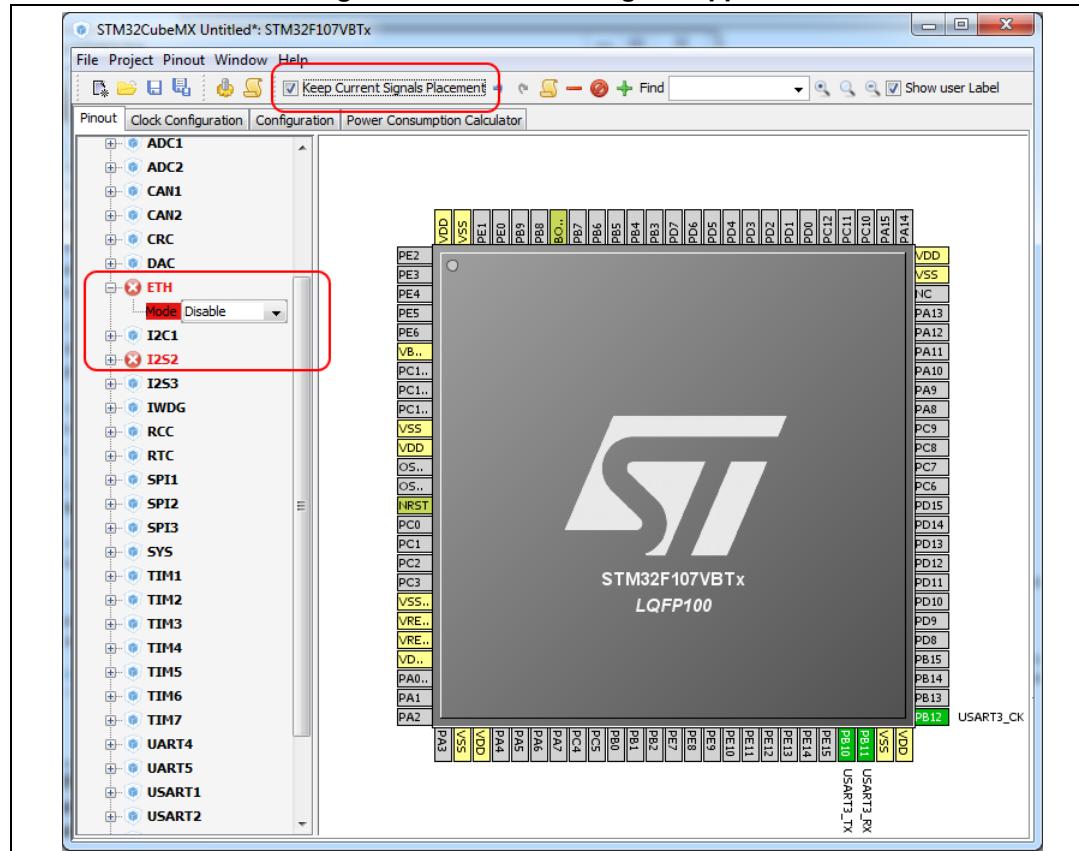
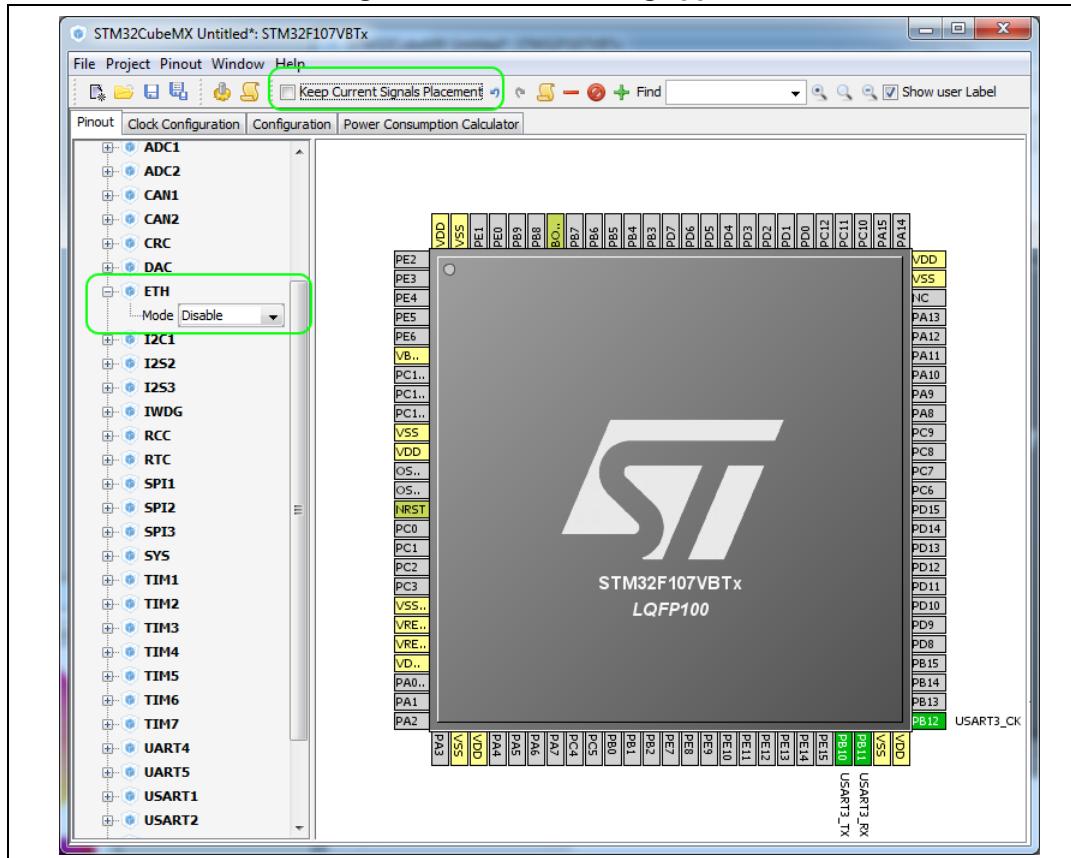


Figure 320. Block shifting applied



## A.7 Setting and clearing a peripheral mode

The Peripherals panel and the **Pinout** view are linked: when a peripheral mode is set or cleared, the corresponding pin functions are set or cleared.

## A.8 Mapping a function individually

When STM32CubeMX needs a pin that has already been assigned manually to a function (no peripheral mode set), it can move this function to another pin, only if

**Keep Current Signals Placement** is unchecked and the function is not pinned (no pin icon).

## A.9 GPIO signals mapping

I/O signals (GPIO\_Input, GPIO\_Output, GPIO\_Analog) can be assigned to pins either manually through the **Pinout** view or automatically through the **Pinout** menu. Such pins can no longer be assigned automatically to another signal: STM32CubeMX signal automatic placement does not take into account this pin anymore since it does not shift I/O signals to other pins.

The pin can still be manually assigned to another signal or to a reset state.

## Appendix B STM32CubeMX C code generation design choices and limitations

### B.1 STM32CubeMX generated C code and user sections

The C code generated by STM32CubeMX provides user sections as illustrated below. They allow user C code to be inserted and preserved at next C code generation.

User sections shall neither be moved nor renamed. Only the user sections defined by STM32CubeMX are preserved. User created sections will be ignored and lost at next C code generation.

```
/* USER CODE BEGIN 0 */
(..)
/* USER CODE END 0 */
```

*Note:* STM32CubeMX may generate C code in some user sections. It will be up to the user to clean the parts that may become obsolete in this section. For example, the while(1) loop in the main function is placed inside a user section as illustrated below:

```
/* Infinite loop */
/* USER CODE BEGIN WHILE */
while (1)
{
    /* USER CODE END WHILE */

    /* USER CODE BEGIN 3 */
}
/* USER CODE END 3 */
```

### B.2 STM32CubeMX design choices for peripheral initialization

STM32CubeMX generates peripheral \_*Init* functions that can be easily identified thanks to the MX\_ prefix:

```
static void MX_GPIO_Init(void);
static void MX_<Peripheral Instance Name>_Init(void);
static void MX_I2S2_Init(void);
```

An MX\_<peripheral instance name>\_*Init* function exists for each peripheral instance selected by the user (e.g., MX\_I2S2\_*Init*). It performs the initialization of the relevant handle structure (e.g., &hi2s2 for I2S second instance) that is required for HAL driver initialization (e.g., HAL\_I2S\_*Init*) and the actual call to this function:

```
void MX_I2S2_Init(void)
{
    hi2s2.Instance = SPI2;
    hi2s2.Init.Mode = I2S_MODE_MASTER_TX;
    hi2s2.Init.Standard = I2S_STANDARD_PHILLIPS;
    hi2s2.Init.DataFormat = I2S_DATAFORMAT_16B;
    hi2s2.Init.MCLKOutput = I2S_MCLKOUTPUT_DISABLE;
```

```

    hi2s2.Init.AudioFreq = I2S_AUDIOFREQ_192K;
    hi2s2.Init.CPOL = I2S_CPOL_LOW;
    hi2s2.Init.ClockSource = I2S_CLOCK_PLL;
    hi2s2.Init.FullDuplexMode = I2S_FULLDUPLEXMODE_ENABLE;
    HAL_I2S_Init(&hi2s2);
}

```

By default, the peripheral initialization is done in *main.c*. If the peripheral is used by a middleware mode, the peripheral initialization can be done in the middleware corresponding .c file.

Customized *HAL\_<Peripheral Name>\_MspInit()* functions are created in the *stm32f4xx\_hal\_msp.c* file to configure the low-level hardware (GPIO, CLOCK) for the selected peripherals.

## B.3 STM32CubeMX design choices and limitations for middleware initialization

### B.3.1 Overview

STM32CubeMX does not support C user code insertion in Middleware stack native files although stacks such as LwIP might require it in some use cases.

STM32CubeMX generates middleware *Init* functions that can be easily identified thanks to the MX\_ prefix:

```

MX_LWIP_Init(); // defined in lwip.h file
MX_USB_HOST_Init(); // defined in usb_host.h file
MX_FATFS_Init(); // defined in fatfs.h file

```

Note however the following exceptions:

- No *Init* function is generated for FreeRTOS unless the user chooses, from the Project settings window, to generate *Init* functions as pairs of .c/.h files. Instead, a *StartDefaultTask* function is defined in the *main.c* file and CMSIS-RTOS native function (*osKernelStart*) is called in the main function.
- If FreeRTOS is enabled, the *Init* functions for the other middlewares in use are called from the *StartDefaultTask* function in the *main.c* file.

Example:

```

void StartDefaultTask(void const * argument)
{
    /* init code for FATFS */
    MX_FATFS_Init();
    /* init code for LWIP */
    MX_LWIP_Init();
    /* init code for USB_HOST */
    MX_USB_HOST_Init();
    /* USER CODE BEGIN 5 */
    /* Infinite loop */
    for(;;)
    {

```

```

        osDelay(1);
    }
/* USER CODE END 5 */
}

```

### B.3.2 USB host

USB peripheral initialization is performed within the middleware initialization C code in the *usbh\_conf.c* file, while USB stack initialization is done within the *usb\_host.c* file.

When using the USB Host middleware, the user is responsible for implementing the *USBH\_UserProcess* callback function in the generated *usb\_host.c* file.

From STM32CubeMX user interface, the user can select to register one class or all classes if the application requires switching dynamically between classes.

### B.3.3 USB device

USB peripheral initialization is performed within the middleware initialization C code in the *usbd\_conf.c* file, while USB stack initialization is done within the *usb\_device.c* file.

USB VID, PID and String standard descriptors are configured via STM32CubeMX user interface and available in the *usbd\_desc.c* generated file. Other standard descriptors (configuration, interface) are hard-coded in the same file preventing support of USB composite devices.

When using the USB Device middleware, the user is responsible for implementing the functions in the *usbd\_<classname>\_if.c* class interface file for all device classes (e.g., *usbd\_storage\_if.c*).

USB MTP and CCID classes are not supported.

### B.3.4 FatFs

FatFs is a generic FAT/exFAT file system solution well suited for small embedded systems.

FatFs configuration is available in *ffconf.h* generated file.

The initialization of the SDIO peripheral for the FatFs SD card mode and of the FMC peripheral for the FatFs External SDRAM and External SRAM modes are kept in the *main.c* file.

Some files need to be modified by the user to match user board specificities (BSP in STM32Cube embedded software package can be used as example):

- *bsp\_driver\_sd.c/h* generated files when using FatFs SD card mode
- *bsp\_driver\_sram.c/h* generated files when using FatFs External SRAM mode
- *bsp\_driver\_sdram.c/h* generated files when using FatFs External SDRAM mode.

Multi-drive FatFs is supported, which means that multiple logical drives can be used by the application (External SDRAM, External SRAM, SD card, USB disk, User defined). However support of multiple instances of a given logical drive is not available (e.g. FatFs using two instances of USB hosts or several RAM disks).

NOR and NAND Flash memory are not supported. In this case, the user shall select the FatFs user-defined mode and update the *user\_diskio.c* driver file generated to implement the interface between the middleware and the selected peripheral.

### B.3.5 FreeRTOS

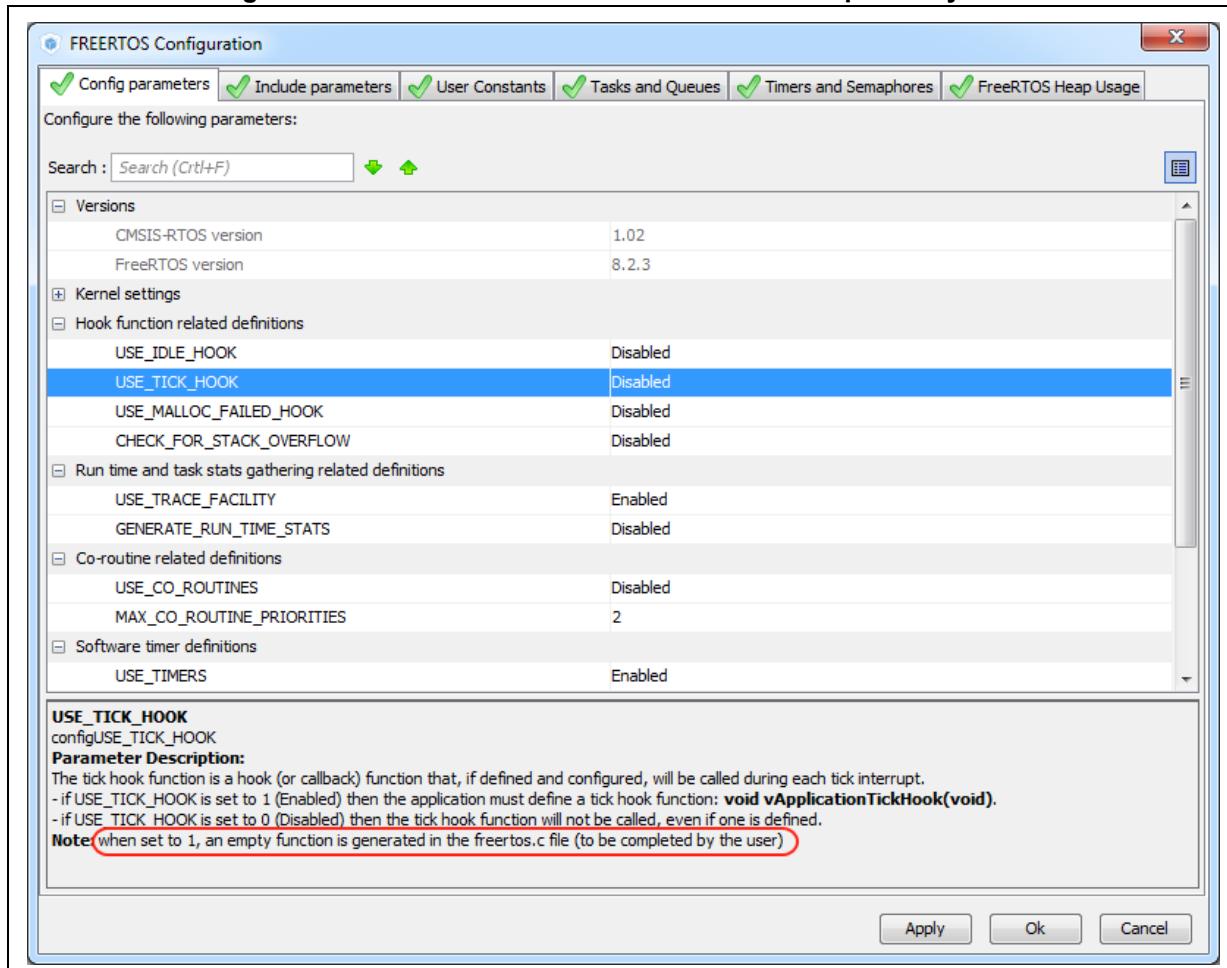
FreeRTOS is a free real-time embedded operating system well suited for microcontrollers.

FreeRTOS configuration is available in *FreeRTOSConfig.h* generated file.

When FreeRTOS is enabled, all other selected middleware modes (e.g., LwIP, FatFs, USB) will be initialized within the same FreeRTOS thread in the main.c file.

When GENERATE\_RUN\_TIME\_STATS, CHECK\_FOR\_STACK\_OVERFLOW, USE\_IDLE\_HOOK, USE\_TICK\_HOOK and USE\_MALLOC\_FAILED\_HOOK parameters are activated, STM32CubeMX generates *freertos.c* file with empty functions that the user shall implement. This is highlighted by the tooltip (see [Figure 321](#)).

**Figure 321. FreeRTOS HOOK functions to be completed by user**



### B.3.6 LwIP

LwIP is a small independent implementation of the TCP/IP protocol suite: its reduced RAM usage makes it suitable for use in embedded systems with tens of Kbytes of free RAM.

LwIP initialization function is defined in *lwip.c*, while LwIP configuration is available in *lwipopts.h* generated file.

STM32CubeMX supports LwIP over Ethernet only. The Ethernet peripheral initialization is done within the middleware initialization C code.

STM32CubeMX does not support user C code insertion in stack native files. However, some LwIP use cases require modifying stack native files (e.g., *cc.h*, *mib2.c*): user modifications shall be backed up since they will be lost at next STM32CubeMX generation.

Starting with LwIP release 1.5, STM32CubeMX LwIP supports IPv6 (see [Figure 323](#)).

DHCP must be disabled, to configure a static IP address.

**Figure 322. LwIP 1.4.1 configuration**

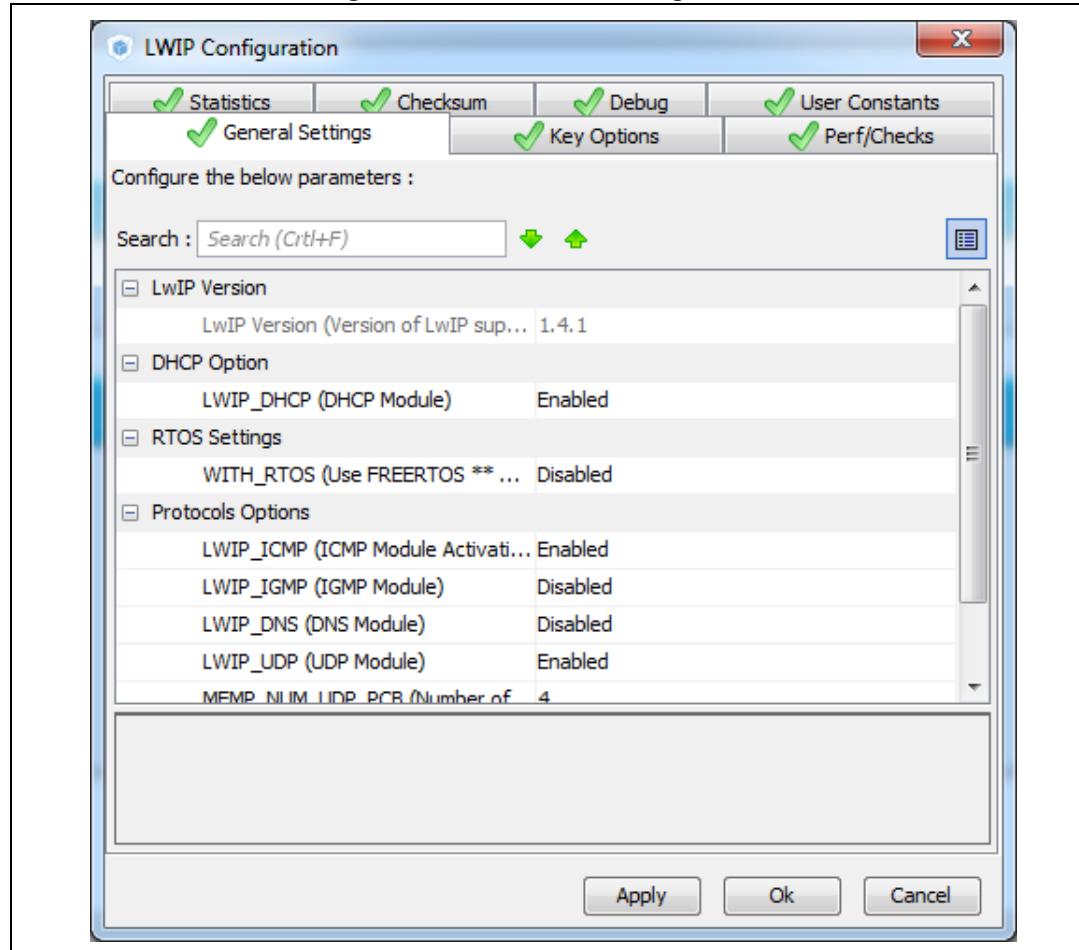
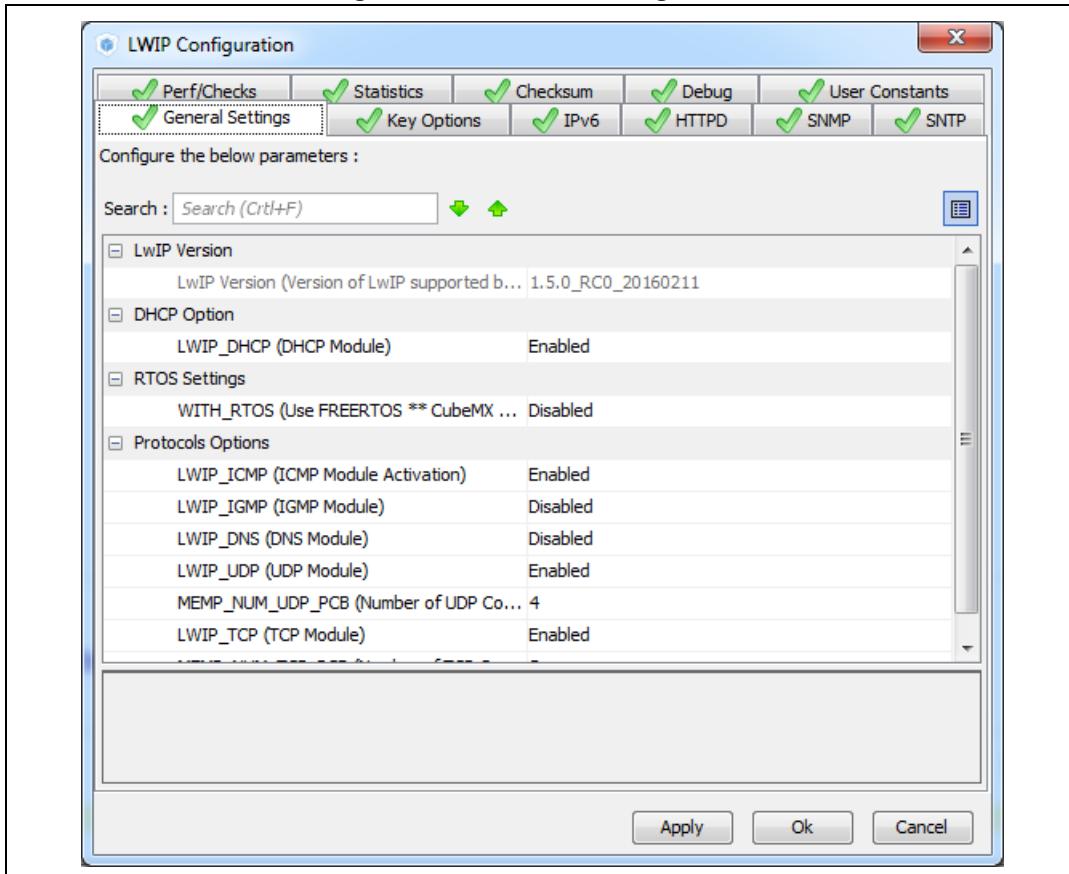


Figure 323. LwIP 1.5 configuration



STM32CubeMX generated C code will report compilation errors when specific parameters are enabled (disabled by default). The user must fix the issues with a stack patch (downloaded from Internet) or user C code. The following parameters generate an error:

- MEM\_USE\_POOLS: user C code to be added either in *lwipopts.h* or in *cc.h* (stack file).
- PPP\_SUPPORT, PPPOE\_SUPPORT: user C code required
- MEMP\_SEPARATE\_POOLS with MEMP\_OVERFLOW\_CHECK > 0: a stack patch required
- MEM\_LIBC\_MALLOC & RTOS enabled: stack patch required
- LWIP\_EVENT\_API: stack patch required

In STM32CubeMX, the user must enable FreeRTOS in order to use LwIP with the netconn and sockets APIs. These APIs require the use of threads and consequently of an operating system. Without FreeRTOS, only the LwIP event-driven raw API can be used.

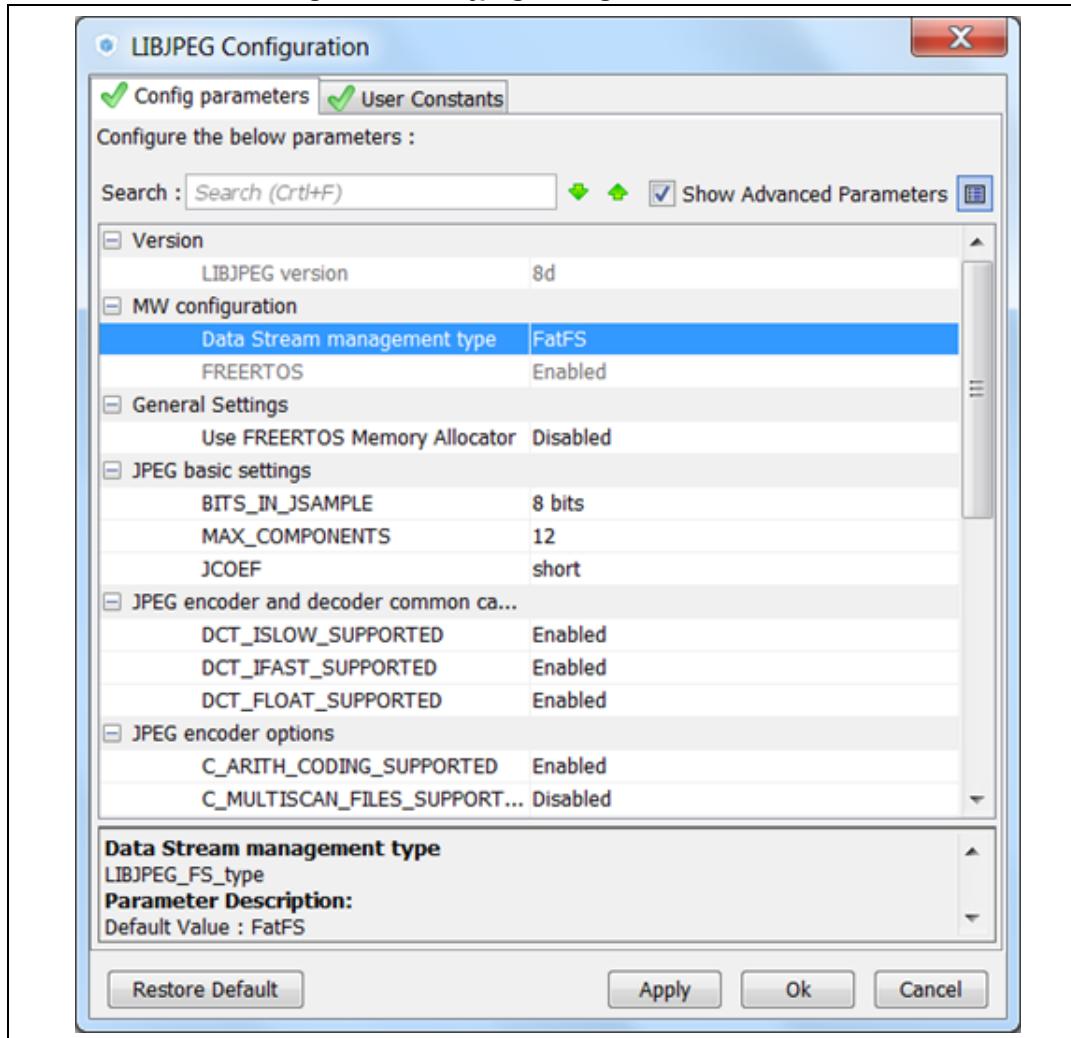
### B.3.7 Libjpeg

Libjpeg is a widely used C-library that allows reading and writing JPEG files. It is delivered within STM32CubeF7, STM32CubeH7, STM32CubeF2 and STM32CubeF4 embedded software packages.

STM32CubeMX generates the following files, whose content can be configured by the user through STM32CubeMX user interface:

- **libjpeg.c.h**  
The *MX\_LIBJPEG\_Init()* initialization function is generated within the libjpeg.c file. It is empty. It is up to the user to enter in the user sections the code and the calls to the libjpeg functions required for the application.
- **jdata\_conf.c**  
This file is generated only when FatFs is selected as data stream management type.
- **jdata\_conf.h**  
The content of this file is adjusted according to the datastream management type selected.
- **jconfig.h**  
This file is generated by STM32CubeMX, but cannot be configured.
- **jmorecfg.h**  
Some but not all the define statements contained in this file can be modified through the STM32CubeMX libjpeg configuration menu.

Figure 324. Libjpeg configuration window



### B.3.8 Mbed TLS

Mbed TLS is a C-library that allows including cryptographic capabilities to embedded products. It handles Secure Sockets Layer (SSL) and Transport Layer Security (TLS) protocols, that are used for establishing a secure, encrypted and authenticated link between two parties over an insecure network. Mbed TLS comes with an intuitive API and minimal coding footprint. Visit <https://tls.mbed.org/> for more details.

Mbed TLS is delivered within STM32CubeF2, STM32CubeF4, STM32CubeF7 and STM32CubeH7 embedded software packages.

Mbed TLS can work without LwIP stack (see [Figure 325: Mbed TLS without LwIP](#)).

If LwIP stack is used, FreeRTOS must be enabled as well (see [Figure 326: Mbed TLS with LwIP and FreeRTOS](#)).

STM32CubeMX generates the following files, whose contents can be modified by the user through STM32CubeMX user interface (see [Figure 327: Mbed TLS configuration window](#)) and/or using user sections in the code itself:

- *mbedtls\_config.h*
- *mbedtls.h*
- *net\_sockets.c* (generated only if LwIP is enabled)
- *mbedtls.c*

Figure 325. Mbed TLS without LwIP

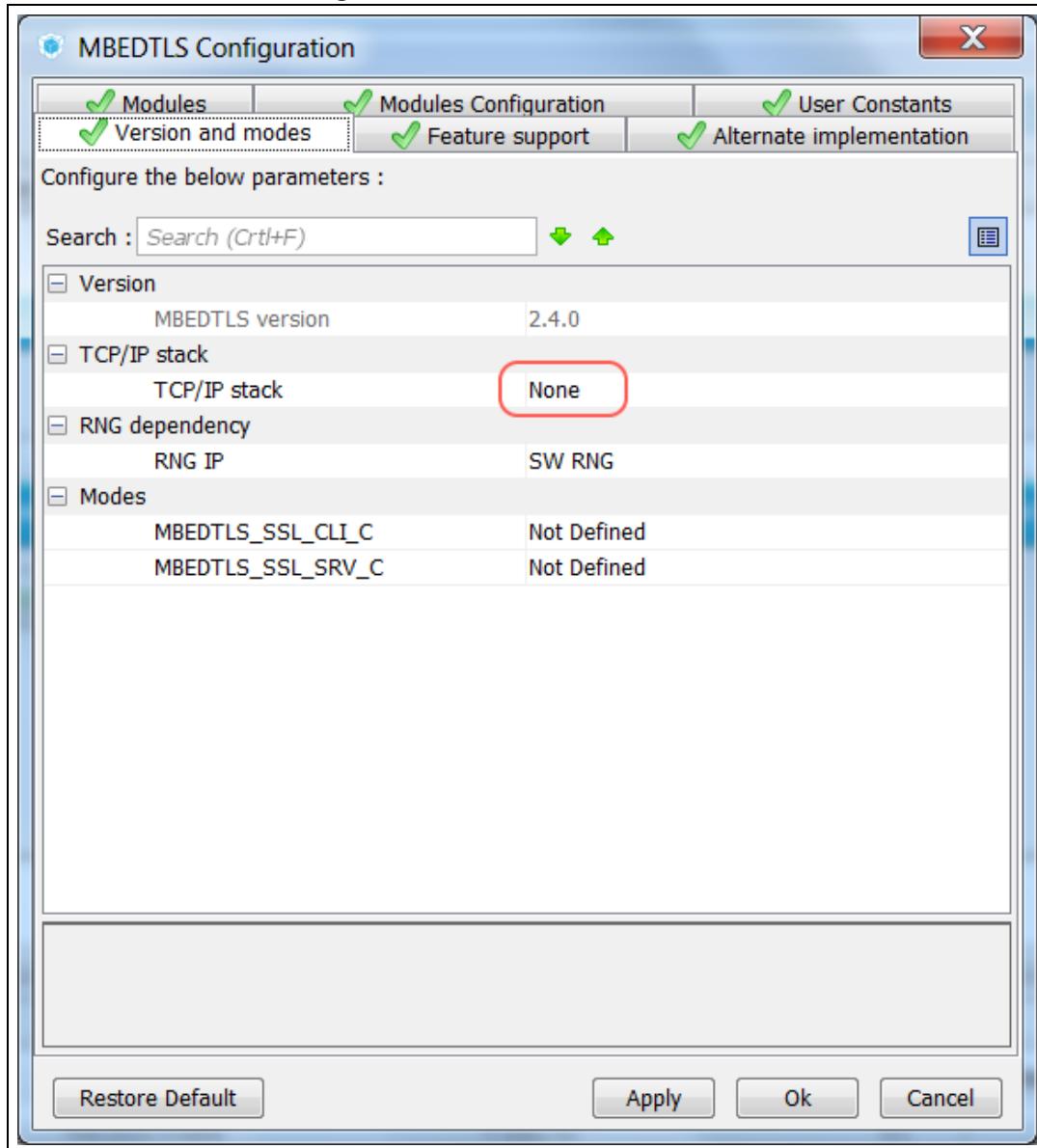


Figure 326. Mbed TLS with LwIP and FreeRTOS

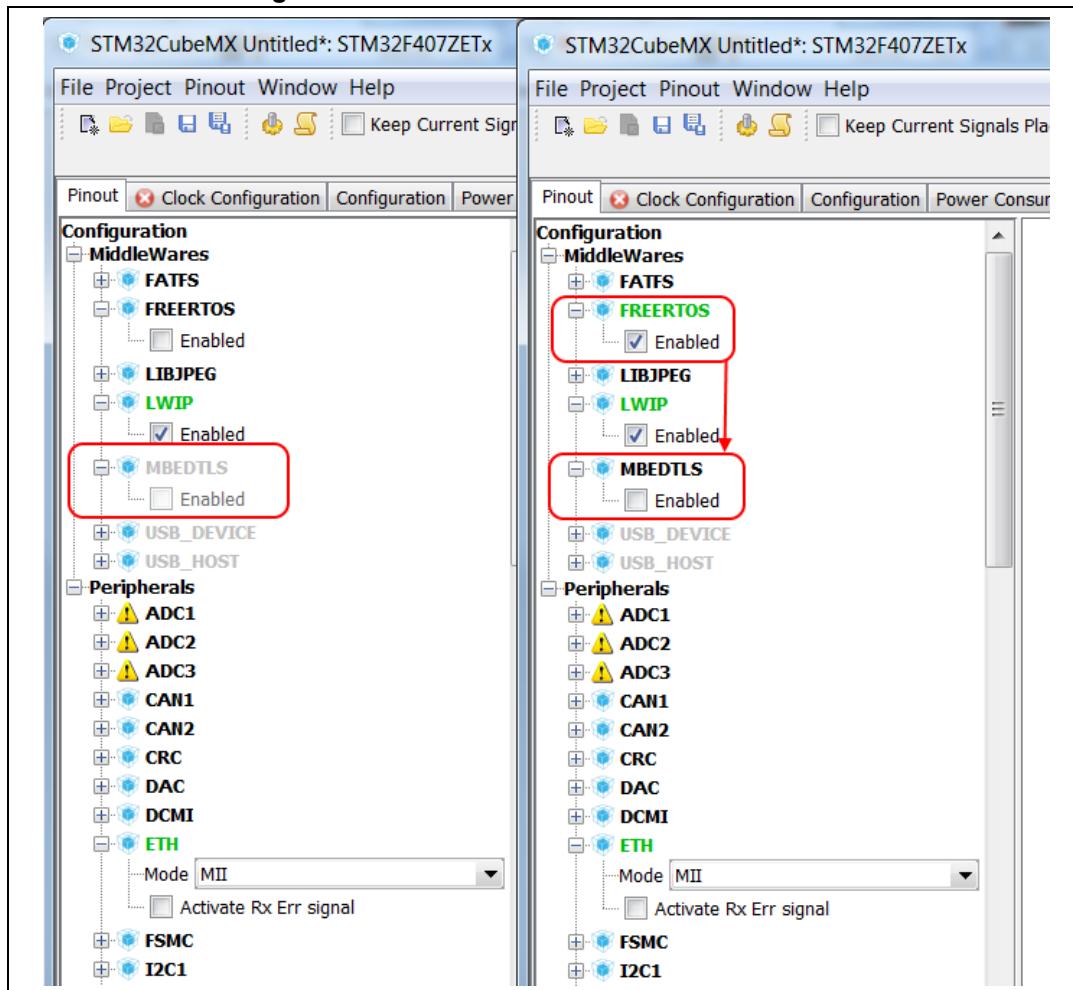
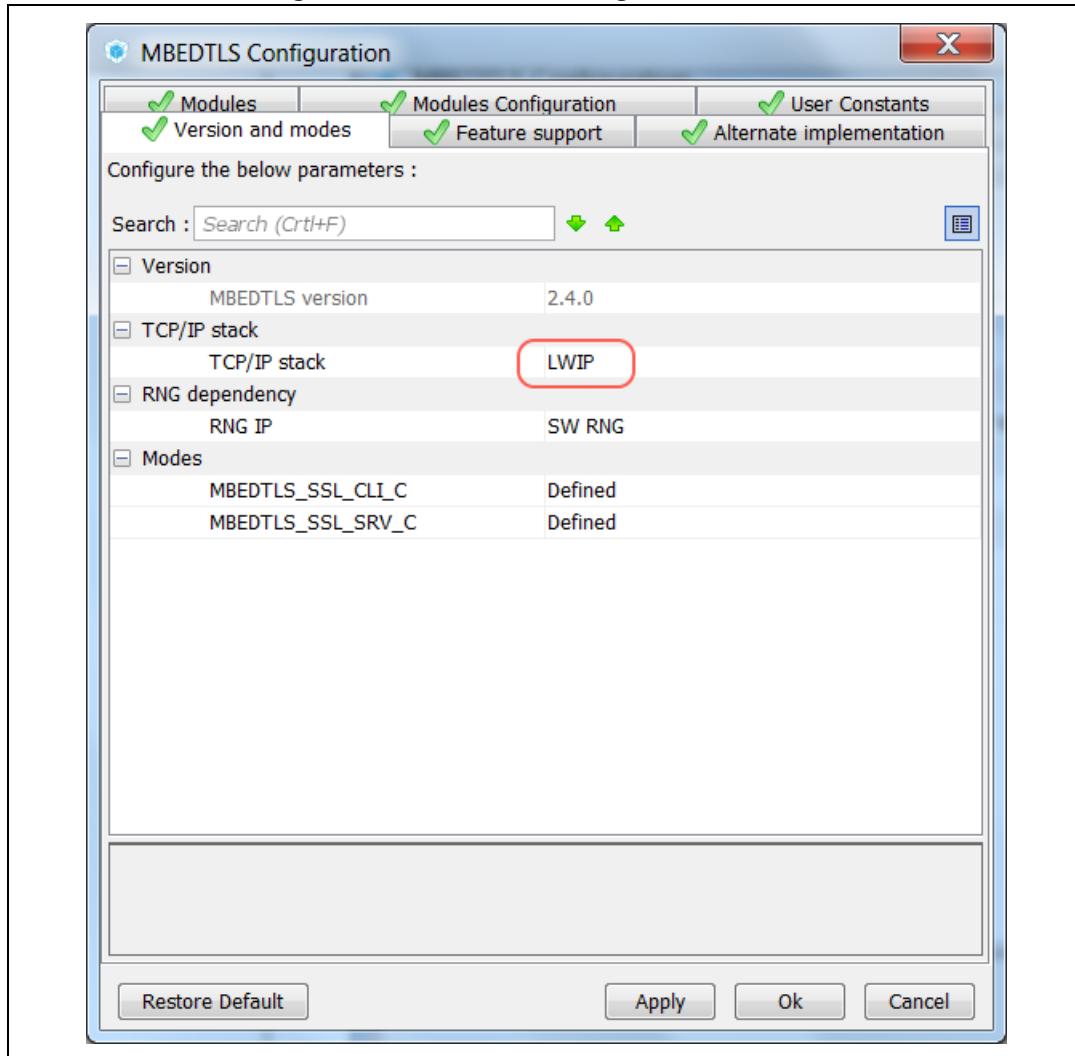


Figure 327. Mbed TLS configuration window



### B.3.9 TouchSensing

The STM32 TouchSensing library is a C-library that allows the creation of higher-end human interfaces by replacing conventional electromechanical switches by capacitive sensors with STM32 microcontrollers.

It requires the touch-sensing peripheral to be configured on the microcontroller.

STM32CubeMX generates the following files, whose contents can be modified by the user through STM32CubeMX user interface (see [Figure 328: Enabling the TouchSensing peripheral](#), [Figure 329: Touch-sensing sensor selection panel](#) and [Figure 330: TouchSensing configuration panel](#)) and/or using user sections in the code itself:

- *touchsensing.c/.h*
- *tsl\_user.c/.h*
- *tsl\_conf.h*

Figure 328. Enabling the TouchSensing peripheral

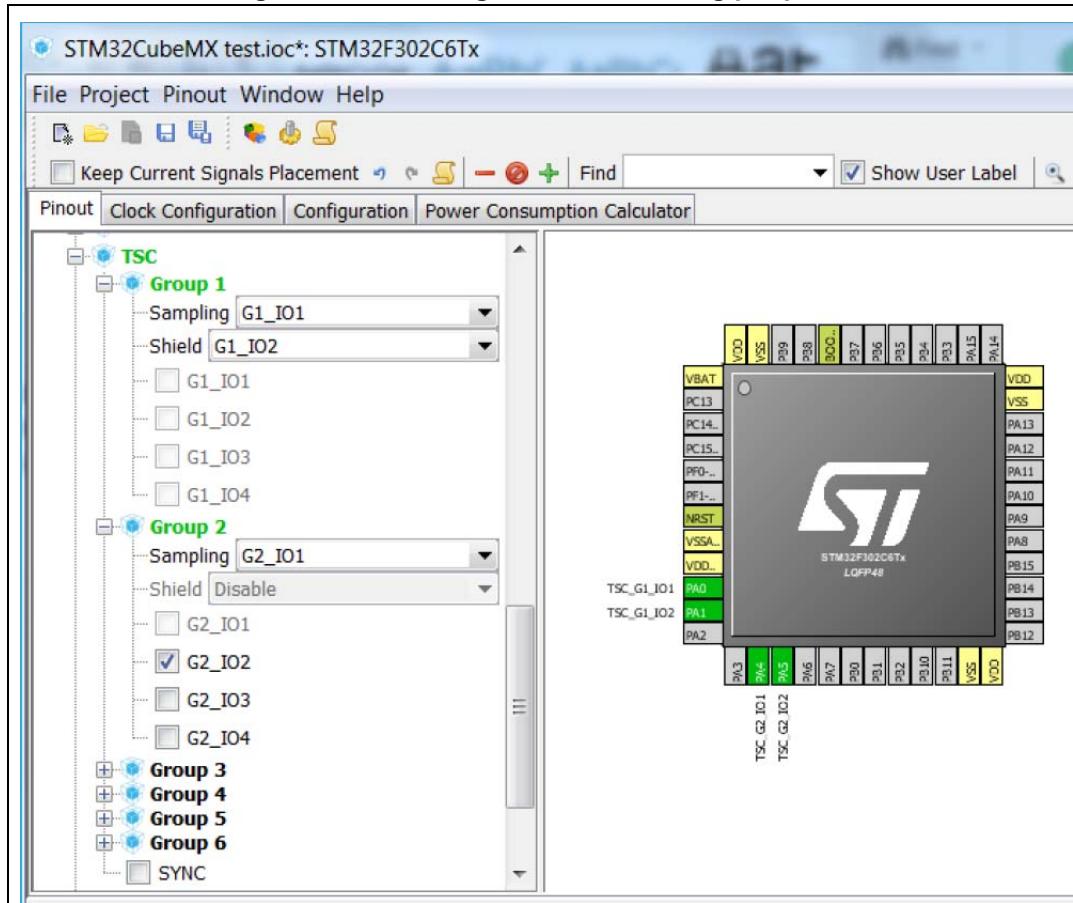


Figure 329. Touch-sensing sensor selection panel

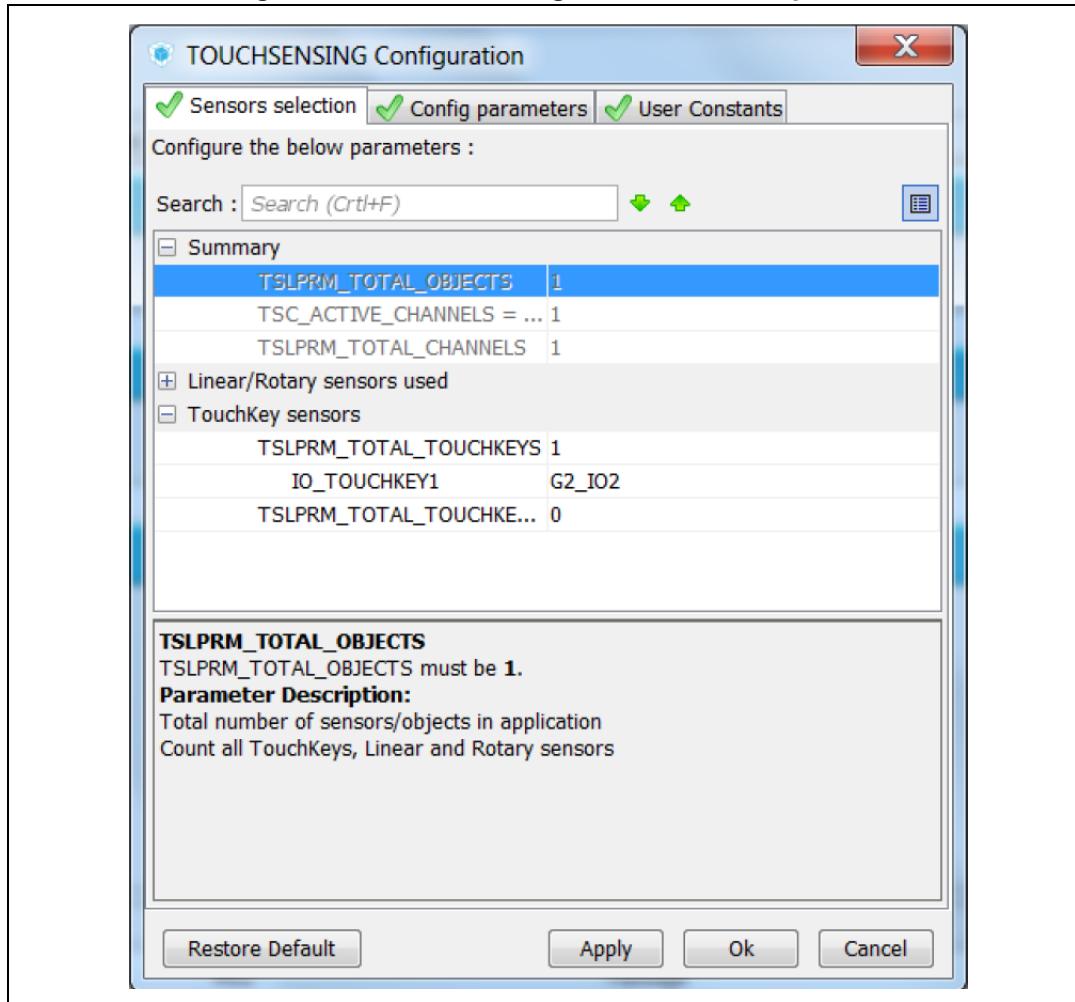
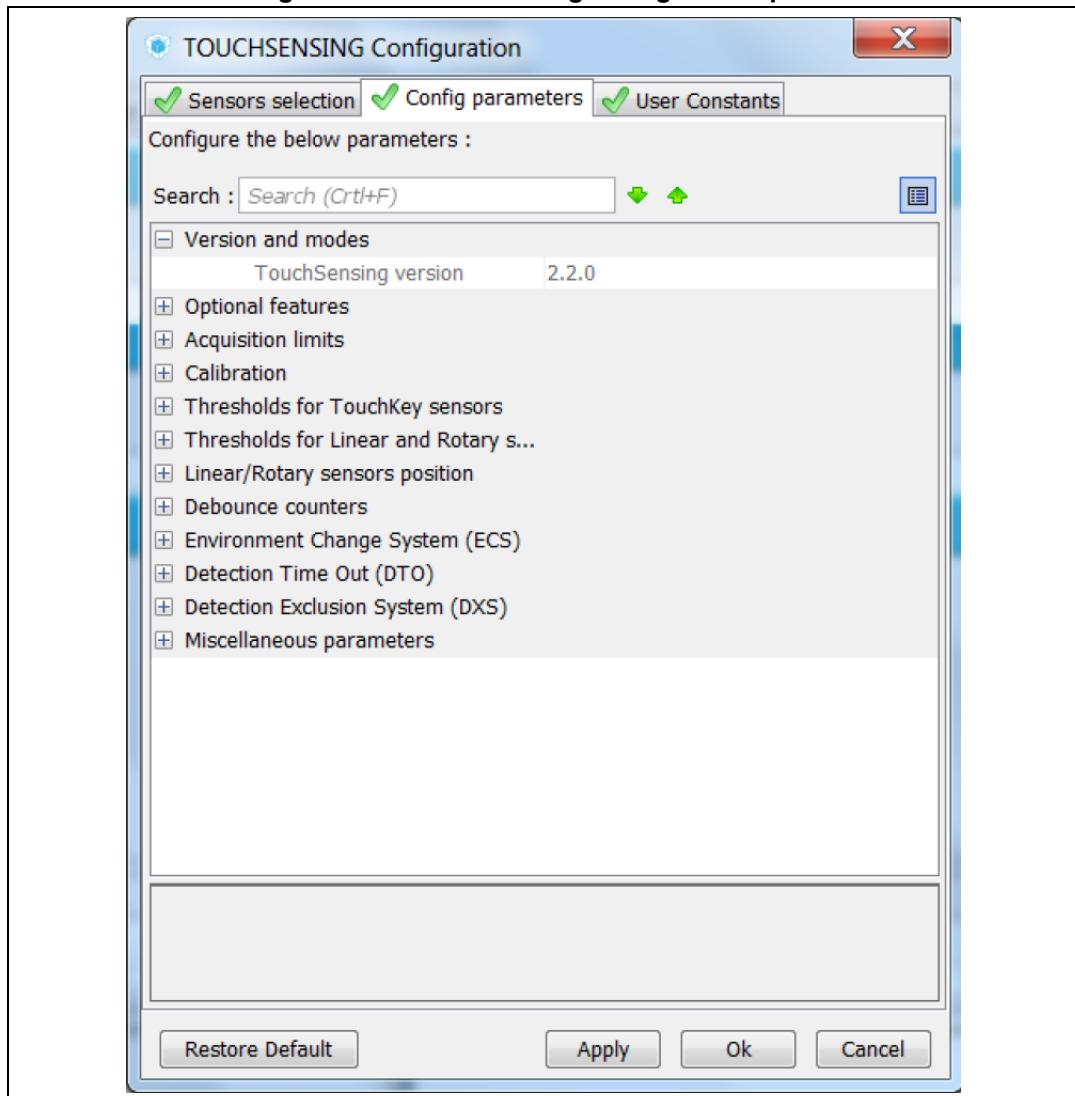


Figure 330. TouchSensing configuration panel



### B.3.10 PDM2PCM

The PDM2PCM library is a C-library that allows converting a pulse density modulated (PDM) data output into a 16-bit pulse-code modulation (PCM) format. It requires the CRC peripheral to be enabled.

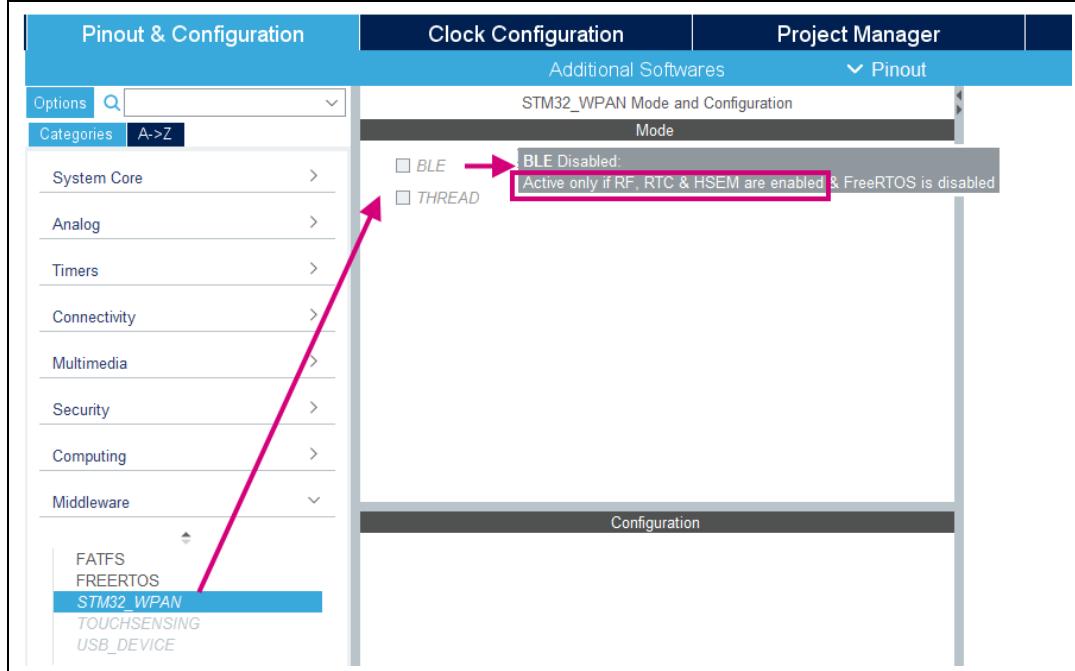
STM32CubeMX generates the following files, whose content can be modified by the user through STM32CubeMX user interface and/or using user sections in the code itself:

- *pdm2pcm.h/c*

### B.3.11 STM32WPAN BLE/Thread (STM32WB Series only)

STM32WPAN BLE and Thread middleware are now supported in STM32CubeMX.

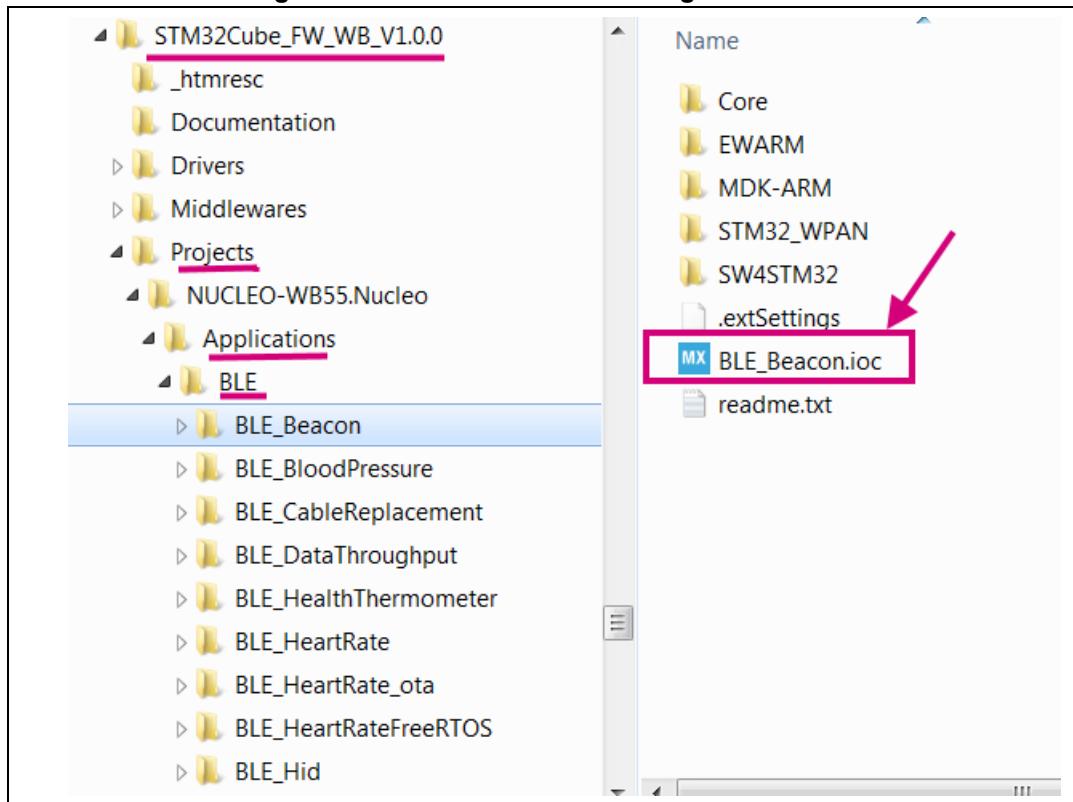
Figure 331. BLE and Thread middleware support in STM32CubeMX



They are exclusive in a given project and configuration with FreeRTOS is not yet supported.

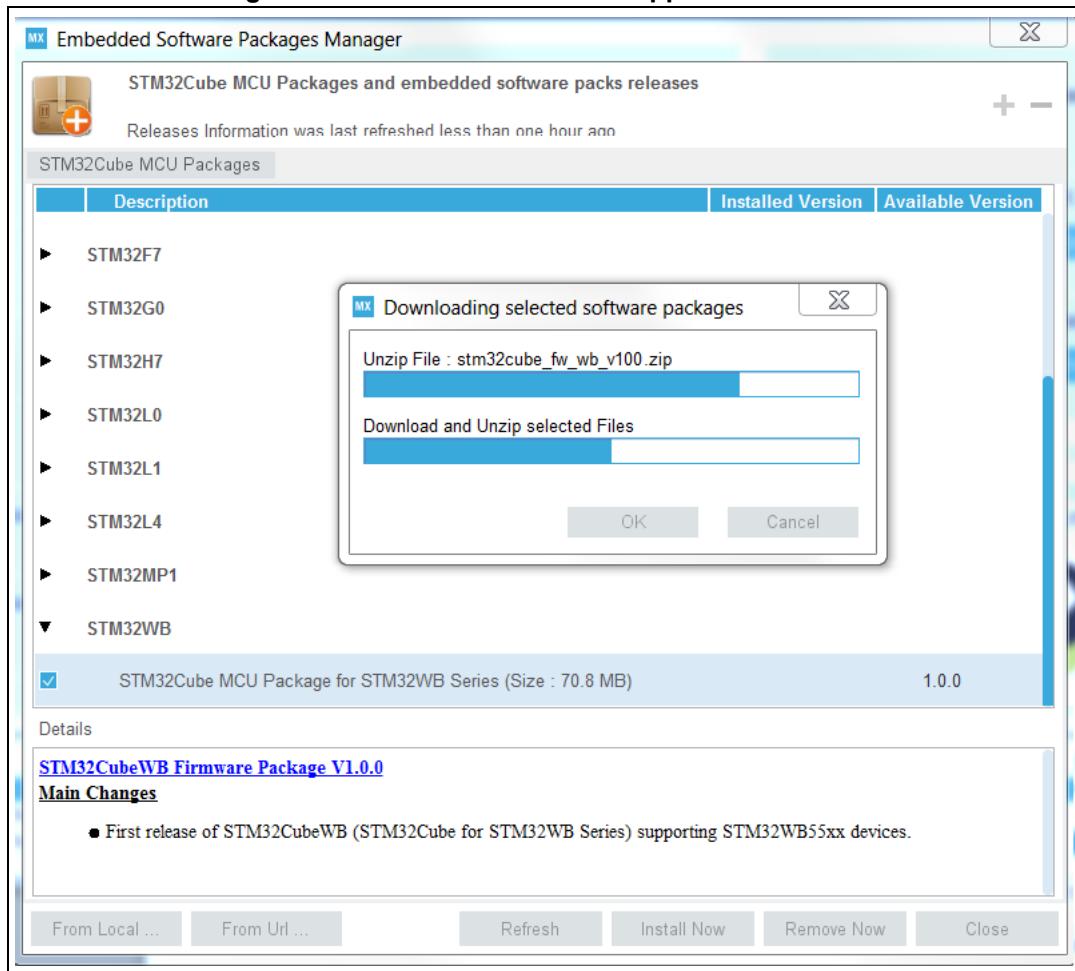
Application projects generated with STM32CubeMX can be found in the project folder of the STM32CubeWB MCU package.

Figure 332. STM32CubeWB Package download



This package can be installed through STM32CubeMX following the standard procedure described in [Section 3.4.2: Installing STM32 MCU packages](#).

**Figure 333. STM32CubeWB BLE applications folder**



## BLE configuration

To enable BLE some peripherals (RTC, HSEM, RF) must be activated first.

Then, an application type must be selected, it can be one among Transparent mode, Server profile, Router profile or Client profile.

Finally, the mode and other parameters relevant to this application type must be configured.

**Note:**

*The BLE Transparent mode and all Thread applications require either the USART or the LPUART peripheral to be configured as well.*

Figure 334. BLE Server profile selection

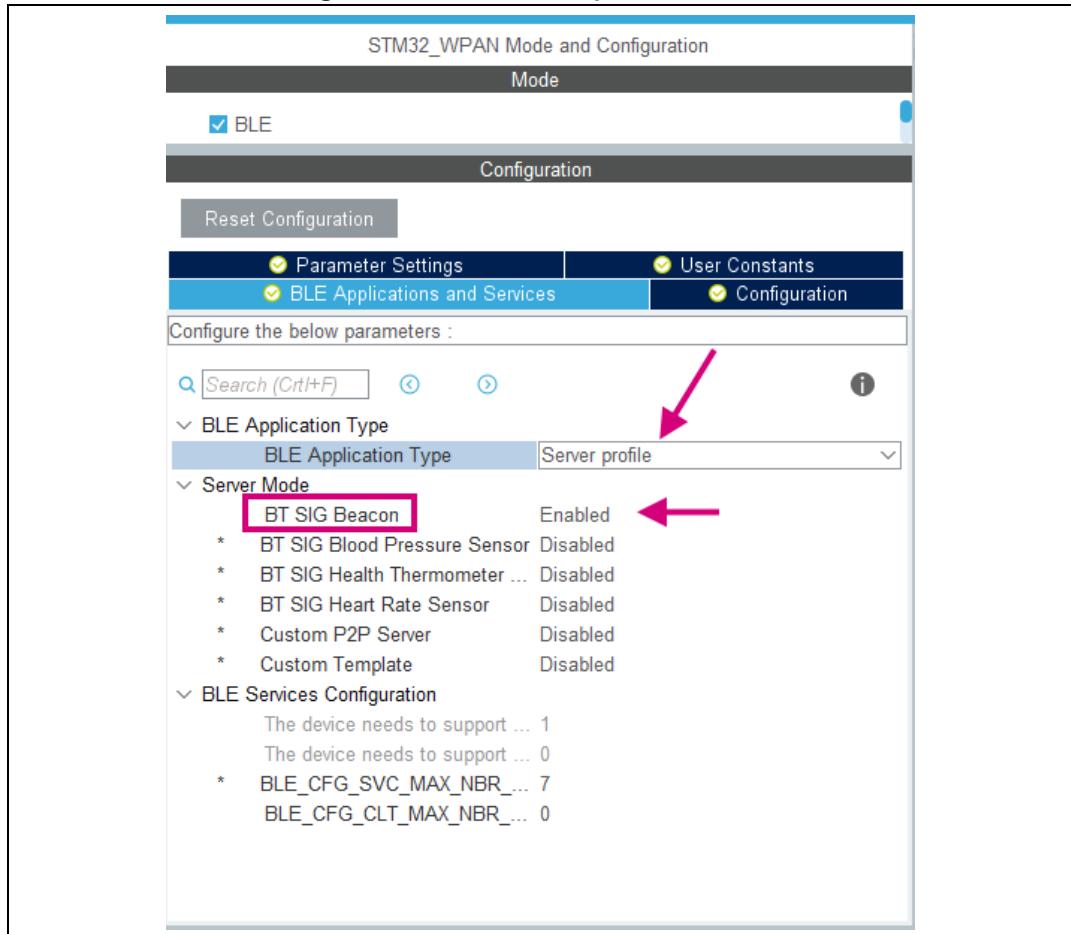
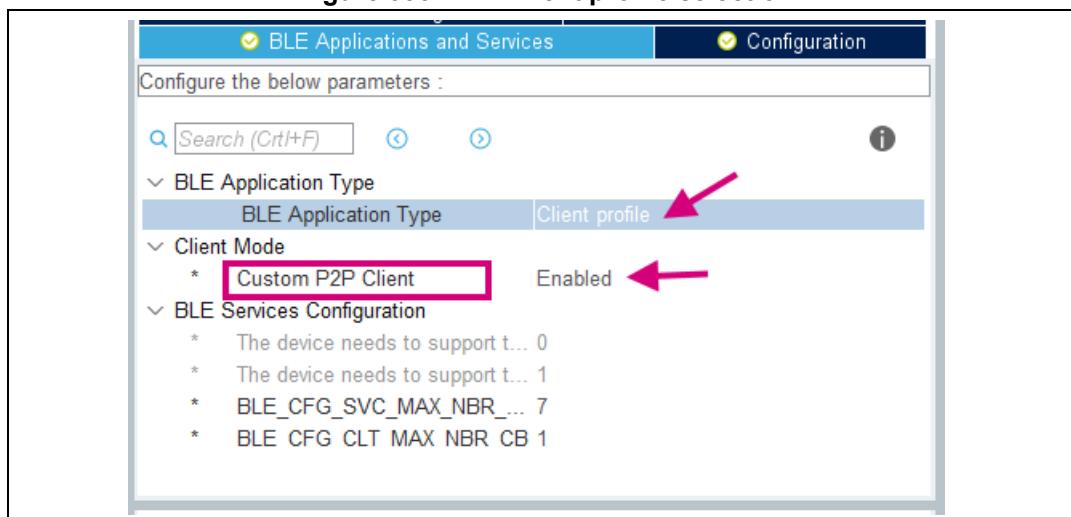


Figure 335. BLE Client profile selection

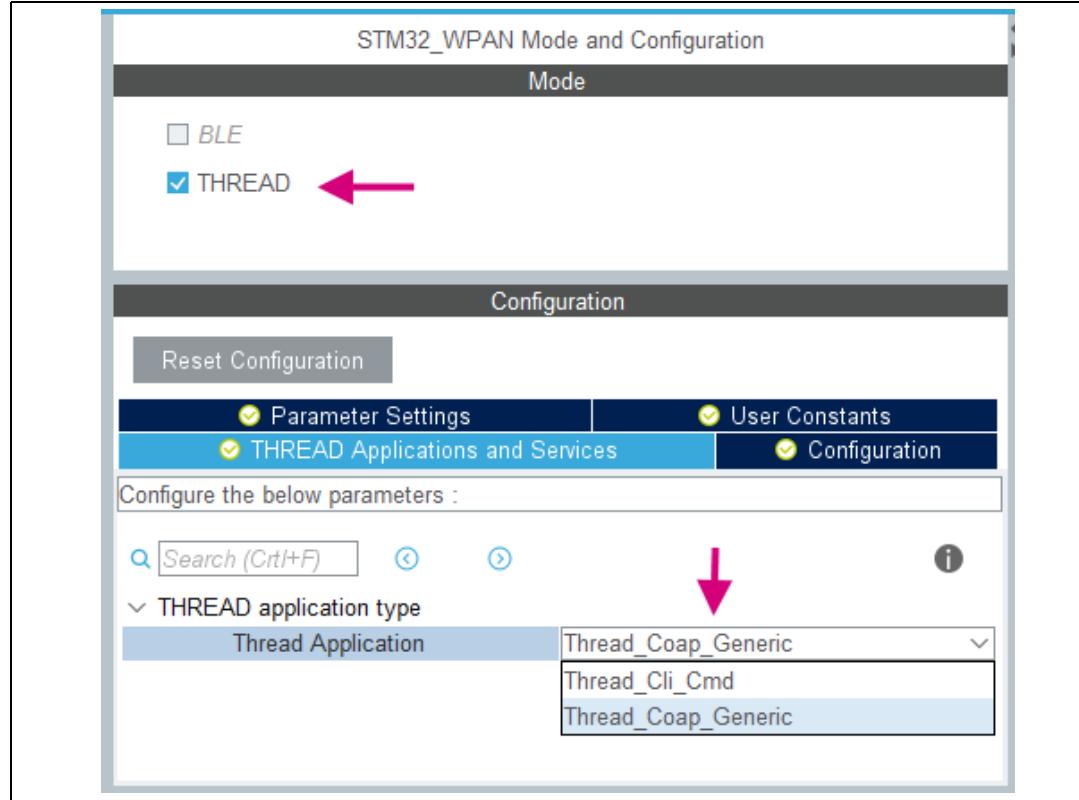


### Thread configuration

To enable Thread some peripherals (RTC, HSEM, RF) must be activated first.

Then, an application type must be selected and the relevant parameters configured.

**Figure 336. Thread application selection**



### B.3.12 OpenAmp and RESMGR.Utility (STM32MP1 Series and STM32H7 dual-core product lines)

New software and hardware have been introduced on dual-core products to enable multi-core cooperation.

- For STM32MP1 Series only: the inter-processor communication controller (IPCC) used to exchange data between two processor instances relies on the fact that shared memory buffers are allocated in the MCU SRAM and that each processor owns specific register bank and interrupts.
- For STM32MP1 Series only: the OpenAMP middleware for intercommunication between Cortex-A and Cortex-M cores implements the RPMsg messaging protocol (see [Figure 337](#)).
- The resource manager library (RESMGR.Utility) for system resource management: multi-processor devices give the possibility to run independent firmware on several cores (see [Figure 338](#)). This implies a core could use some peripherals without knowledge of the usage of these same peripherals: the role of the resource management library is to control the assignment of a peripheral to a dedicated core and to provide a method to configure the system resources used to operate that peripheral (see [Figure 339](#)).

Figure 337. Enabling OpenAmp for STM32MP1 devices

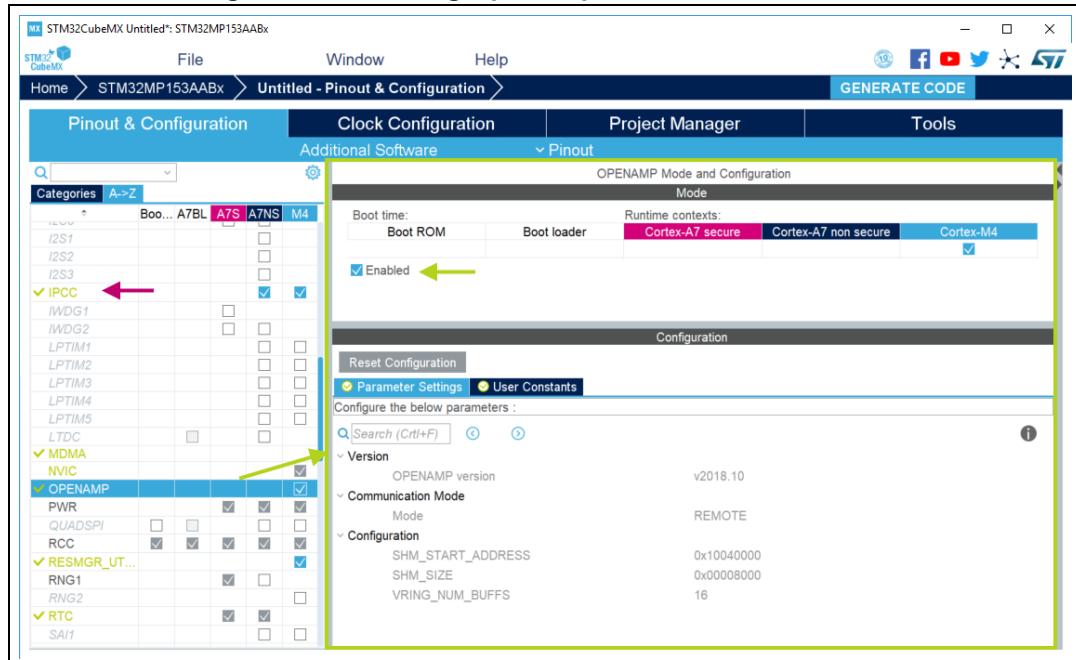


Figure 338. Enabling the Resource Manager for STM32MP1 devices

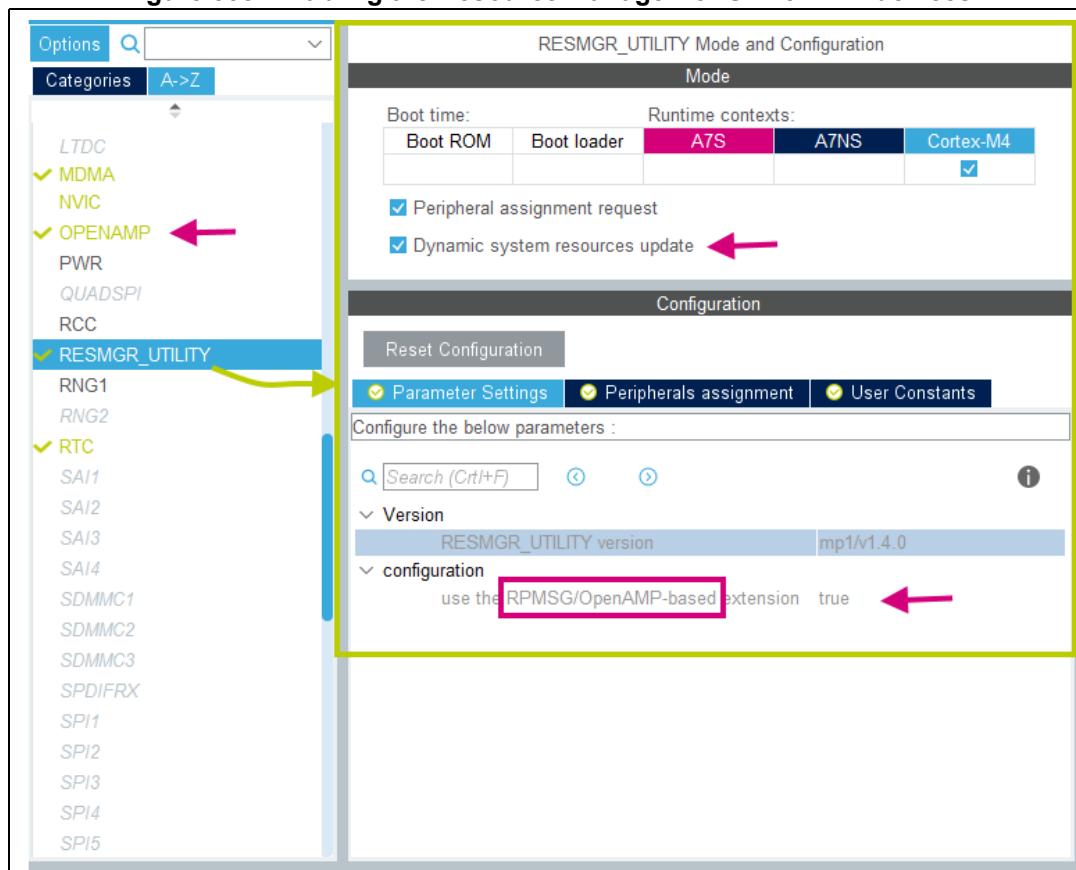
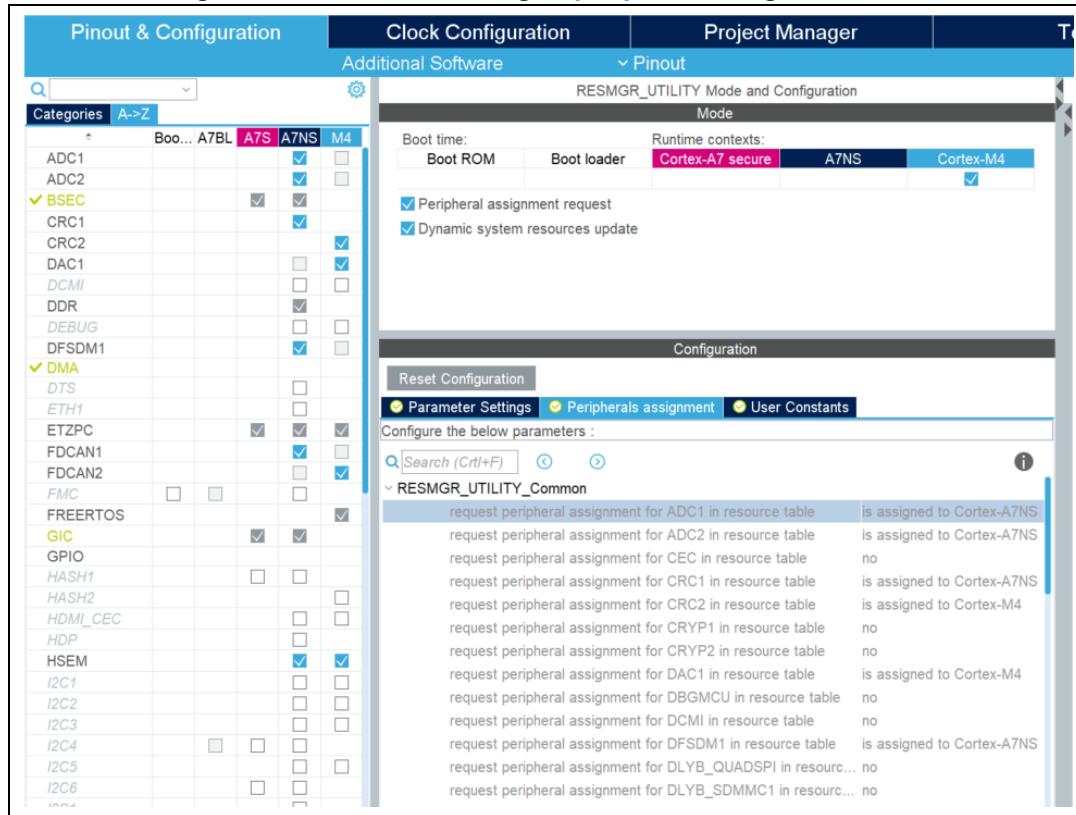


Figure 339. Resource Manager: peripheral assignment view



For more details visit STM32MP1 dedicated wiki site at <https://wiki.st.com/stm32mpu>.

## Appendix C STM32 microcontrollers naming conventions

STM32 microcontroller part numbers are codified following the below naming conventions:

- Device subfamilies

The higher the number, the more features available.

For example STM32L0 line includes STM32L051, L052, L053, L061, L062, L063 subfamilies where STM32L06x part numbers come with AES while STM32L05x do not.

The last digit indicates the level of features. In the above example:

- 1 = Access line
- 2 = with USB
- 3 = with USB and LCD.

- Pin counts

- F = 20 pins
- G = 28 pins
- K = 32 pins
- T = 36 pins
- S = 44 pins
- C = 48 pins
- R = 64 (or 66) pins
- M = 80 pins
- O = 90 pins
- V = 100 pins
- Q = 132 pins (e. g. STM32L162QDH6)
- Z = 144 pins
- I = 176 (+25) pins
- B = 208 pins (e. g. STM32F429BIT6)
- N = 216 pins

- Flash memory sizes

- 4 = 16 Kbytes of Flash memory
- 6 = 32 Kbytes of Flash memory
- 8 = 64 Kbytes of Flash memory
- B = 128 Kbytes of Flash memory
- C = 256 Kbytes of Flash memory
- D = 384 Kbytes of Flash memory
- E = 512 Kbytes of Flash memory
- F = 768 Kbytes of Flash memory
- G = 1024 Kbytes of Flash memory
- I = 2048 Kbytes of Flash memory

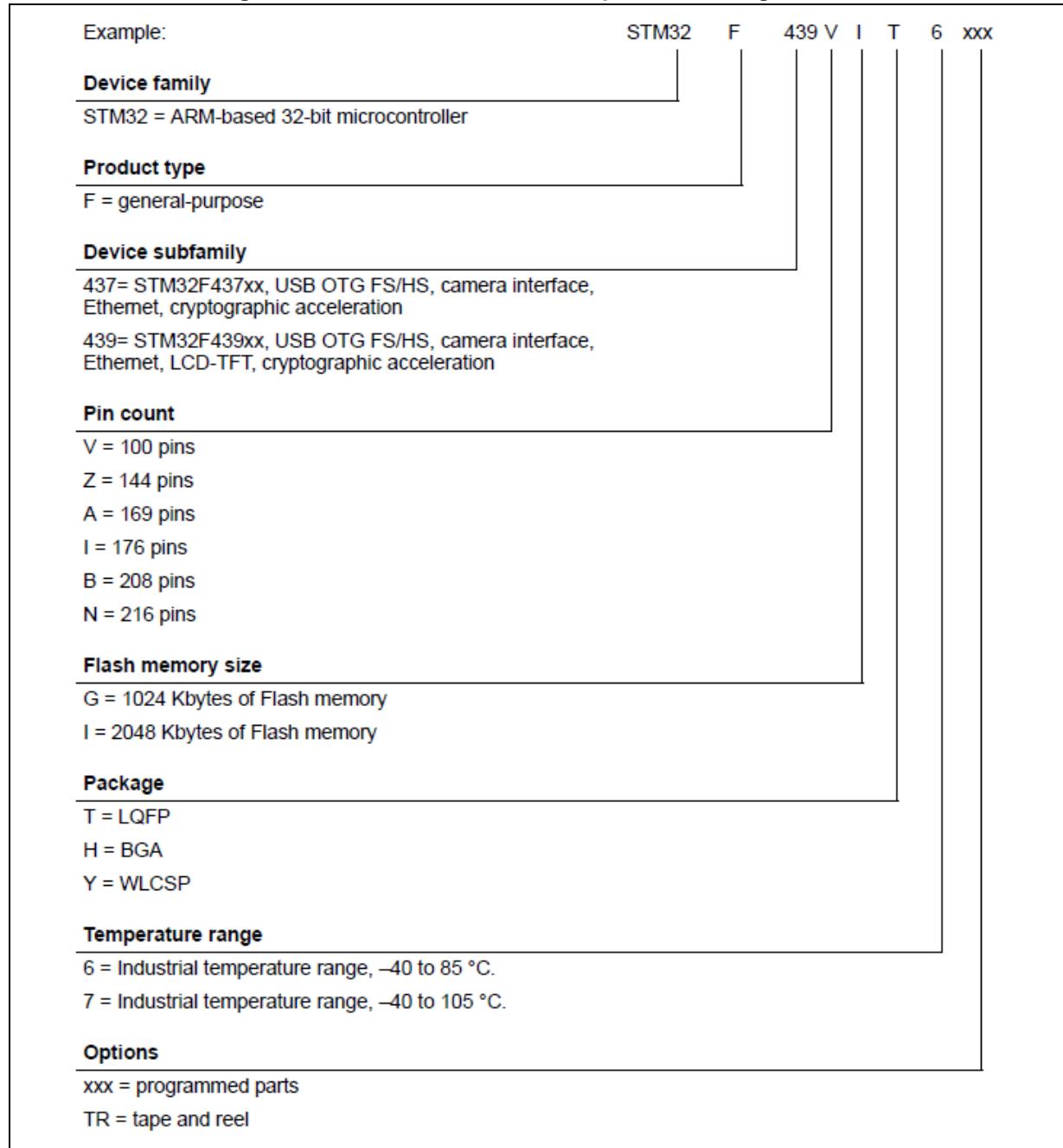
- Packages

- B = SDIP
- H = BGA

- M = SO
- P = TSSOP
- T = LQFP
- U = VFQFPN
- Y = WLCSP

*Figure 340* shows an example of STM32 microcontroller part numbering scheme.

**Figure 340. STM32 microcontroller part numbering scheme**



## Appendix D STM32 microcontrollers power consumption parameters

This section provides an overview on how to use STM32CubeMX Power Consumption Calculator.

Microcontroller power consumption depends on chip size, supply voltage, clock frequency and operating mode. Embedded applications can optimize STM32 MCU power consumption by reducing the clock frequency when fast processing is not required and choosing the optimal operating mode and voltage range to run from. A description of STM32 power modes and voltage range is provided below.

### D.1 Power modes

STM32 MCUs support different power modes (refer to STM32 MCU datasheets for full details).

#### D.1.1 STM32L1 Series

STM32L1 microcontrollers feature up to 6 power modes, including 5 low-power modes:

- **Run mode**

This mode offers the highest performance using HSE/HSI clock sources. The CPU runs up to 32 MHz and the voltage regulator is enabled.

- **Sleep mode**

This mode uses HSE or HSI as system clock sources. The voltage regulator is enabled and the CPU is stopped. All peripherals continue to operate and can wake up the CPU when an interrupt/event occurs.

- **Low- power run mode**

This mode uses the multispeed internal (MSI) RC oscillator set to the minimum clock frequency (131 kHz) and the internal regulator in low-power mode. The clock frequency and the number of enabled peripherals are limited.

- **Low-power sleep mode**

This mode is achieved by entering Sleep mode. The internal voltage regulator is in low-power mode. The clock frequency and the number of enabled peripherals are limited. A typical example would be a timer running at 32 kHz.

When the wakeup is triggered by an event or an interrupt, the system returns to the Run mode with the regulator ON.

- **Stop mode**

This mode achieves the lowest power consumption while retaining RAM and register contents. Clocks are stopped. The real-time clock (RTC) can be backed up by using LSE/LSI at 32 kHz/37 kHz. The number of enabled peripherals is limited. The voltage regulator is in low-power mode.

The device can be woken up from Stop mode by any of the EXTI lines.

- **Standby mode**

This mode achieves the lowest power consumption. The internal voltage regulator is switched off so that the entire  $V_{CORE}$  domain is powered off. Clocks are stopped and the real-time clock (RTC) can be preserved up by using LSE/LSI at 32 kHz/37 kHz.

RAM and register contents are lost except for the registers in the Standby circuitry. The number of enabled peripherals is even more limited than in Stop mode.

The device exits Standby mode upon reset, rising edge on one of the three WKUP pins, or if an RTC event occurs (if the RTC is ON).

**Note:** When exiting Stop or Standby modes to enter the Run mode, STM32L1 MCUs go through a state where the MSI oscillator is used as clock source. This transition can have a significant impact on the global power consumption. For this reason, the Power Consumption Calculator introduces two transition steps: **WU\_FROM\_STOP** and **WU\_FROM\_STANDBY**. During these steps, the clock is automatically configured to MSI.

## D.1.2 STM32F4 Series

STM32F4 microcontrollers feature a total of 5 power modes, including 4 low-power modes:

- **Run mode**

This is the default mode at power-on or after a system reset. It offers the highest performance using HSE/HSI clock sources. The CPU can run at the maximum frequency depending on the selected power scale.

- **Sleep mode**

Only the CPU is stopped. All peripherals continue to operate and can wake up the CPU when an interrupt/even occurs. The clock source is the clock that was set before entering Sleep mode.

- **Stop mode**

This mode achieves a very low power consumption using the RC oscillator as clock source. All clocks in the 1.2 V domain are stopped as well as CPU and peripherals. PLL, HSI RC and HSE crystal oscillators are disabled. The content of registers and internal SRAM are kept.

The voltage regulator can be put either in normal Main regulator mode (MR) or in Low-power regulator mode (LPR). Selecting the regulator in low-power regulator mode increases the wakeup time.

The Flash memory can be put either in Stop mode to achieve a fast wakeup time or in Deep power-down to obtain a lower consumption with a slow wakeup time.

The Stop mode features two sub-modes:

- **Stop in Normal mode (default mode)**

In this mode, the 1.2 V domain is preserved in nominal leakage mode and the minimum V<sub>12</sub> voltage is 1.08 V.

- **Stop in Under-drive mode**

In this mode, the 1.2 V domain is preserved in reduced leakage mode and V<sub>12</sub> voltage is less than 1.08 V. The regulator (in Main or Low-power mode) is in under-drive or low-voltage mode. The Flash memory must be in Deep-power-down mode. The wakeup time is about 100 µs higher than in normal mode.

- **Standby mode**

This mode achieves very low power consumption with the RC oscillator as a clock source. The internal voltage regulator is switched off so that the entire 1.2 V domain is powered off: CPU and peripherals are stopped. The PLL, the HSI RC and the HSE crystal oscillators are disabled. SRAM and register contents are lost except for registers in the backup domain and the 4-byte backup SRAM when selected. Only RTC and LSE oscillator blocks are powered. The device exits Standby mode when an

external reset (NRST pin), an IWDG reset, a rising edge on the WKUP pin, or an RTC alarm/ wakeup/ tamper/time stamp event occurs.

- **V<sub>BAT</sub> operation**

It allows to significantly reduced power consumption compared to the Standby mode. This mode is available when the V<sub>BAT</sub> pin powering the Backup domain is connected to an optional standby voltage supplied by a battery or by another source. The V<sub>BAT</sub> domain is preserved (RTC registers, RTC backup register and backup SRAM) and RTC and LSE oscillator blocks powered. The main difference compared to the Standby mode is external interrupts and RTC alarm/events do not exit the device from V<sub>BAT</sub> operation. Increasing V<sub>DD</sub> to reach the minimum threshold does.

### D.1.3 STM32L0 Series

STM32L0 microcontrollers feature up to 8 power modes, including 7 low-power modes to achieve the best compromise between low-power consumption, short startup time and available wakeup sources:

- **Run mode**

This mode offers the highest performance using HSE/HSI clock sources. The CPU can run up to 32 MHz and the voltage regulator is enabled.

- **Sleep mode**

This mode uses HSE or HSI as system clock sources. The voltage regulator is enabled and only the CPU is stopped. All peripherals continue to operate and can wake up the CPU when an interrupt/event occurs.

- **Low-power run mode**

This mode uses the internal regulator in low-power mode and the multispeed internal (MSI) RC oscillator set to the minimum clock frequency (131 kHz). In Low-power run mode, the clock frequency and the number of enabled peripherals are both limited.

- **Low-power sleep mode**

This mode is achieved by entering Sleep mode with the internal voltage regulator in low-power mode. Both the clock frequency and the number of enabled peripherals are limited. Event or interrupt can revert the system to Run mode with regulator on.

- **Stop mode with RTC**

The Stop mode achieves the lowest power consumption with, while retaining the RAM, register contents and real time clock. The voltage regulator is in low-power mode. LSE or LSI is still running. All clocks in the V<sub>CORE</sub> domain are stopped, the PLL, MSI RC, HSE crystal and HSI RC oscillators are disabled.

Some peripherals featuring wakeup capability can enable the HSI RC during Stop mode to detect their wakeup condition. The device can be woken up from Stop mode by any of the EXTI line, in 3.5 µs, and the processor can serve the interrupt or resume the code.

- **Stop mode without RTC**

This mode is identical to “Stop mode with RTC”, except for the RTC clock which is stopped here.

- **Standby mode with RTC**

The Standby mode achieves the lowest power consumption with the real time clock running. The internal voltage regulator is switched off so that the entire V<sub>CORE</sub> domain

is powered off. The PLL, MSI RC, HSE crystal and HSI RC oscillators are also switched off. The LSE or LSI is still running.

After entering Standby mode, the RAM and register contents are lost except for registers in the Standby circuitry (wakeup logic, IWDG, RTC, LSI, LSE Crystal 32 KHz oscillator, RCC\_CSR register).

The device exits Standby mode in 60  $\mu$ s when an external reset (NRST pin), an IWDG reset, a rising edge on one of the three WKUP pins, RTC alarm (Alarm A or Alarm B), RTC tamper event, RTC timestamp event or RTC Wakeup event occurs.

- **Standby mode without RTC**

This mode is identical to Standby mode with RTC, except that the RTC, LSE and LSI clocks are stopped.

The device exits Standby mode in 60  $\mu$ s when an external reset (NRST pin) or a rising edge on one of the three WKUP pin occurs.

**Note:** *The RTC, the IWDG, and the corresponding clock sources are not stopped automatically by entering Stop or Standby mode. The LCD is not stopped automatically by entering Stop mode.*

## D.2 Power consumption ranges

STM32 MCUs power consumption can be further optimized thanks to the dynamic voltage scaling feature: the main internal regulator output voltage V12 that supplies the logic (CPU, digital peripherals, SRAM and Flash memory) can be adjusted by software by selecting a power range (STM32L1 and STM32L0) or power scale (STM32 F4).

Power consumption range definitions are provided below (refer to STM32 MCU datasheets for full details).

### D.2.1 STM32L1 Series features three $V_{CORE}$ ranges

- High Performance **Range 1** ( $V_{DD}$  range limited to 2.0-3.6 V), with the CPU running at up to 32 MHz  
The voltage regulator outputs a 1.8 V voltage (typical) as long as the  $V_{DD}$  input voltage is above 2.0 V. Flash program and erase operations can be performed.
- Medium Performance **Range 2** (full  $V_{DD}$  range), with a maximum CPU frequency of 16 MHz  
At 1.5 V, the Flash memory is still functional but with medium read access time. Flash program and erase operations are still possible.
- Low Performance **Range 3** (full  $V_{DD}$  range), with a maximum CPU frequency limited to 4 MHz (generated only with the multispeed internal RC oscillator clock source)  
At 1.2 V, the Flash memory is still functional but with slow read access time. Flash Program and erase operations are no longer available.

## D.2.2 STM32F4 Series features several V<sub>CORE</sub> scales

The scale can be modified only when the PLL is OFF and when HSI or HSE is selected as system clock source.

- **Scale 1** (V<sub>12</sub> voltage range limited to 1.26 - 1.40 V), default mode at reset.  
HCLK frequency range = 144 MHz to 168 MHz (180 MHz with over-drive).  
This is the default mode at reset.
- **Scale 2** (V<sub>12</sub> voltage range limited to 1.20 - 1.32 V).  
HCLK frequency range is up to 144 MHz (168 MHz with over-drive).
- **Scale 3** (V<sub>12</sub> voltage range limited to 1.08 - 1.20 V), default mode when exiting Stop mode.  
HCLK frequency ≤120 MHz.

The voltage scaling is adjusted to f<sub>HCLK</sub> frequency as follows:

- **STM32F429x/39x MCUs:**
  - **Scale 1:** up to 168 MHz (up to 180 MHz with over-drive)
  - **Scale 2:** from 120 to 144 MHz (up to 168 MHz with over-drive)
  - **Scale 3:** up to 120 MHz.
- **STM32F401x MCUs:**
  - No Scale 1
  - **Scale 2:** from 60 to 84 MHz
  - **Scale 3:** up to 60 MHz.
- **STM32F40x/41x MCUs:**
  - **Scale 1:** up to 168 MHz
  - **Scale 2:** up to 144 MHz

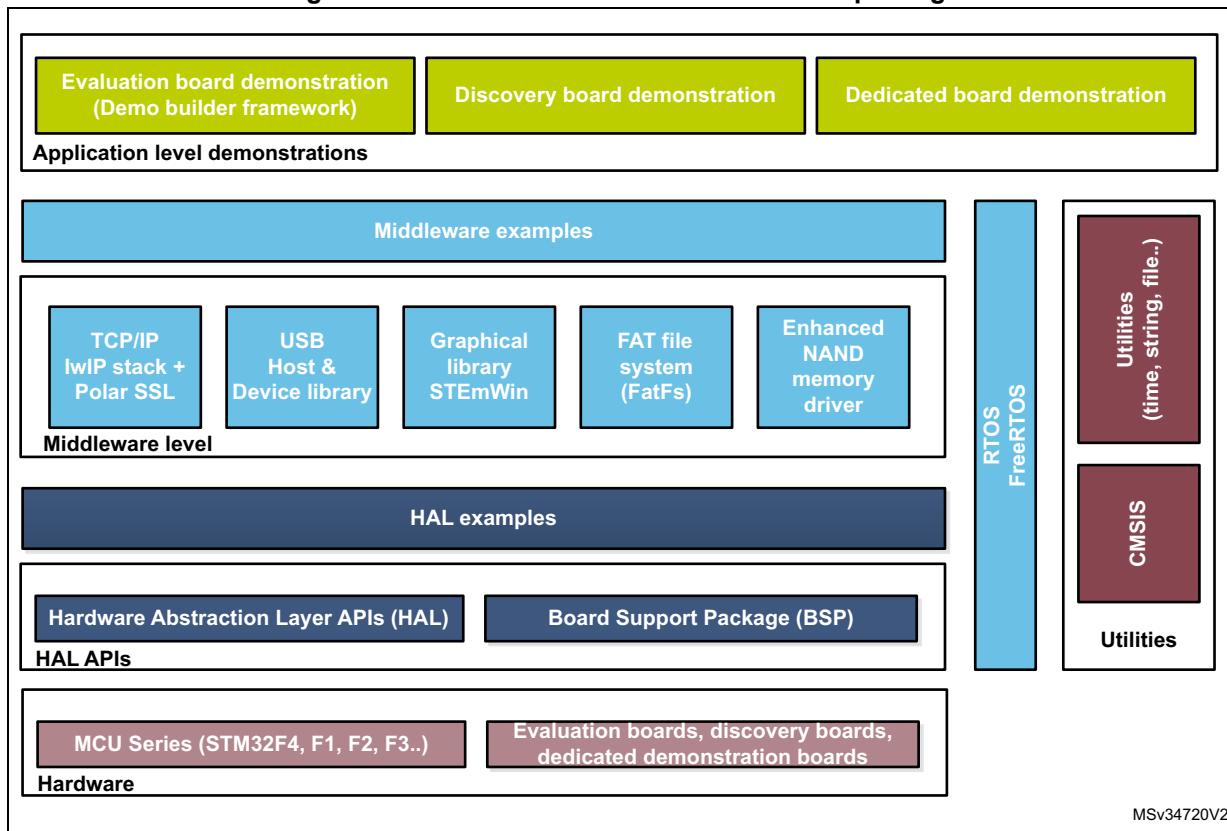
## D.2.3 STM32L0 Series features three V<sub>CORE</sub> ranges

- Range 1 (V<sub>DD</sub> range limited to 1.71 to 3.6 V), with CPU running at a frequency up to 32 MHz
- Range 2 (full V<sub>DD</sub> range), with a maximum CPU frequency of 16 MHz
- Range 3 (full V<sub>DD</sub> range), with a maximum CPU frequency limited to 4.2 MHz.

## Appendix E STM32Cube embedded software packages

Along with STM32CubeMX C code generator, embedded software packages are part of STM32Cube initiative (refer to *DB2164 databrief*): these packages include a low-level hardware abstraction layer (HAL) that covers the microcontroller hardware, together with an extensive set of examples running on STMicroelectronics boards (see *Figure 341*). This set of components is highly portable across the STM32 Series. The packages are fully compatible with STM32CubeMX generated C code.

**Figure 341. STM32Cube Embedded Software package**



Note: *STM32CubeF0, STM32CubeF1, STM32CubeF2, STM32CubeF3, STM32CubeF4, STM32CubeL0 and STM32CubeL1 embedded software packages are available on st.com. They are based on STM32Cube release v1.1 (other Series will be introduced progressively) and include the embedded software libraries used by STM32CubeMX for initialization C code generation.*

*The user should use STM32CubeMX to generate the initialization C code and the examples provided in the package to get started with STM32 application development.*

## Revision history

**Table 24. Document revision history**

Date	Revision	STM32CubeMX release number	Changes
17-Feb-2014	1	4.1	Initial release.
04-Apr-2014	2	4.2	<p>Added support of STM32CubeF2 and STM32F2 Series in cover page, <a href="#">Section 2.2: Key features</a>, <a href="#">Section 5.14.1: Peripherals and Middleware Configuration window</a>, and <a href="#">Appendix E: STM32Cube embedded software packages</a>.</p> <p>Updated <a href="#">Section 11.1: Creating a new STM32CubeMX Project</a>, <a href="#">Section 11.2: Configuring the MCU pinout</a>, <a href="#">Section 11.6: Configuring the MCU initialization parameters</a>.</p> <p>Section “Generating GPIO initialization C code move to <a href="#">Section 8: Tutorial 3- Generating GPIO initialization C code (STM32F1 Series only)</a> and content updated.</p> <p>Added <a href="#">Section 18.6: Why do I get the error “Java 8 update 45” when installing “Java 8 update 45” or a more recent version of the JRE?</a>.</p>
24-Apr-2014	3	4.3	<p>Added support of STM32CubeL0 and STM32L0 Series in cover page, <a href="#">Section 2.2: Key features</a>, <a href="#">Section 2.3: Rules and limitations</a> and <a href="#">Section 5.14.1: Peripherals and Middleware Configuration window</a></p> <p>Added board selection in <a href="#">Table 13: File menu functions</a>, <a href="#">Section 5.7.3: Pinout menu</a> and <a href="#">Section 4.2: New Project window</a>.</p> <p>Updated <a href="#">Table 15: Pinout menu</a>.</p> <p>Updated <a href="#">Figure 128: Power Consumption Calculator default view</a> and added battery selection in <a href="#">Section 5.2.1: Building a power consumption sequence</a>.</p> <p>Updated note in <a href="#">Section 5.2: Power Consumption Calculator view</a></p> <p>Updated <a href="#">Section 11.1: Creating a new STM32CubeMX Project</a>.</p> <p>Added <a href="#">Section 18.6: Why does the RTC multiplexer remain inactive on the Clock tree view?</a>, <a href="#">Section 18.7: How can I select LSE and HSE as clock source and change the frequency?</a>, and <a href="#">Section 18.8: Why STM32CubeMX does not allow me to configure PC13, PC14, PC15 and PI8 as outputs when one of them is already configured as an output?</a>.</p>

**Table 24. Document revision history**

Date	Revision	STM32CubeMX release number	Changes
19-Jun-2014	4	4.4	<p>Added support of STM32CubeF0, STM32CubeF3, STM32F0 and STM32F3 Series in cover page, <a href="#">Section 2.2: Key features</a>, <a href="#">Section 2.3: Rules and limitations</a>.</p> <p>Added board selection capability and pin locking capability in <a href="#">Section 2.2: Key features</a>, <a href="#">Table 2: Home page shortcuts</a>, <a href="#">Section 4.2: New Project window</a>, <a href="#">Section 5.7: Toolbar and menus</a>, <a href="#">Section 4.11: Set unused / Reset used GPIOs windows</a>, <a href="#">Section 4.9: Project Manager view</a>, and <a href="#">Section 5.15: Pinout view</a>. Added <a href="#">Section 5.15.1: Pinning and labeling signals on pins</a>.</p> <p>Updated <a href="#">Section 5.16: Configuration view</a> and <a href="#">Section 4.8: Clock Configuration view</a> and <a href="#">Section 5.2: Power Consumption Calculator view</a>.</p> <p>Updated <a href="#">Figure 38: STM32CubeMX Main window upon MCU selection</a>, <a href="#">Figure 100: Project Settings window</a>, <a href="#">Figure 126: About window</a>, <a href="#">Figure 140: STM32CubeMX Pinout view</a>, <a href="#">Figure 120: Chip view</a>, <a href="#">Figure 128: Power Consumption Calculator default view</a>, <a href="#">Figure 129: Battery selection</a>, <a href="#">Figure 87: Building a power consumption sequence</a>, <a href="#">Figure 131: Power consumption sequence: New Step default view</a>, <a href="#">Figure 138: Power Consumption Calculator view after sequence building</a>, <a href="#">Figure 139: Sequence table management functions</a>, <a href="#">Figure 88: PCC Edit Step window</a>, <a href="#">Figure 83: Power consumption sequence: new step configured (STM32F4 example)</a>, <a href="#">Figure 136: ADC selected in Pinout view</a>, <a href="#">Figure 137: Power Consumption Calculator Step configuration window: ADC enabled using import pinout</a>, <a href="#">Figure 141: Description of the Results area</a>, <a href="#">Figure 100: Peripheral power consumption tooltip</a>, <a href="#">Figure 257: Power Consumption Calculation example</a>, <a href="#">Figure 155: Sequence table</a> and <a href="#">Figure 156: Power Consumption Calculation results</a>.</p> <p>Updated <a href="#">Figure 142: STM32CubeMX Configuration view</a> and <a href="#">Figure 39: STM32CubeMX Configuration view - STM32F1 Series titles</a>.</p> <p>Added STM32L1 in <a href="#">Section 5.2: Power Consumption Calculator view</a>.</p> <p>Removed Figure Add a new step using the PCC panel from <a href="#">Section 8.1.1: Adding a step</a>. Removed Figure Add a new step to the sequence from <a href="#">Section 5.2.2: Configuring a step in the power sequence</a>.</p> <p>Updated <a href="#">Section 8.2: Reviewing results</a>.</p> <p>Updated appendix <a href="#">B.3.4: FatFs</a> and <a href="#">Appendix D: STM32 microcontrollers power consumption parameters</a>. Added Appendix <a href="#">D.1.3: STM32L0 Series</a> and <a href="#">D.2.3: STM32L0 Series features three VCORE ranges</a>.</p>

**Table 24. Document revision history**

Date	Revision	STM32CubeMX release number	Changes
19-Sep-2014	5	4.5	<p>Added support of STM32CubeL1 Series in cover page, <a href="#">Section 2.2: Key features</a>, <a href="#">Section 2.3: Rules and limitations</a>,</p> <p>Updated <a href="#">Section 3.2.3: Uninstalling STM32CubeMX standalone version</a>.</p> <p>Added off-line updates in <a href="#">Section 3.4: Getting updates using STM32CubeMX</a>, modified <a href="#">Figure 8: Embedded Software Packages Manager window</a>, and <a href="#">Section 3.4.2: Installing STM32 MCU packages</a>.</p> <p>Updated <a href="#">Section 4: STM32CubeMX user interface</a> introduction, <a href="#">Table 2: Home page shortcuts</a> and <a href="#">Section 4.2: New Project window</a>.</p> <p>Added <a href="#">Figure 30: New Project window - Board selector</a>.</p> <p>Updated <a href="#">Figure 108: Project Settings code generator</a>.</p> <p>Modified step 3 in <a href="#">Section 4.9: Project Manager view</a>.</p> <p>Updated <a href="#">Figure 39: STM32CubeMX Configuration view - STM32F1 Series</a>.</p> <p>Added STM32L1 in <a href="#">Section 5.14.1: Peripherals and Middleware Configuration window</a>.</p> <p>Updated <a href="#">Figure 62: GPIO Configuration window - GPIO selection</a>; <a href="#">Section 4.4.12: GPIO Configuration window</a> and <a href="#">Figure 67: DMA MemToMem configuration</a>.</p> <p>Updated introduction of <a href="#">Section 4.8: Clock Configuration view</a>.</p> <p>Updated <a href="#">Section 4.8.1: Clock tree configuration functions</a> and <a href="#">Section 4.8.3: Recommendations</a>, <a href="#">Section 5.2: Power Consumption Calculator view</a>, <a href="#">Figure 131: Power consumption sequence: New Step default view</a>, <a href="#">Figure 138: Power Consumption Calculator view after sequence building</a>, <a href="#">Figure 83: Power consumption sequence: new step configured (STM32F4 example)</a>, and <a href="#">Figure 137: Power Consumption Calculator Step configuration window: ADC enabled using import pinout</a>. Added <a href="#">Figure 140: Power Consumption: Peripherals consumption chart</a> and updated <a href="#">Figure 100: Peripheral power consumption tooltip</a>. Updated <a href="#">Section 5.2.4: Power sequence step parameters glossary</a>.</p> <p>Updated <a href="#">Section 6: STM32CubeMX C Code generation overview</a>.</p> <p>Updated <a href="#">Section 11.1: Creating a new STM32CubeMX Project</a> and <a href="#">Section 11.2: Configuring the MCU pinout</a>.</p> <p>Added <a href="#">Section 12: Tutorial 2 - Example of FatFs on an SD card using STM32429I-EVAL evaluation board</a> and updated <a href="#">Section 8: Tutorial 3- Generating GPIO initialization C code (STM32F1 Series only)</a>.</p> <p>Updated <a href="#">Section 5.2.2: Configuring a step in the power sequence</a>.</p>

**Table 24. Document revision history**

Date	Revision	STM32CubeMX release number	Changes
19-Jan-2015	6	4.6	<p>Complete project generation, power consumption calculation and clock tree configuration now available on all STM32 Series.</p> <p>Updated <a href="#">Section 2.2: Key features</a> and <a href="#">Section 2.3: Rules and limitations</a>.</p> <p>Updated Eclipse IDEs in <a href="#">Section 3.1.3: Software requirements</a>.</p> <p>Updated <a href="#">Figure 6: Updater Settings window</a>, <a href="#">Figure 8: Embedded Software Packages Manager window</a> and <a href="#">Figure 30: New Project window - Board selector</a>, Updated <a href="#">Section 4.9: Project Manager view</a> and <a href="#">Section 4.12: Update Manager windows</a>.</p> <p>Updated <a href="#">Figure 126: About window</a>.</p> <p>Removed Figure <a href="#">STM32CubeMX Configuration view - STM32F1 Series</a>.</p> <p>Updated <a href="#">Table 17: STM32CubeMX Chip view - Icons and color scheme</a>.</p> <p>Updated <a href="#">Section 5.14.1: Peripherals and Middleware Configuration window</a>.</p> <p>Updated <a href="#">Figure 65: Adding a new DMA request</a> and <a href="#">Figure 67: DMA MemToMem configuration</a>.</p> <p>Updated <a href="#">Section 4.8.1: Clock tree configuration functions</a>.</p> <p>Updated <a href="#">Figure 129: Battery selection</a>, <a href="#">Figure 87: Building a power consumption sequence</a>, <a href="#">Figure 88: PCC Edit Step window</a>.</p> <p>Added <a href="#">Section 6.3: Custom code generation</a>.</p> <p>Updated <a href="#">Figure 211: Clock tree view</a> and <a href="#">Figure 216: Pinout &amp; Configuration view</a>.</p> <p>Updated peripheral configuration sequence and <a href="#">Figure 218: Timer 3 configuration window</a> in <a href="#">Section 11.6.2: Configuring the peripherals</a>.</p> <p>Removed Tutorial 3: Generating GPIO initialization C code (STM32F1 Series only).</p> <p>Updated <a href="#">Figure 222: GPIO mode configuration</a>.</p> <p>Updated <a href="#">Figure 257: Power Consumption Calculation example</a> and <a href="#">Figure 155: Sequence table</a>.</p> <p>Updated Appendix <a href="#">A.1: Block consistency</a>, <a href="#">A.2: Block inter-dependency</a> and <a href="#">A.3: One block = one peripheral mode</a>.</p> <p>Appendix <a href="#">A.4: Block remapping (STM32F10x only)</a>: updated <a href="#">Section : Example</a>.</p> <p>Appendix <a href="#">A.6: Block shifting (only for STM32F10x and when "Keep Current Signals placement" is unchecked)</a>: updated <a href="#">Section : Example</a></p> <p>Updated Appendix <a href="#">A.8: Mapping a function individually</a>.</p> <p>Updated Appendix <a href="#">B.3.1: Overview</a>.</p> <p>Updated Appendix <a href="#">D.1.3: STM32L0 Series</a>.</p>

**Table 24. Document revision history**

Date	Revision	STM32CubeMX release number	Changes
19-Mar-2015	7	4.7	<p><b>Section 2.2: Key features:</b> removed Pinout initialization C code generation for STM32F1 Series from; updated Complete project generation.</p> <p>Updated <a href="#">Figure 8: Embedded Software Packages Manager window</a>, <a href="#">Figure 30: New Project window - Board selector</a>.</p> <p>Updated IDE list in <a href="#">Section 4.9: Project Manager view</a> and modified <a href="#">Figure 100: Project Settings window</a>.</p> <p>Updated <a href="#">Section 4.8.1: Clock tree configuration functions</a>. Updated <a href="#">Figure 96: STM32F469NIHx clock tree configuration view</a>.</p> <p><b>Section 5.2: Power Consumption Calculator view:</b> added transition checker option. Updated <a href="#">Figure 128: Power Consumption Calculator default view</a>, <a href="#">Figure 129: Battery selection</a> and <a href="#">Figure 87: Building a power consumption sequence</a>. Added <a href="#">Figure 132: Enabling the transition checker option on an already configured sequence - All transitions valid</a>, <a href="#">Figure 133: Enabling the transition checker option on an already configured sequence - At least one transition invalid</a> and <a href="#">Figure 134: Transition checker option - Show log</a>. Updated <a href="#">Figure 138: Power Consumption Calculator view after sequence building</a>. Updated <a href="#">Section : Managing sequence steps</a>, <a href="#">Section : Managing the whole sequence (load, save and compare)</a>. Updated <a href="#">Figure 88: PCC Edit Step window</a> and <a href="#">Figure 141: Description of the Results area</a>.</p> <p>Updated <a href="#">Figure 257: Power Consumption Calculation example</a>, <a href="#">Figure 155: Sequence table</a>, <a href="#">Figure 156: Power Consumption Calculation results</a> and <a href="#">Figure 158: Power consumption results - IP consumption chart</a>.</p> <p>Updated Appendix <a href="#">B.3.1: Overview</a> and <a href="#">B.3.5: FreeRTOS</a>.</p>
28-May-2015	8	4.8	<p>Added <a href="#">Section 3.2.2: Installing STM32CubeMX from command line</a> and <a href="#">Section 3.3.2: Running STM32CubeMX in command-line mode</a>.</p>
09-Jul-2015	9	4.9	<p>Added STLM32F7 and STM32L4 microcontroller Series.</p> <p>Added Import project feature. Added Import function in <a href="#">Table 13: File menu functions</a>. Added <a href="#">Section 4.10: Import Project window</a>. Updated <a href="#">Figure 131: Power consumption sequence: New Step default view</a>, <a href="#">Figure 88: PCC Edit Step window</a>, <a href="#">Figure 83: Power consumption sequence: new step configured (STM32F4 example)</a>, <a href="#">Figure 137: Power Consumption Calculator Step configuration window: ADC enabled using import pinout</a> and <a href="#">Figure 87: Peripheral power consumption tooltip</a>.</p> <p>Updated command line to run STM32CubeMX in <a href="#">Section 3.3.2: Running STM32CubeMX in command-line mode</a>.</p> <p>Updated note in <a href="#">Section 5.16: Configuration view</a>.</p> <p>Added new clock tree configuration functions in <a href="#">Section 4.8.1</a>.</p> <p>Updated <a href="#">Figure 224: Middleware tooltip</a>.</p> <p>Modified code example in Appendix <a href="#">B.1: STM32CubeMX generated C code and user sections</a>.</p> <p>Updated Appendix <a href="#">B.3.1: Overview</a>.</p> <p>Updated generated .h files in Appendix <a href="#">B.3.4: FatFs</a>.</p>

**Table 24. Document revision history**

Date	Revision	STM32CubeMX release number	Changes
27-Aug-2015	10	4.10	<p>Replace UM1742 by UM1940 in <a href="#">Section : Introduction</a>.</p> <p>Updated command line to run STM32CubeMX in command-line mode in <a href="#">Section 3.3.2: Running STM32CubeMX in command-line mode</a>. Modified <a href="#">Table 1: Command line summary</a>.</p> <p>Updated board selection in <a href="#">Section 4.2: New Project window</a>.</p> <p>Updated <a href="#">Section 5.16: Configuration view overview</a>. Updated <a href="#">Section 5.14.1: Peripherals and Middleware Configuration window</a>, <a href="#">Section 4.4.12: GPIO Configuration window</a> and <a href="#">Section 4.4.13: DMA Configuration window</a>. Added <a href="#">Section 4.4.11: User Constants configuration window</a>.</p> <p>Updated <a href="#">Section 4.8: Clock Configuration view</a> and added reserve path.</p> <p>Updated <a href="#">Section 11.1: Creating a new STM32CubeMX Project</a>, <a href="#">Section 11.5: Configuring the MCU clock tree</a>, <a href="#">Section 11.6: Configuring the MCU initialization parameters</a>, <a href="#">Section 11.7.2: Downloading firmware package and generating the C code</a>, <a href="#">Section 11.8: Building and updating the C code project</a>. Added <a href="#">Section 11.9: Switching to another MCU</a>.</p> <p>Updated <a href="#">Section 12: Tutorial 2 - Example of FatFs on an SD card using STM32429I-EVAL evaluation board</a> and replaced STM32F429I-EVAL by STM32429I-EVAL.</p>
16-Oct-2015	11	4.11	<p>Updated <a href="#">Figure 8: Embedded Software Packages Manager window</a> and <a href="#">Section 3.4.6: Checking for updates</a>.</p> <p>Character string constant supported in <a href="#">Section 4.4.11: User Constants configuration window</a>.</p> <p>Updated <a href="#">Section 4.8: Clock Configuration view</a>.</p> <p>Updated <a href="#">Section 5.2: Power Consumption Calculator view</a>.</p> <p>Modified <a href="#">Figure 257: Power Consumption Calculation example</a>.</p> <p>Updated <a href="#">Section 13: Tutorial 3 - Using the Power Consumption Calculator to optimize the embedded application consumption and more</a>.</p> <p>Added Eclipse Mars in <a href="#">Section 3.1.3: Software requirements</a></p>
03-Dec-2015	12	4.12	<p>Code generation options now supported by the Project settings menu.</p> <p>Updated <a href="#">Section 3.1.3: Software requirements</a>.</p> <p>Added project settings in <a href="#">Section 4.10: Import Project window</a>.</p> <p>Updated <a href="#">Figure 113: Automatic project import</a>; modified <a href="#">Manual project import</a> step and updated <a href="#">Figure 114: Manual project import</a> and <a href="#">Figure 115: Import Project menu - Try import with errors</a>; modified third step of the import sequence.</p> <p>Updated <a href="#">Figure 83: Clock Tree configuration view with errors</a>.</p> <p>Added mxconstants.h in <a href="#">Section 6.1: STM32Cube code generation using only HAL drivers (default mode)</a>.</p> <p>Updated <a href="#">Figure 257: Power Consumption Calculation example</a> to <a href="#">Figure 266: Step 10 optimization</a>.</p> <p>Updated <a href="#">Figure 267: Power sequence results after optimizations</a>.</p>

**Table 24. Document revision history**

Date	Revision	STM32CubeMX release number	Changes
03-Feb-2016	13	4.13	<p>Updated <a href="#">Section 2.2: Key features</a>:</p> <ul style="list-style-type: none"> <li>– Information related to .ioc files.</li> <li>– Clock tree configuration</li> <li>– Automatic updates of STM32CubeMX and STM32Cube.</li> </ul> <p>Updated limitation related to STM32CubeMX C code generation in <a href="#">Section 2.3: Rules and limitations</a>.</p> <p>Added Linux in <a href="#">Section 3.1.1: Supported operating systems and architectures</a>. Updated Java Run Time Environment release number in <a href="#">Section 3.1.3: Software requirements</a>.</p> <p>Updated <a href="#">Section 3.2.1: Installing STM32CubeMX standalone version</a>, <a href="#">Section 3.2.3: Uninstalling STM32CubeMX standalone version</a> and <a href="#">Section 3.3.1: Downloading STM32CubeMX plug-in installation package</a>.</p> <p>Updated <a href="#">Section 3.3.1: Running STM32CubeMX as standalone application</a>.</p> <p>Updated <a href="#">Section 4.9: Project Manager view</a> and <a href="#">Section 4.12: Update Manager windows</a>.</p> <p>Updated <a href="#">Section 5.15.1: Pinning and labeling signals on pins</a>.</p> <p>Added <a href="#">Section 4.4.16: Setting HAL timebase source</a></p> <p>Updated <a href="#">Figure 143: Configuration window tabs for GPIO, DMA and NVIC settings (STM32F4 Series)</a>.</p> <p>Added note related to GPIO configuration in output mode in <a href="#">Section 4.4.12: GPIO Configuration window</a>; updated <a href="#">Figure 62: GPIO Configuration window - GPIO selection</a>.</p> <p>Modified <a href="#">Figure 128: Power Consumption Calculator default view</a>, <a href="#">Figure 86: Building a power consumption sequence</a>, <a href="#">Figure 130: Step management functions</a>, <a href="#">Figure 132: Enabling the transition checker option on an already configured sequence - All transitions valid</a>, <a href="#">Figure 133: Enabling the transition checker option on an already configured sequence - At least one transition invalid</a>.</p> <p>Added import pinout button icon in <a href="#">Section : Importing pinout</a>.</p> <p>Added <a href="#">Section : Selecting/deselecting all peripherals</a>. Modified <a href="#">Figure 138: Power Consumption Calculator view after sequence building</a>. Updated <a href="#">Section : Managing the whole sequence (load, save and compare)</a>. Updated <a href="#">Figure 141: Description of the Results area</a> and <a href="#">Figure 100: Peripheral power consumption tooltip</a>.</p> <p>Updated <a href="#">Figure 257: Power Consumption Calculation example</a> and <a href="#">Figure 259: Sequence table</a>.</p> <p>Updated <a href="#">Section 6.3: Custom code generation</a>.</p> <p>Updated <a href="#">Figure 203: Pinout view with MCUs selection</a> and <a href="#">Figure 204: Pinout view without MCUs selection window</a> in <a href="#">Section 11.1: Creating a new STM32CubeMX Project</a>.</p> <p>Updated <a href="#">Section 11.6.2: Configuring the peripherals</a>.</p> <p>Updated <a href="#">Figure 229: Project Settings and toolchain selection</a> and <a href="#">Figure 230: Project Manager menu - Code Generator tab</a> in <a href="#">Section 11.7.1: Setting project options</a>, and <a href="#">Figure 231: Missing firmware package warning message</a> in <a href="#">Section 11.7.2: Downloading firmware package and generating the C code</a>.</p>

**Table 24. Document revision history**

Date	Revision	STM32CubeMX release number	Changes
15-Mar-2016	14	4.14	<p>Upgraded STM32CubeMX released number to 4.14.0.</p> <p>Added import of previously saved projects and generation of user files from templates in <a href="#">Section 2.2: Key features</a>.</p> <p>Added MacOS in <a href="#">Section 3.1.1: Supported operating systems and architectures</a>, <a href="#">Section 3.2.1: Installing STM32CubeMX standalone version</a>, <a href="#">Section 3.2.3: Uninstalling STM32CubeMX standalone version</a> and <a href="#">Section 3.4.3: Running STM32CubeMX plug-in from Eclipse IDE</a>.</p> <p>Added command lines allowing the generation of user files from templates in <a href="#">Section 3.3.2: Running STM32CubeMX in command-line mode</a>.</p> <p>Updated new library installation sequence in <a href="#">Section 3.4.1: Updater configuration</a>.</p> <p>Updated <a href="#">Figure 107: Pinout menus (Pinout tab selected)</a> and <a href="#">Figure 108: Pinout menus (Pinout tab not selected)</a> in <a href="#">Section 5.7.3: Pinout menu</a>.</p> <p>Modified <a href="#">Table 16: Window menu</a>.</p> <p>Updated <a href="#">Section 5.7: Output windows</a>.</p> <p>Updated <a href="#">Figure 100: Project Settings window</a> and <a href="#">Section 4.9.1: Project tab</a>.</p> <p>Updated <a href="#">Figure 80: NVIC settings when using SysTick as HAL timebase, no FreeRTOS</a> and <a href="#">Figure 81: NVIC settings when using FreeRTOS and SysTick as HAL timebase</a> in <a href="#">Section 4.4.16: Setting HAL timebase source</a>.</p> <p>Updated <a href="#">Figure 53: User Constants tab</a> and <a href="#">Figure 54: Extract of the generated main.h file</a> in <a href="#">Section 4.4.11: User Constants configuration window</a>.</p> <p><a href="#">Section 4.4.12: GPIO Configuration window</a>: updated <a href="#">Figure 62: GPIO Configuration window - GPIO selection</a>, <a href="#">Figure 63: GPIO configuration grouped by peripheral</a> and <a href="#">Figure 64: Multiple Pins Configuration</a>.</p> <p>Updated <a href="#">Section 4.4.14: NVIC Configuration window</a>.</p>
18-May-2016	15	4.15	<p>Import project function is no more limited to MCUs of the same Series (see <a href="#">Section 2.2: Key features</a>, <a href="#">Section 5.7.1: File menu</a> and <a href="#">Section 4.10: Import Project window</a> ).</p> <p>Updated command lines in <a href="#">Section 3.3.2: Running STM32CubeMX in command-line mode</a>.</p> <p><a href="#">Table 1: Command line summary</a>: modified all examples related to config commands as well as set dest_path &lt;path&gt; example.</p> <p>Added caution note for Load Project menu in <a href="#">Table 13: File menu functions</a>.</p> <p>Updated Generate Code menu description in <a href="#">Table 14: Project menu</a>.</p> <p>Updated Set unused GPIOs menu in <a href="#">Table 15: Pinout menu</a>.</p> <p>Added case where FreeRTOS is enabled in <a href="#">Section : Enabling interruptions using the NVIC tab view</a>.</p> <p>Added <a href="#">Section 4.4.15: FreeRTOS configuration panel</a>.</p> <p>Updated Appendix <a href="#">B.3.5: FreeRTOS</a> and <a href="#">B.3.6: LwIP</a>.</p>

**Table 24. Document revision history**

Date	Revision	STM32CubeMX release number	Changes
23-Sep-2016	16	4.17	<p>Replaced <i>mxconstants.h</i> by <i>main.h</i> in the whole document.</p> <p>Updated <a href="#">Introduction</a>, <a href="#">Section 3.1.1: Supported operating systems and architectures</a> and <a href="#">Section 3.1.3: Software requirements</a>.</p> <p>Added <a href="#">Section 3.4.3: Installing STM32 MCU package patches</a>.</p> <p>Updated Load project description in <a href="#">Table 2: Home page shortcuts</a>.</p> <p>Updated Clear Pinouts function in <a href="#">Table 15: Pinout menu</a>.</p> <p>Updated <a href="#">Section 4.9.3: Advanced Settings tab</a> to add Low Layer driver.</p> <p>Added No check and Decimal and hexadecimal check options in <a href="#">Table 17: Peripheral and Middleware Configuration window buttons and tooltips</a>.</p> <p>Updated <a href="#">Section : Tasks and Queues Tab</a> and <a href="#">Figure 77: FreeRTOS Heap usage</a>.</p> <p>Updated <a href="#">Figure 62: GPIO Configuration window - GPIO selection</a>.</p> <p>Replaced PCC by Power Consumption Calculator in the whole document.</p> <p>Added <a href="#">Section 6.2: STM32Cube code generation using Low Layer drivers</a>; updated <a href="#">Table 20: LL versus HAL: STM32CubeMX generated source files</a> and <a href="#">Table 21: LL versus HAL: STM32CubeMX generated functions and function calls</a>.</p> <p>Updated <a href="#">Figure 307: Pinout view - Enabling the RTC</a>.</p> <p>Added <a href="#">Section 14: Tutorial 4 - Example of UART communications with an STM32L053xx Nucleo board</a>.</p> <p>Added correspondence between STM32CubeMX release number and document revision.</p>
21-Nov-2016	17	4.18	<p>Removed Windows XP and added Windows 10 in <a href="#">Section 3.1.3: Software requirements</a>.</p> <p>Updated <a href="#">Section 3.2.3: Uninstalling STM32CubeMX standalone version</a>.</p> <p>Added setDriver command line in <a href="#">Table 1: Command line summary</a>.</p> <p>Added List pinout compatible MCUs feature:</p> <ul style="list-style-type: none"> <li>– Updated <a href="#">Table 15: Pinout menu</a>.</li> <li>– Added <a href="#">Section 15: Tutorial 5: Exporting current project configuration to a compatible MCU</a></li> </ul> <p>Added Firmware location selection option in <a href="#">Section 4.9.1: Project tab</a> and <a href="#">Figure 100: Project Settings window</a>.</p> <p>Added Restore Default feature:</p> <ul style="list-style-type: none"> <li>– Updated <a href="#">Table 8: Peripheral and Middleware Configuration window buttons and tooltips</a></li> <li>– Updated <a href="#">Figure 55: Using constants for peripheral parameter settings</a>.</li> </ul>

**Table 24. Document revision history**

Date	Revision	STM32CubeMX release number	Changes
12-Jan-2017	18	4.19	<p>Project import no more limited to microcontrollers belonging to the same Series: updated <a href="#">Introduction</a>, <a href="#">Figure 113: Automatic project import</a>, <a href="#">Figure 114: Manual project import</a>, <a href="#">Figure 115: Import Project menu - Try import with errors</a> and <a href="#">Figure 116: Import Project menu - Successful import after adjustments</a>.</p> <p>Modified Appendix <a href="#">B.3.4: FatFs</a>, <a href="#">B.3.5: FreeRTOS</a> and <a href="#">B.3.6: LwIP</a>. Added Appendix <a href="#">B.3.7: Libjpeg</a>.</p>
02-Mar-2017	19	4.20	<p><a href="#">Table 17: STM32CubeMX Chip view - Icons and color scheme</a>:</p> <ul style="list-style-type: none"> <li>– Updated list of alternate function example.</li> <li>– Updated example and description corresponding to function mapping on a pin.</li> <li>– Added example and description for analog signals sharing the same pin.</li> </ul> <p>Updated <a href="#">Figure 87: Peripheral Configuration window (STM32F4 Series)</a>, <a href="#">Figure 53: User Constants tab</a>, <a href="#">Figure 59: Deleting a user constant used for peripheral configuration - Consequence on peripheral configuration</a>, <a href="#">Figure 60: Searching for a name in a user constant list</a> and <a href="#">Figure 61: Searching for a value in a user constant list</a>.</p> <p>Added <a href="#">Section 5.2.6: SMPS feature</a>.</p> <p>Added <a href="#">Section 6.4: Additional settings for C project generation</a>.</p> <p>Added STM32CubeF4 to the list of packages that include Libjpeg in <a href="#">Appendix B.3.7: Libjpeg</a>.</p>
05-May-2017	20	4.21	<p>Minor modifications in <a href="#">Section 1: STM32Cube overview</a>.</p> <p>Updated <a href="#">Figure 26: New Project window - MCU selector</a> and <a href="#">Figure 100: Project Settings window</a>.</p> <p>Updated description of Project settings in <a href="#">Section 4.9.1: Project tab</a>.</p> <p>Updated <a href="#">Figure 111: Advanced Settings window</a>.</p> <p>In Appendix <a href="#">B.3.7: Libjpeg</a>, added STM32CubeF2 and STM32CubeH7 in the list of software packages in which Libjpeg is embedded.</p> <p>Modified <a href="#">Figure 341: STM32Cube Embedded Software package look-and-feel</a>.</p>

**Table 24. Document revision history**

Date	Revision	STM32CubeMX release number	Changes
06-Jul-2017	21	4.22	<p>Added STM32H7 to the list of supported STM32 Series.</p> <p>Added MCU data and documentation refresh capability in <a href="#">Section 3.4: Getting updates using STM32CubeMX</a> and updated <a href="#">Figure 6: Updater Settings window</a>.</p> <p>Added capability to identify close MCUs in <a href="#">Section 4.2: New Project window</a>, updated <a href="#">Figure 26: New Project window - MCU selector</a>, added <a href="#">Figure 28: New Project window - MCU list with close function</a> and <a href="#">Figure 29: New Project window - List showing close MCUs..</a>, updated <a href="#">Figure 202: MCU selection</a>.</p> <p>Updated <a href="#">Figure 38: STM32CubeMX Main window upon MCU selection</a>.</p> <p>Added Rotate clockwise/Counter clockwise and Top/Bottom view in <a href="#">Table 15: Pinout menu</a>.</p> <p>Added <a href="#">Section 4.1.4: Social links</a>.</p> <p>Updated <a href="#">Figure 149: Configuring the SMPS mode for each step</a>.</p> <p>Updated <a href="#">Section 6.2: STM32Cube code generation using Low Layer drivers</a>.</p> <p>Updated <a href="#">Figure 229: Project Settings and toolchain selection</a>.</p>
05-Sep-2017	22	4.22.1	<p>Added STM32L4+ Series in <a href="#">Introduction</a>, <a href="#">Section 5.2: Power Consumption Calculator view</a> and <a href="#">Section 6.2: STM32Cube code generation using Low Layer drivers</a>.</p> <p>Added guidelines to run STM32CubeMX on MacOS in <a href="#">Section 3.3.1: Running STM32CubeMX as standalone application</a>. Removed MacOS from <a href="#">Section 3.4.3: Running STM32CubeMX plug-in from Eclipse IDE</a>.</p> <p>Added <a href="#">Section 18.9: Ethernet configuration: why cannot I specify DP83848 or LAN8742A in some cases?</a></p>
18-Oct-2017	23	4.23	<p>Added <a href="#">Section 1: General information</a>.</p> <p>Renamed <b>Display close</b> button into <b>Display similar items</b> in <a href="#">Section 4.2: New Project window</a>.</p> <p>Added <b>Refresh Data</b> and <b>Docs &amp; Resources</b> menus in <a href="#">Section 5.7.5: Help menu</a>.</p> <p>Added STM32F2, STM32F4 and STM32F7 Series in <a href="#">Section 6.2: STM32Cube code generation using Low Layer drivers</a>.</p> <p>Added Appendix <a href="#">B.3.8: Mbed TLS</a>.</p> <p>Updated STM32CubeMX release number corresponding to user manual revision 22.</p>

**Table 24. Document revision history**

Date	Revision	STM32CubeMX release number	Changes
16-Jan-2018	24	4.24	<p>Replaced “STM32Cube firmware package” by “STM32Cube MCU package”.</p> <p>Updated <a href="#">Section 1: STM32Cube overview</a>.</p> <p>Updated MacOS in <a href="#">Section 3.1.1: Supported operating systems and architectures</a>. Updated Eclipse requirements in <a href="#">Section 3.1.3: Software requirements</a>.</p> <p><a href="#">Section 3.4: Getting updates using STM32CubeMX</a>:</p> <ul style="list-style-type: none"> <li>– updated section introduction</li> <li>– updated <a href="#">Figure 13: Connection Parameters tab - No proxy</a></li> <li>– <a href="#">Section 3.4.2</a> renamed into “Installing STM32 MCU packages” and updated.</li> <li>– renamed <a href="#">Section 3.4.3</a> into “Installing STM32 MCU package patches”</li> <li>– added <a href="#">Section 3.4.4: Installing embedded software packs</a></li> <li>– updated <a href="#">Section 3.4.6: Checking for updates</a></li> </ul> <p>Updated <a href="#">Figure 30: New Project window - Board selector</a>.</p> <p>Updated <a href="#">Figure 39: STM32CubeMX Main window upon board selection (peripherals not initialized)</a> and introductory sentence.</p> <p>Updated <a href="#">Figure 40: STM32CubeMX Main window upon board selection (peripherals initialized with default configuration)</a> and introductory sentence.</p> <p>Added “Select additional software components” menu in <a href="#">Table 14: Project menu</a>.</p> <p>“Install new libraries” menu renamed “Manage embedded software packages” and corresponding description updated in <a href="#">Table 17: Help menu</a>.</p> <p>Updated <a href="#">Section 3.4.5: Removing already installed embedded software packages</a>.</p> <p>Updated <a href="#">Section 4.12: Update Manager windows</a></p> <p>Added <a href="#">Section 4.13: Additional software component selection window</a>.</p> <p>Added pin stacking function in <a href="#">Table 17: STM32CubeMX Chip view - Icons and color scheme</a>.</p> <p><a href="#">Section 6.2: STM32Cube code generation using Low Layer drivers</a>: added STM32F0, STM32F3, STM32L0 in the list of product Series supporting low-level drivers.</p> <p><a href="#">Section 12: Tutorial 2 - Example of FatFs on an SD card using STM32429I-EVAL evaluation board</a>: updated <a href="#">Figure 249: Board selection</a> and modified step 6 of the sequence for generating a project and running tutorial 2.</p> <p><a href="#">Section 14: Tutorial 4 - Example of UART communications with an STM32L053xx Nucleo board</a>: updated <a href="#">Figure 268: Selecting NUCLEO_L053R8 board</a>.</p> <p>Added <a href="#">Section 16: Tutorial 6 – Adding embedded software packs to user projects</a>.</p>

**Table 24. Document revision history**

Date	Revision	STM32CubeMX release number	Changes
16-Jan-2018	24 (cont'd)	4.24	<p>Added Appendix <a href="#">B.3.9: TouchSensing</a> and <a href="#">B.3.10: PDM2PCM</a>.  <a href="#">Section 4.4.14: NVIC Configuration window</a>/Default initialization sequence of interrupts: changed color corresponding to interrupt enabling code from green to black bold.</p>
07-Mar-2018	25	4.25	<p>Updated <a href="#">Introduction</a>, <a href="#">Section 1: STM32Cube overview</a>, <a href="#">Section 2.3: Rules and limitations</a>, <a href="#">Section 3.2.1: Installing STM32CubeMX standalone version</a>, <a href="#">Section 4: STM32CubeMX user interface</a>, <a href="#">Section 4.9.1: Project tab</a> and <a href="#">Section 5.13.1: Peripheral and Middleware tree panel</a>.</p> <p>Minor text edits across the whole document.</p> <p>Updated <a href="#">Table 13: File menu functions</a> and <a href="#">Table 12: Relations between power over-drive and HCLK frequency</a>.</p> <p>Updated <a href="#">Figure 26: New Project window - MCU selector</a>, <a href="#">Figure 27: Enabling graphics choice in MCU selector</a>, <a href="#">Figure 100: Project Settings window</a>, <a href="#">Figure 105: Selecting a different firmware location</a>, <a href="#">Figure 77: Enabling STemWin framework</a>, <a href="#">Figure 116: Configuration view for Graphics</a>, <a href="#">Figure 308: Pinout view - Enabling LSE and HSE clocks</a> and <a href="#">Figure 309: Pinout view - Setting LSE/HSE clock frequency</a>.</p> <p>Added <a href="#">Export to Excel feature</a>, <a href="#">Show favorite MCUs feature</a> and <a href="#">Section 4.4.16: Graphics frameworks and simulator</a>.</p> <p>Added <a href="#">Section 17: Tutorial 8 – Using STemWin Graphics framework</a>, <a href="#">Section 18: Tutorial 9: Using STM32CubeMX Graphics simulator</a> and their subsections.</p> <p>Added <a href="#">Section B.3.11: Graphics</a>.</p>

**Table 24. Document revision history**

Date	Revision	STM32CubeMX release number	Changes
05-Sep-2018	26	4.27	<p>Updated STM32Cube logo on cover page.</p> <p>Replaced STMCube™ by STM32Cube™ in the whole document.</p> <p>Updated <a href="#">Section 1: STM32Cube overview</a>.</p> <p>Updated <a href="#">Figure 1: Overview of STM32CubeMX C code generation flow</a>.</p> <p>Updated <a href="#">Section 2.2: Key features</a> to add new features: graphic simulator feature, Support of embedded software packages in CMSIS-Pack format and Contextual Help.</p> <p>Changed <a href="#">Section 3.4</a> title into “Getting updates using STM32CubeMX”. Suppressed figures <i>Connection Parameters tab - No proxy</i> and <i>Connection Parameters tab - Use System proxy parameters</i>. Updated <a href="#">Figure 9: Managing embedded software packages - Help menu</a>.</p> <p>In <a href="#">Section 3.4.4: Installing embedded software packs</a>, updated step 3f of the embedded software pack installation sequence and added <a href="#">Figure 14: License agreement acceptance</a>.</p> <p><a href="#">Section 4.2: New Project window</a>: updated <a href="#">Figure 26: New Project window - MCU selector</a>, <a href="#">Figure 27: Marking an MCU as favorite</a> and <a href="#">Figure 30: New Project window - Board selector</a>.</p> <p><a href="#">Section 5.7.1: File menu</a>: added caution note for New Project in <a href="#">Table 13: File menu functions</a>. Updated <a href="#">Figure 107: Pinout menus (Pinout tab selected)</a> and <a href="#">Figure 108: Pinout menus (Pinout tab not selected)</a>.</p> <p><a href="#">Section 4.9: Project Manager view</a>:</p> <ul style="list-style-type: none"> <li>– Added note related to project saving (step 3).</li> <li>– Updated <a href="#">Figure 100: Project Settings window</a></li> <li>– Updated <a href="#">Section 4.9.1: Project tab</a> and <a href="#">Figure 105: Selecting a different firmware location</a>.</li> </ul> <p>Added <a href="#">Section 4.13.4: Component dependencies panel, Contextual help</a>, <a href="#">Section 10: Support of additional software components using CMSIS-Pack standard</a> and <a href="#">Section 17: Tutorial 7 – Using the X-Cube-BLE1 software pack</a>.</p>
12-Nov-2018	27	4.28	<p>Updated <a href="#">Section 3.4.2: Installing STM32 MCU packages</a>, <a href="#">Section 3.4.4: Installing embedded software packs</a>, <a href="#">Section 3.4.5: Removing already installed embedded software packages</a>, <a href="#">Section 3.4.6: Checking for updates</a> and the figures in it.</p> <p>Updated <a href="#">Section 4: STM32CubeMX user interface</a>, its subsections and the figures and the tables in them.</p> <p>Updated <a href="#">Section 10: Support of additional software components using CMSIS-Pack standard</a>, sections 11.6.1 to 11.6.5, <a href="#">Section 11.7.1: Setting project options</a>, <a href="#">Section 11.7.2: Downloading firmware package and generating the C code</a>, <a href="#">Section 11.8: Building and updating the C code project</a>, <a href="#">Section 11.9: Switching to another MCU</a>, <a href="#">Section 12: Tutorial 2 - Example of FatFs on an SD card using STM32429I-EVAL evaluation board</a> and the figures in it, <a href="#">Section 15: Tutorial 5: Exporting current project configuration to a compatible MCU</a> and the figures in it, <a href="#">Section 16: Tutorial 6 – Adding embedded software packs to user projects</a> and <a href="#">Section 17: Tutorial 7 – Using the X-Cube-BLE1 software pack</a>.</p>

**Table 24. Document revision history**

Date	Revision	STM32CubeMX release number	Changes
12-Nov-2018	27 (cont'd)	5.0	<p>Added <a href="#">Section 19: Tutorial 10: Using ST-TouchGFX framework</a> and its subsections.</p> <p>Updated <a href="#">Table 21: LL versus HAL: STM32CubeMX generated functions and function calls</a>.</p> <p>Removed former <a href="#">Figure 164: Enabling and configuring a CMSIS-Pack software component</a>, <a href="#">Figure 192: FatFs peripheral instances</a>, <a href="#">Figure 213: Project Import status</a>, <a href="#">Figure 254: Saving software component selection as user preferences</a> and <a href="#">Figure 268: Configuring X-Cube-BLE1</a>.</p> <p>Updated <a href="#">Figure 1: Overview of STM32CubeMX C code generation flow</a>, <a href="#">Figure 4: STM32Cube Installation Wizard</a>, <a href="#">Figure 7: Closing STM32CubeMX perspective</a>, <a href="#">Figure 9: Opening Eclipse plug-in</a>, <a href="#">Figure 10: STM32CubeMX perspective</a>, <a href="#">Figure 142: Overall peripheral consumption</a>, <a href="#">Figure 173: User constant generating define statements</a>, <a href="#">Figure 199: Selecting a CMSIS-Pack software component</a>, <a href="#">Figure 200: Enabling and configuring a CMSIS-Pack software component</a>, <a href="#">Figure 201: Project generated with CMSIS-Pack software component</a>, <a href="#">Figure 202: MCU selection</a>, <a href="#">Figure 203: Pinout view with MCUs selection</a>, <a href="#">Figure 204: Pinout view without MCUs selection window</a>, <a href="#">Figure 206: Timer configuration</a>, <a href="#">Figure 207: Simple pinout configuration</a>, <a href="#">Figure 208: Save Project As window</a>, <a href="#">Figure 209: Generate Project Report - New project creation</a>, <a href="#">Figure 210: Generate Project Report - Project successfully created</a>, <a href="#">Figure 211: Clock tree view</a>, <a href="#">Figure 216: Pinout &amp; Configuration view</a>, <a href="#">Figure 217: Case of Peripheral and Middleware without configuration parameters</a>, <a href="#">Figure 218: Timer 3 configuration window</a>, <a href="#">Figure 219: Timer 3 configuration</a>, <a href="#">Figure 220: Enabling Timer 3 interrupt</a>, <a href="#">Figure 221: GPIO configuration color scheme and tooltip</a>, <a href="#">Figure 222: GPIO mode configuration</a>, <a href="#">Figure 223: DMA parameters configuration window</a>, <a href="#">Figure 224: Middleware tooltip</a>, <a href="#">Figure 225: USB Host configuration</a>, <a href="#">Figure 225: USB Host configuration</a>, <a href="#">Figure 226: FatFs over USB mode enabled</a>, <a href="#">Figure 227: System view with FatFs and USB enabled</a>, <a href="#">Figure 228: FatFs define statements</a>, <a href="#">Figure 229: Project Settings and toolchain selection</a>, <a href="#">Figure 230: Project Manager menu - Code Generator tab</a>, <a href="#">Figure 231: Missing firmware package warning message</a>, <a href="#">Figure 233: Updater settings for download</a>, <a href="#">Figure 234: Updater settings with connection</a>, <a href="#">Figure 235: Downloading the firmware package</a>, <a href="#">Figure 236: Unzipping the firmware package</a>, <a href="#">Figure 237: C code generation completion message</a>, <a href="#">Figure 247: Import Project menu</a>, <a href="#">Figure 277: Project Settings menu</a>, <a href="#">Figure 287: Additional software components enabled for the current project</a>, <a href="#">Figure 288: Pack software components - no configurable parameters</a>, <a href="#">Figure 289: Pack tutorial - project settings</a>, <a href="#">Figure 292: Embedded software packages</a>, <a href="#">Figure 294: Installing Embedded software packages</a>, <a href="#">Figure 295: Starting a new project - selecting the NUCLEO-L053R8 board</a>, <a href="#">Figure 296: Starting a new project - initializing all peripherals</a>, <a href="#">Figure 297: Selecting X-Cube-BLE1 components</a>, <a href="#">Figure 298: Configuring peripherals and GPIOs</a>, <a href="#">Figure 299: Configuring NVIC interrupts</a>, <a href="#">Figure 300: Enabling X-Cube-BLE1</a>, <a href="#">Figure 300: Enabling X-Cube-BLE1</a>, <a href="#">Figure 301: Configuring the SensorDemo project</a> and <a href="#">Figure 312: Graphics simulator user interface</a>.</p>

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Date	Revision	STM32CubeMX release number	Changes
19-Feb-2019	28	5.0	<p>Updated <a href="#">Introduction</a>, <a href="#">Section 1: STM32Cube overview</a>, <a href="#">Section 2.2: Key features</a>, <a href="#">Section 3.1.3: Software requirements</a>, <a href="#">Section 3.4.2: Installing STM32 MCU packages</a>, <a href="#">Section 4: STM32CubeMX user interface</a>, <a href="#">Resolving pin conflicts</a>, <a href="#">Section 4.4.10: Component Configuration panel</a>, <a href="#">Section 4.8: Clock Configuration view</a>, <a href="#">Section 4.9: Project Manager view</a>, <a href="#">Section 4.9.1: Project tab</a>, <a href="#">Section 4.9.3: Advanced Settings tab</a>, <a href="#">Using the transition checker</a>, <a href="#">Section 9.2: STM32CubeMX Device tree generation</a>, <a href="#">Section 6.3.2: Saving and selecting user templates</a>, <a href="#">.extSettings file example and generated outcomes</a> and <a href="#">Section 11.6.4: Configuring the DMAs</a>.</p> <p>Added <a href="#">Section 4.5: Pinout &amp; Configuration view for STM32MP1 Series</a>, <a href="#">Section 4.5.2: Boot stages configuration</a>, <a href="#">Section 5: STM32CubeMX tools</a>, <a href="#">Section 9: Device tree generation (STM32MP1 Series only)</a>, <a href="#">Section B.3.11: STM32WPAN BLE/Thread (STM32WB Series only)</a>, <a href="#">Section B.3.12: OpenAmp and RESMGR.Utility (STM32MP1 Series and STM32H7 dual-core product lines)</a> and their subsections.</p> <p>Removed former <a href="#">Section 1: General information</a>.</p> <p>Updated <a href="#">Table 2: Home page shortcuts</a>, <a href="#">Table 5: Component list, mode icons and color schemes</a>, <a href="#">Table 6: Pinout menu and shortcuts</a> and title of <a href="#">Table 9: Clock configuration view widgets</a>.</p> <p>Updated <a href="#">Figure 100: Project Settings window</a>, <a href="#">Figure 101: Project folder</a>, <a href="#">Figure 105: Selecting a different firmware location</a>, <a href="#">Figure 113: Automatic project import</a>, <a href="#">Figure 114: Manual project import</a>, <a href="#">Figure 115: Import Project menu - Try import with errors</a>, <a href="#">Figure 116: Import Project menu - Successful import after adjustments</a>, <a href="#">Figure 117: Set unused pins window</a>, <a href="#">Figure 118: Reset used pins window</a>, <a href="#">Figure 126: About window</a>, <a href="#">Figure 194: STM32CubeMX generated DTS – Extract 3</a>, <a href="#">Figure 199: Selecting a CMSIS-Pack software component</a>, <a href="#">Figure 200: Enabling and configuring a CMSIS-Pack software component</a>, <a href="#">Figure 254: FATFS tutorial - Project settings</a> and <a href="#">Figure 255: C code generation completion message</a>.</p>
16-Apr-2019	29	5.1	<p>Updated <a href="#">Introduction</a>, <a href="#">Section 3.1.3: Software requirements</a>, <a href="#">Section 4.2: New Project window</a>, <a href="#">MCU close selector feature</a>, <a href="#">External clock sources</a>, <a href="#">Importing pinout</a>, <a href="#">Selecting/deselecting all peripherals</a>, <a href="#">Section 4.5: Pinout &amp; Configuration view for STM32MP1 Series</a>, <a href="#">Section 4.13: Additional software component selection window</a>, <a href="#">Section 5.3.1: DDR configuration</a>, <a href="#">Section 6.2: STM32Cube code generation using Low Layer drivers</a>, <a href="#">BLE configuration</a> and <a href="#">Section B.3.12: OpenAmp and RESMGR.Utility (STM32MP1 Series and STM32H7 dual-core product lines)</a>.</p> <p>Added <a href="#">Section 4.2.1: MCU selector</a>, <a href="#">Section 4.2.2: Board selector</a>, <a href="#">Section 4.2.4: Cross selector</a>, <a href="#">Section 4.6: Pinout &amp; Configuration view for STM32H7 dual-core product lines</a>, <a href="#">Section 5.2.8: Example feature (STM32MP1 and STM32H7 dual-core only)</a> and <a href="#">Section 7: Code generation for dual-core MCUs (STM32H7 dual-core product lines only)</a>.</p> <p>Removed former <a href="#">Section 3.3: Installing STM32CubeMX plug-in version</a> and its subsections, and former <a href="#">Section 3.4.3: Running STM32CubeMX plug-in from Eclipse IDE</a>.</p>

**Table 24. Document revision history**

Date	Revision	STM32CubeMX release number	Changes
16-Apr-2019	29 (cont'd)	5.1	<p>Updated <a href="#">Table 3: Window menu</a>.</p> <p>Updated figures <a href="#">27</a> to <a href="#">30</a>, <a href="#">Figure 111: Advanced Settings window</a>, figures <a href="#">128</a> to <a href="#">135</a>, <a href="#">137</a> to <a href="#">140</a> and <a href="#">142</a> to <a href="#">151</a>, <a href="#">Figure 229: Project Settings and toolchain selection</a> and figures <a href="#">257</a> to <a href="#">267</a>,</p> <p>Added <a href="#">Figure 24: New Project window shortcuts</a>, <a href="#">Figure 84: STM32MP1 Series: assignment options for GPIOs</a>, <a href="#">Figure 339: Resource Manager: peripheral assignment view</a> and <a href="#">Figure 341: STM32Cube Embedded Software package</a>.</p>
01-Oct-2019	30	5.2	<p>Updated <a href="#">Introduction</a>, <a href="#">Section 2.2: Key features</a>, <a href="#">Section 3.3.2: Running STM32CubeMX in command-line mode</a>, <a href="#">Part number selection</a>, <a href="#">Section 4.13: Additional software component selection window</a>, <a href="#">Section 4.13.1: Introduction on software components</a>, <a href="#">Section 4.13.2: Filter panel</a>, <a href="#">Section 4.13.3: Packs panel</a>, <a href="#">Section 4.13.4: Component dependencies panel</a>, <a href="#">Section 4.13.6: Updating the tree view for additional software components</a>, <a href="#">Section 5.2: Power Consumption Calculator view</a> and <a href="#">Section 6.2: STM32Cube code generation using Low Layer drivers</a>.</p> <p>Updated <a href="#">Table 1: Command line summary</a>, <a href="#">Table 6: Pinout menu and shortcuts</a>, <a href="#">Table 16: Additional Software window – Packs panel icons</a> and <a href="#">Table 17: Component dependencies panel contextual help</a>.</p> <p>Updated <a href="#">Figure 20: STM32CubeMX Home page</a>, <a href="#">Figure 124: Selection of additional software components</a>, <a href="#">Figure 125: Additional software components - Updated tree view</a>, <a href="#">Figure 199: Selecting a CMSIS-Pack software component</a> and <a href="#">Figure 297: Selecting X-Cube-BLE1 components</a>.</p> <p>Added <a href="#">Section 4.4.8: Pinout for multi-bonding packages</a> and <a href="#">Section 4.13.5: Details and Warnings panel</a>.</p> <p>Added <a href="#">Table 15: Additional Software window – Packs panel columns</a></p>

**Table 24. Document revision history**

Date	Revision	STM32CubeMX release number	Changes
13-Dec-2019	31	5.4	<p>Updated <a href="#">Introduction</a>, <a href="#">Section 1: STM32Cube overview</a>, <a href="#">Section 4.2: New Project window</a>, <a href="#">MCU/MPU selection for a new project</a> and <a href="#">Section 11.7.1: Setting project options</a>.</p> <p>Added <a href="#">Section 4.7: Enabling security in Pinout &amp; Configuration view (STM32L5 Series only)</a> with its subsections, <a href="#">Section 4.8.2: Securing clock resources (STM32L5 Series only)</a> and <a href="#">Section 8: Code generation with Trustzone enabled (STM32L5 Series only)</a>.</p> <p>Removed former <a href="#">Section 4.4.16: Graphics frameworks and simulator</a>, <a href="#">Section 17: Tutorial 8 – Using STemWin Graphics framework</a>, <a href="#">Section 18: Tutorial 9: Using STM32CubeMX Graphics simulator</a>, <a href="#">Section 19: Tutorial 10: Using ST-TouchGFX framework</a> and <a href="#">Section B.3.11: Graphics</a>.</p> <p>Minor text edits across the whole document.</p> <p>Updated <a href="#">Table 1: Command line summary</a>.</p> <p>Updated <a href="#">Figure 47: Pinout view: MCUs with multi-bonding</a>, <a href="#">Figure 48: Pinout view: multi-bonding with extended mode</a>, <a href="#">Figure 84: STM32MP1 Series: assignment options for GPIOs</a>, <a href="#">Figure 100: Project Settings window</a>, <a href="#">Figure 158: DDR Suite - Connection to target</a>, <a href="#">Figure 159: DDR Suite - Target connected</a>, <a href="#">Figure 160: DDR activity logs</a>, <a href="#">Figure 161: DDR interactive logs</a>, <a href="#">Figure 162: DDR register loading</a>, <a href="#">Figure 163: DDR test list from U-Boot SPL</a>, <a href="#">Figure 164: DDR test suite results</a>, <a href="#">Figure 165: DDR tests history</a>, <a href="#">Figure 166: DDR tuning pre-requisites</a>, <a href="#">Figure 167: DDR tuning process</a>, <a href="#">Figure 168: Bit deskew</a>, <a href="#">Figure 169: Eye training (centering) panel</a>, <a href="#">Figure 170: DDR Tuning - saving to configuration</a>, <a href="#">Figure 191: Project settings for STM32CubeIDE toolchain</a> and <a href="#">Figure 229: Project Settings and toolchain selection</a>.</p> <p>Added <a href="#">Figure 25: Enabling TrustZone for STM32L5 Series</a>.</p>

**Table 24. Document revision history**

Date	Revision	STM32CubeMX release number	Changes
10-Jul-2020	32	6.0	<p>Updated <a href="#">Section 2.2: Key features</a>, <a href="#">Section 3.1.1: Supported operating systems and architectures</a>, <a href="#">Section 3.1.3: Software requirements</a>, <a href="#">Section 3.2.1: Installing STM32CubeMX standalone version</a>, <a href="#">Section 3.4: Getting updates using STM32CubeMX</a>, <a href="#">Section 3.4.4: Installing embedded software packs</a>, <a href="#">Section 4.2: New Project window</a>, <a href="#">Export to Excel feature</a>, <a href="#">Section 4.4: Pinout &amp; Configuration view</a>, <a href="#">Section 4.9.3: Advanced Settings tab</a> and <a href="#">Section 18.6: Why do I get the error “Java 8 update 45” when installing “Java 8 update 45” or a more recent version of the JRE?</a>.</p> <p>Added <a href="#">Section 4.2.3: Example selector</a>, <a href="#">Section 5.1: External Tools</a>, <a href="#">Section 18.1: Since I changed my login to access the Internet, some software packs appear not available.</a> and <a href="#">Section 18.2: On dual-context products why some peripherals or middleware are not available for a given context?</a>.</p> <p>Removed former <a href="#">MCU selection based on graphics criteria</a>.</p> <p>Updated <a href="#">Table 4: Help menu shortcuts</a> and <a href="#">Table 14: Additional software window - Filter icons</a>.</p> <p>Updated <a href="#">Figure 20: STM32CubeMX Home page</a>, <a href="#">Figure 24: New Project window shortcuts</a>, <a href="#">Figure 30: New Project window - Board selector</a>, <a href="#">Figure 33: Cross selector - Data refresh prerequisite</a>, <a href="#">Figure 111: Advanced Settings window</a>, <a href="#">Figure 121: Additional Software window</a>, <a href="#">Figure 196: Device tree generation for the Linux kernel</a>, <a href="#">Figure 197: STM32CubeMX Device tree generation for U-boot</a>, <a href="#">Figure 198: STM32CubeMX Device tree generation for TF-A</a>, <a href="#">Figure 297: Selecting X-Cube-BLE1 components</a> and <a href="#">Figure 306: Java Control Panel</a>.</p>
10-Nov-2020	33	6.1	<p>Updated <a href="#">Introduction</a>, <a href="#">Section 3.1.3: Software requirements</a>, <a href="#">Section 3.4.6: Checking for updates</a>, <a href="#">Section 4.13.3: Packs panel</a>, <a href="#">Section 5.1: External Tools</a>, <a href="#">Section 12: Tutorial 2 - Example of FatFs on an SD card using STM32429I-EVAL evaluation board</a> and <a href="#">Section 18.6: Why do I get the error “Java 8 update 45” when installing “Java 8 update 45” or a more recent version of the JRE?</a>.</p> <p>Added <a href="#">Choosing not to generate code for some peripherals or middlewares</a>.</p> <p>Updated <a href="#">Table 1: Command line summary</a>.</p> <p>Updated <a href="#">Figure 19: Help menu: checking for updates</a>, <a href="#">Figure 20: STM32CubeMX Home page</a>, <a href="#">Figure 111: Advanced Settings window</a>, <a href="#">Figure 121: Additional Software window</a>, <a href="#">Figure 127: ST Tools</a> and <a href="#">Figure 250: SDIO peripheral configuration</a>.</p>

**Table 24. Document revision history**

Date	Revision	STM32CubeMX release number	Changes
12-Feb-2021	34	6.2	<p>Updated <a href="#">Section 3.1.1: Supported operating systems and architectures</a>, <a href="#">Section 3.1.3: Software requirements</a>, <a href="#">Section 3.2.1: Installing STM32CubeMX standalone version</a>, <a href="#">Section 3.2.2: Installing STM32CubeMX from command line</a>, <a href="#">Section 3.2.3: Uninstalling STM32CubeMX standalone version</a>, <a href="#">Section 3.3.2: Running STM32CubeMX in command-line mode</a>, <a href="#">Warning: in Section 3.4.6: Checking for updates</a>, <a href="#">Section 4.1: Home page</a>, <a href="#">Section 4.13: Additional software component selection window</a>, <a href="#">Section 4.13.2: Filter panel</a>, <a href="#">Section 4.13.3: Packs panel</a>, <a href="#">Section 4.13.4: Component dependencies panel</a>, <a href="#">Section 4.13.5: Details and Warnings panel</a> and <a href="#">Section 12: Tutorial 2 - Example of FatFs on an SD card using STM32429I-EVAL evaluation board</a>.</p> <p>Updated <a href="#">Table 6: Pinout menu and shortcuts</a>.</p> <p>Added <a href="#">Figure 2: Full disk access for macOS</a> and <a href="#">Figure 122: Component dependency resolution</a>.</p> <p>Updated <a href="#">Figure 20: STM32CubeMX Home page</a>, <a href="#">Figure 25: Enabling TrustZone for STM32L5 Series</a>, <a href="#">Figure 121: Additional Software window</a>.</p> <p>Removed former <a href="#">Figure 5: Auto-install command line</a> and former <a href="#">Section 18.6: Why do I get the error “Java 8 update 45” when installing “Java 8 update 45” or a more recent version of the JRE?</a>.</p>

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