UM1779
User manual

Getting started with STM32CubeF0 for STM32F0 Series

Introduction

STMCube™ is an STMicroelectronics original initiative to ease developers' life by reducing development efforts, time and cost. STM32Cube is the implementation of STMCube™ that covers STM32 microcontrollers.

STM32Cube Version 1.x includes:

- The 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 STM32CubeF0 for STM32F0 Series):
  - The STM32Cube HAL, an STM32 abstraction layer embedded software ensuring maximized portability across STM32 portfolio. The HAL is available for all peripherals
  - The Low Layer APIs (LL) offering a fast light-weight expert-oriented layer which is closer to the hardware than the HAL. The LL APIs are available only for a set of peripherals.
  - A consistent set of middleware components such as RTOS, USB, STMTouch™, FatFS and Graphics
  - All embedded software utilities coming with a full set of examples.

This user manual describes how to get started with the STM32CubeF0 firmware package.

Section 1 describes the main features of STM32CubeF0 firmware, part of the STMCube™ initiative. *Section 2* and *Section 3* provide an overview of the STM32CubeF0 architecture and firmware package structure.

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1 STM32CubeF0 main features

STM32CubeF0 gathers, in a single package, all the generic embedded software components required to develop an application on STM32F0 microcontrollers. In line with the STMCube™ initiative, this set of components is highly portable, not only within STM32F0 Series but also to other STM32 Series.

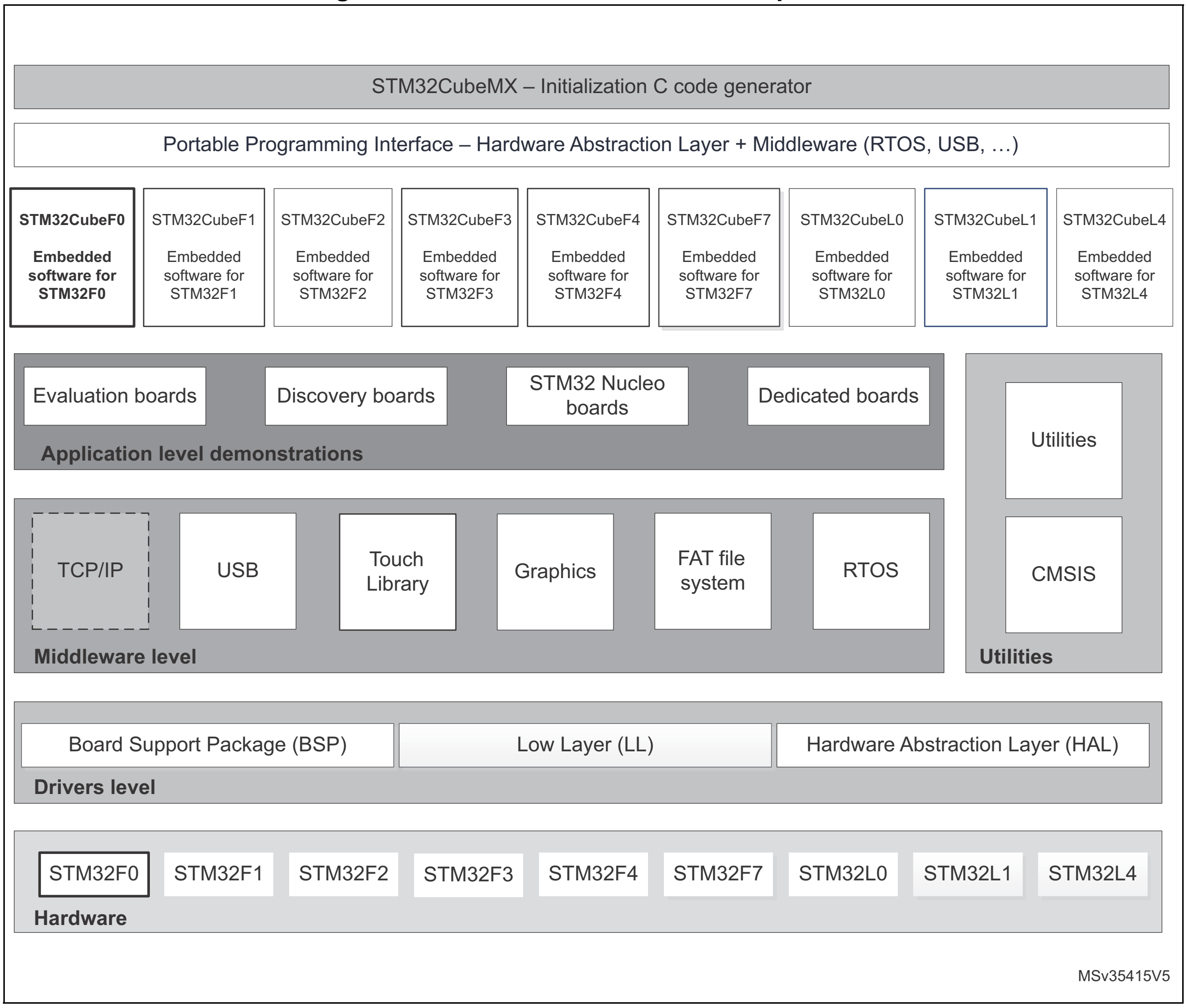
STM32CubeF0 is fully compatible with STM32CubeMX code generator that allows generating initialization code. The package includes Low Layer (LL) and hardware abstraction layer (HAL) APIs that cover the microcontroller hardware, together with an extensive set of examples running on STMicroelectronics boards. The HAL and LL APIs are available in open-source BSD license for user convenience.

STM32CubeF0 package also contains a set of middleware components with the corresponding examples. They come in free user-friendly license terms:

- Full USB Device stack supporting many classes: Audio, HID, MSC, CDC and DFU
- STemWin, a professional graphical stack solution available in binary format and based on STMicroelectronics partner solution SEGGER emWin
- CMSIS-RTOS implementation with FreeRTOS open source solution
- FAT File system based on open source FatFS solution
- STMTouch touch sensing library solution.

Several applications and demonstrations implementing all these middleware components are also provided in the STM32CubeF0 package.

Figure 1. STM32CubeF0 firmware components

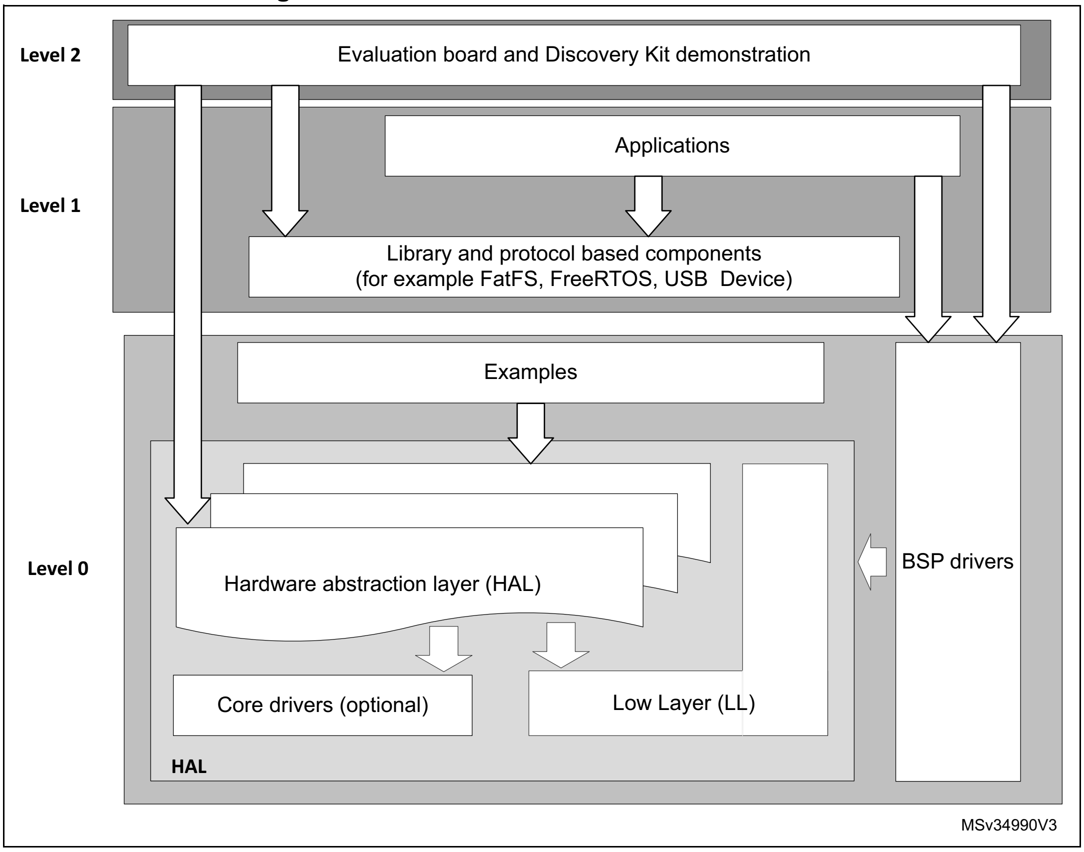


1. Not available in STM32CubeF0 package.

2 STM32CubeF0 architecture overview

The STM32Cube firmware solution is built around three independent levels that can easily interact as described in *Figure 2*.

Figure 2. STM32CubeF0 firmware architecture



2.1 Level 0

This level is divided into three sub-layers:

- Board Support Package (BSP)
- Hardware Abstraction Layer (HAL)
  - HAL peripheral drivers
  - Low Layer drivers
- Basic peripheral usage examples

2.1.1 Board Support Package (BSP)

This layer offers a set of APIs relative to the hardware components in the hardware boards (such as LCD, Audio, microSD and MEMS drivers). It is composed of two parts:

- Component

  This is the driver relative to the external device on the board and not to the STM32. The component driver provide specific APIs to the BSP driver external components and could be portable on any other board.
- BSP driver

  It allows linking the component driver to a specific board and provides a set of user-friendly APIs. The API naming rule is BSP_FUNCT_Action().

  Example: BSP_LED_Init(), BSP_LED_On()

The BSP is based on a modular architecture allowing an easy porting on any hardware by just implementing the low-level routines.

2.1.2 Hardware Abstraction Layer (HAL) and Low Layer (LL)

The STM32CubeF0 HAL and LL are complementary and cover a wide range of applications requirements:

- The HAL drivers offer high-level function-oriented highly-portable APIs. They hide the MCU and peripheral complexity to end user.

  The HAL drivers provide generic multi-instance feature-oriented APIs which simplify user application implementation by providing ready to use process. As example, for the communication peripherals (I2S, UART…), it provides APIs allowing initializing and configuring the peripheral, managing data transfer based on polling, interrupt or DMA process, and handling communication errors that may raise during communication. The HAL driver APIs are split in two categories:
  - Generic APIs which provides common and generic functions to all the STM32 Series
  - Extension APIs which provides specific and customized functions for a specific family or a specific part number.
- The Low Layer APIs provide low-level APIs at register level, with better optimization but less portability. They require a deep knowledge of MCU and peripheral specifications.

  The LL drivers are designed to offer a fast light-weight expert-oriented layer which is closer to the hardware than the HAL. Contrary to the HAL, LL APIs are not provided for peripherals where optimized access is not a key feature, or for those requiring heavy software configuration and/or complex upper-level stack (such as USB).

  The LL drivers feature:
  - A set of functions to initialize peripheral main features according to the parameters specified in data structures
  - A set of functions used to fill initialization data structures with the reset values corresponding to each field
  - Function for peripheral de-initialization (peripheral registers restored to their default values)
  - A set of inline functions for direct and atomic register access
  - Full independence from HAL and capability to be used in standalone mode (without HAL drivers)
  - Full coverage of the supported peripheral features.

2.1.3 Basic peripheral usage examples

This layer encloses the examples build over the STM32 peripheral using only the HAL and BSP resources.

2.2 Level 1

This level is divided into two sub-layers:

- Middleware components
- Examples based on the middleware components.

2.2.1 Middleware components

The middleware is a set of libraries covering USB Device Libraries, STMTouch touch sensing, STemWin, FreeRTOS and FatFS. Horizontal interactions between the components of this layer is done directly by calling the feature APIs while the vertical interaction with the low-level drivers is done through specific callbacks and static macros implemented in the library system call interface. For example, the FatFs implements the disk I/O driver to access microSD drive or the USB Mass Storage Class.

The main features of each middleware component are as follows:

- **USB Device libraries**
  - Several USB classes supported (Mass-Storage, HID, CDC, DFU, LPM and BCD).
  - Support of multi-packet transfer features that allows sending big amounts of data without splitting them into maximum packet size transfers.
  - Use of configuration files to change the core and the library configuration without changing the library code (Read Only).
  - RTOS and Standalone operation.
  - Link with low-level driver through an abstraction layer using the configuration file to avoid any dependency between the Library and the low-level drivers.
- **STemWin Graphical stack**
  - Professional grade solution for GUI development based on SEGGER's emWin solution.
  - Optimized display drivers.
  - Software tools for code generation and bitmap editing (STemWin Builder…).
- **FreeRTOS**
  - Open source standard.
  - CMSIS compatibility layer.
  - Tickless operation during low-power mode.
  - Integration with all STM32Cube middleware modules.
- **FAT File system**
  - FATFS FAT open source library.
  - Long file name support.
  - Dynamic multi-drive support.
  - RTOS and standalone operation.
  - Examples with microSD.

- **STM32 Touch sensing library**
  Robust STMTouch capacitive touch sensing solution supporting proximity, touchkey, linear and rotary touch sensors. It is based a proven surface charge transfer acquisition principle.

2.2.2 Examples based on the middleware components

Each middleware component comes with one or more examples (called also Applications) showing how to use it. Integration examples that use several middleware components are provided as well.

2.3 Level 2

This level is composed of a single layer which consist in a global real-time and graphical demonstration based on the middleware service layer, the low-level abstraction layer and the basic peripheral usage applications for board based features.

3 STM32CubeF0 firmware package overview

3.1 Supported STM32F0 devices and hardware

STM32Cube offers highly portable Hardware Abstraction Layer (HAL) built around a generic architecture. It allows the build-upon layers, such as the middleware layer, to implement their functions without knowing, in-depth, the MCU used. This improves the library code re-usability and guarantees an easy portability on other devices.

In addition, thanks to its layered architecture, the STM32CubeF0 offers full support of all STM32F0 Series. The user has only to define the right macro in stm32f0xx.h.

Table 1 shows the macro to be defined depending on the STM32F0 device used. This macro must also be defined in the compiler preprocessor.

Table 1. Macros for STM32F0 Series

Macro defined in stm32f0xx.h	STM32F0 devices
STM32F030x6	STM32F030F4, STM32F030C6, STM32F030K6
STM32F030x8	STM32F030C8, STM32F030R8
STM32F030xC	STM32F030CC, STM32F030RC
STM32F031x6	STM32F031C4, STM32F031F4, STM32F031G4, STM32F031K4, STM32F031C6, STM32F031F6, STM32F031G6, STM32F031K6
STM32F051x8	STM32F051K4, STM32F051C4, STM32F051R4, STM32F051K6, STM32F051C6, STM32F051R6,STM32F051K8, STM32F051C8, STM32F051R8
STM32F070x6	STM32F070F6, STM32F070C6
STM32F070xB	STM32F070RB, STM32F070CB
STM32F071xB	STM32F071V8, STM32F071CB, STM32F071RB, STM32F071VB
STM32F042x6	STM32F042F4, STM32F042G4, STM32F042K4, STM32F042T4, STM32F042C4, STM32F042F6, STM32F042G6, STM32F042K6, STM32F042T6, STM32F042C6
STM32F072xB	STM32F072C8, STM32F072R8, STM32F072V8, STM32F072CB, STM32F072RB, STM32F072VB
STM32F038xx	STM32F038C6, STM32F038F6, STM32F038G6, STM32F038K6
STM32F048xx	STM32F048C6, STM32F048G6, STM32F048T6
STM32F058xx	STM32F058K8, STM32F058C8, STM32F058R8
STM32F078xx	STM32F078CB, STM32F078RB, STM32F078VB
STM32F091xx	STM32F091CB, STM32F091RB, STM32F091VB, STM32F091CC, STM32F091RC, STM32F091VC
STM32F098xx	STM32F098CC, STM32F098RC, STM32F098VC

STM32CubeF0 features a rich set of examples and applications at all levels making it easy to understand and use any HAL driver and/or middleware components. These examples run on the STMicroelectronics boards listed in *Table 2*.

Table 2. Boards for STM32F0 Series

Board	STM32F0 supported devices
STM32072B-EVAL	STM32F072xB
STM32091C-EVAL	STM32F091xC
STM32F072B-DISCOVERY	STM32F072xB
STM32F0308-DISCOVERY	STM32F030x8
NUCLEO-F070RB	STM32F070xB
NUCLEO-F072RB	STM32F072xB
NUCLEO-F030R8	STM32F030x8
NUCLEO-F031K6	STM32F031K6
NUCLEO-F042K6	STM32F042K6
NUCLEO-F091RC	STM32F091xC

STM32CubeF0 support both Nucleo-32 and Nucleo-64 boards.

- Nucleo-64 boards are compatible with Adafruit LCD display Arduino™ UNO shields which embed a microSD connector and a joystick in addition to the LCD.
- Nucleo-32 boards are compatible with Gravitech 7-segment display Arduino™ NANO shields which allow displaying up to four-digit numbers and characters.

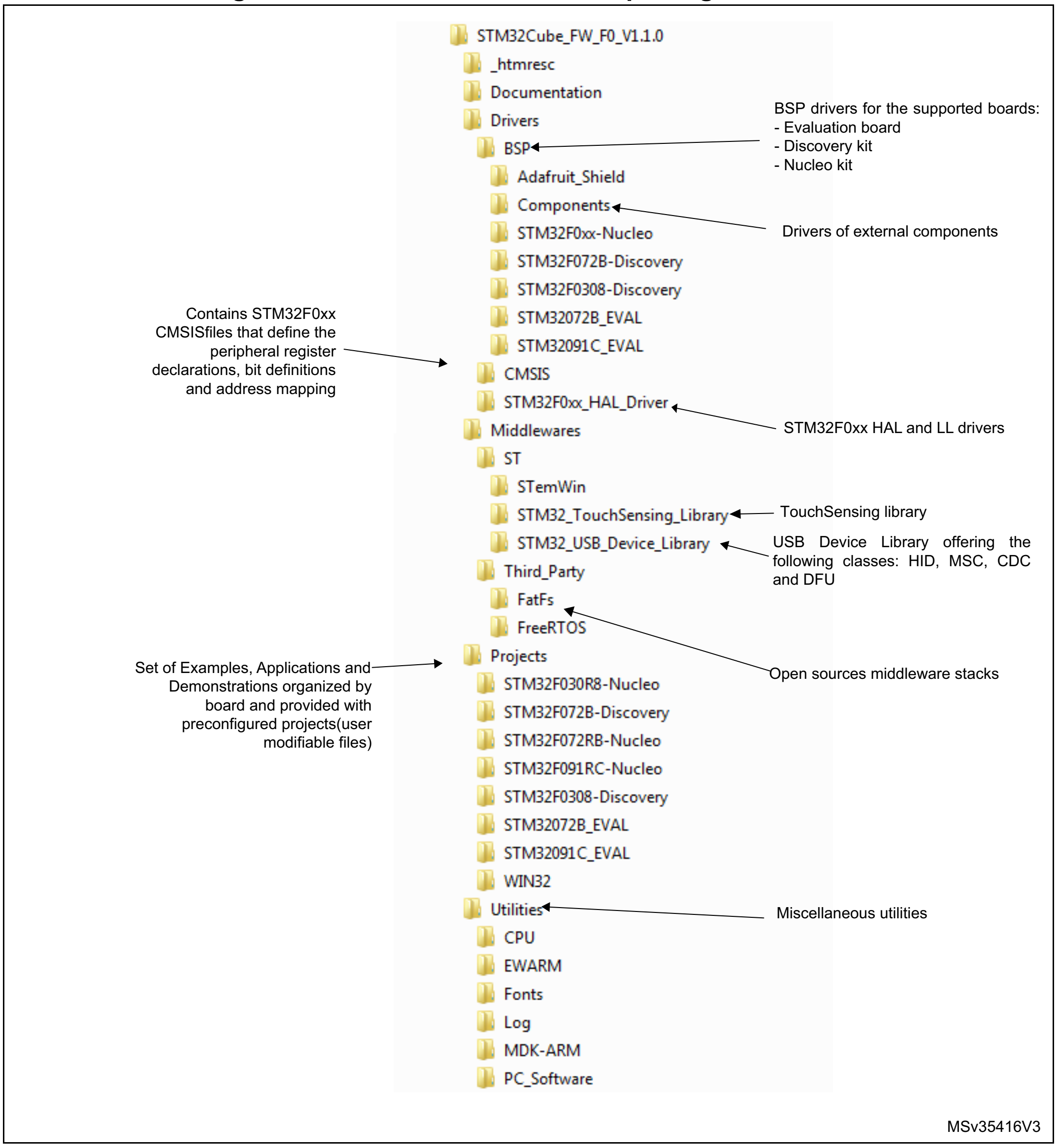
The Arduino™ shield drivers are provided within the BSP component. Their usage is illustrated by a demonstration firmware.

The STM32CubeF0 firmware is able to run on any compatible hardware. The user simply updates the BSP drivers to port the provided examples on his own board, if this latter has the same hardware features (LED, LCD display, buttons...).

3.2 Firmware package overview

The STM32CubeF0 firmware solution is provided in one single zip package having the structure shown in *Figure 3*.

Figure 3. STM32CubeF0 firmware package structure

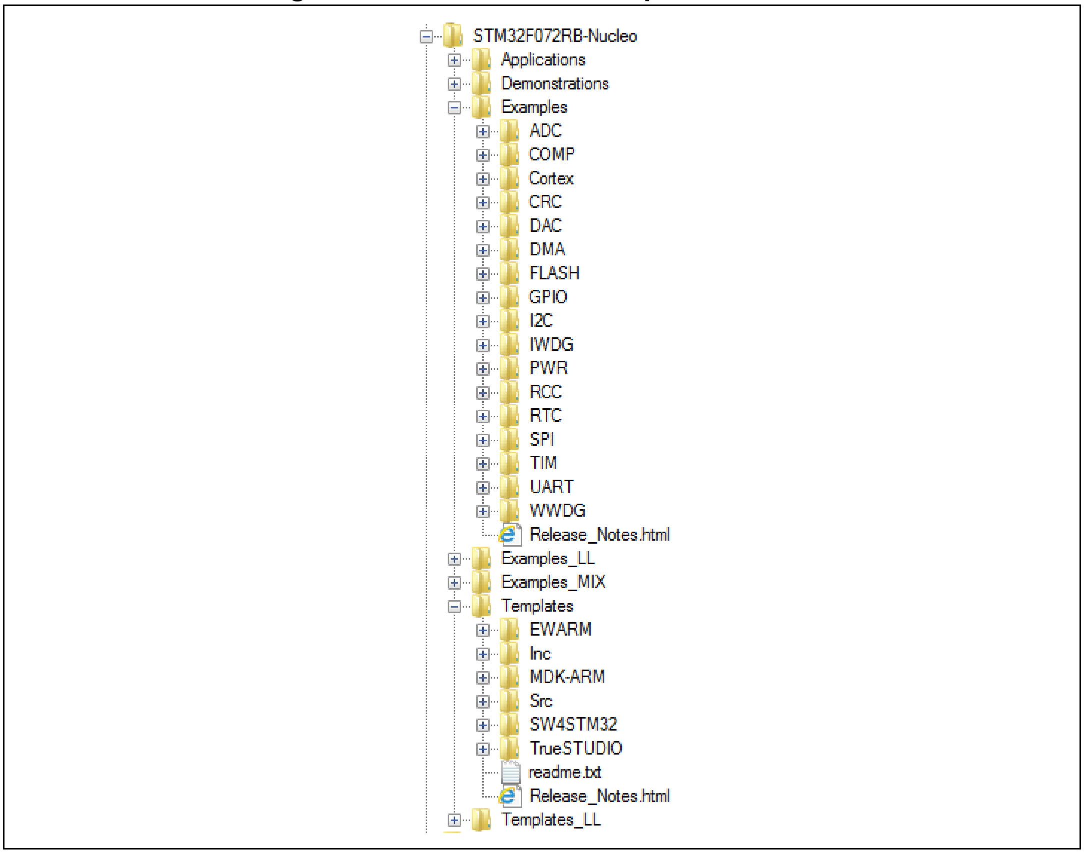


1. The components files must not be modified by the user. Only the \Projects sources can be changed by the user.

For each board, a set of examples are provided with pre-configured projects for EWARM, MDK-ARM, TrueSTUDIO and SW4STM32 toolchains.

Figure 4 shows the project structure for the NUCLEO-F072RB board.

Figure 4. STM32CubeF0 examples overview



The examples are classified depending on the STM32Cube level they apply to, and are named as explained below:

- Level 0 examples are called *Examples*, *Examples_LL* and *Examples_MIX*. They use respectively HAL drivers, LL drivers and a mix of HAL and LL drivers without any middleware component.
- Level 1 examples are called *Applications.* They provide typical use cases of each middleware component.

The template projects available in the *Templates* and *Templates_LL* directories allow to quickly build any firmware application on a given board.

All examples have the same structure:

- *\Inc* folder that contains all header files.
- *\Src* folder for the sources code.
- *\EWARM*, *\MDK-ARM*, *\SW4STM32* and *\TrueSTUDIO* folders contain the pre-configured project for each toolchain.
- *readme.txt* describing the example behavior and needed environment to make it working

Table 3 gives the number of projects available for each board.

Table 3. Number of examples for each board

Level	STM32F072B -Discovery	STM32F030 R8-Nucleo8	STM32F072 RB-Nucleo	STM32F070 RB-Nucleo	STM32F042 K6-Nucleo	STM32091C _EVAL	STM32F0308- Discovery	STM32F091 RC-Nucleo	STM32F031 K6-Nucleo	STM32072B _EVAL	Total
Templates_LL	1	1	1	1	1	1	1	1	1	1	10
Templates	1	1	1	1	1	1	1	1	1	1	10
Examples_MIX	0	0	11	0	0	0	0	0	0	0	11
Examples_LL	0	0	74	0	0	0	0	0	0	0	74
Examples	46	30	45	33	17	45	29	46	17	41	349
Demonstrations	1	1	1	1	1	1	1	1	1	0	9
Applications	5	1	1	1	0	15	1	3	0	14	41
Total	54	34	134	37	20	63	33	53	20	57	**504**

4 Getting started with STM32CubeF0

4.1 Running your first example

This section explains how simple is to run a first example within STM32CubeF0. It uses as illustration the generation of a simple LED toggle running on NUCLEO-F091RC board:

1. Download the STM32CubeF0 firmware package. Unzip it into a directory of your choice. Make sure not to modify the package structure shown in *Figure 3*. Note that it is also recommended to copy the package at a location close to your root volume (e.g. C\Eval or G:\Tests) because some IDEs encounter problems when the path length is too long.
2. Browse to \Projects\STM32F091RC-Nucleo\Examples.
3. Open \GPIO, then \GPIO_EXTI folder.
4. Open the project with your preferred toolchain. A quick overview on how to open, build and run an example with the supported toolchains is given below.
5. Rebuild all files and load your image into target memory.
6. Run the example: each time you press the USER pushbutton, the LED2 toggles (for more details, refer to the example readme file).

To open, build and run an example with the supported toolchains:, follow the steps below:

- EWARM
  a) Under the example folder, open \EWARM sub-folder.
  b) Launch the Project.eww workspace[a].
  c) Rebuild all files: **Project->Rebuild all**.
  d) Load project image: **Project->Debug**.
  e) Run program: **Debug->Go(F5)**.
- MDK-ARM
  a) Under the example folder, open \MDK-ARM sub-folder.
  b) Launch the Project.uvprojx workspace[a].
  c) Rebuild all files: **Project->Rebuild all target files**.
  d) Load project image: **Debug->Start/Stop Debug Session**.
  e) Run program: **Debug->Run (F5)**.
- SW4STM32
  a) Open the SW4STM32 toolchain
  b) Click **File->Switch Workspace->Other** and browse to the SW4STM32 workspace directory
  c) Click **File->Import**, select **General->Existing Projects into Workspace** and then click **Next**.
  d) Browse to the SW4STM32 workspace directory and select the project.
  e) Rebuild all project files: select the project in the **Project explorer** window then click the **Project->build project** menu.
  f) Run program: Run->Debug (F11)
- TrueSTUDIO
  a) Open the TrueSTUDIO toolchain.
  b) Click **File->Switch Workspace->Other** and browse to TrueSTUDIO workspace directory.
  c) Click **File->Import**, select **General->Existing Projects into Workspace** and then click **Next**.
  d) Browse to the TrueSTUDIO workspace directory, select the project.
  e) Rebuild all project files: select the project in the **Project explorer** window then click the **Project->build project** menu.
  f) Run program: **Run->Debug (F11)**.

a. The workspace name may change from one example to another.

4.2 Developing your own application

4.2.1 HAL application

This section describes the steps required to create your own HAL application using STM32CubeF0:

1. **Create your project**

   To create a new project, you can either start from the *Template* project provided for each board under \Projects\<STM32xxx_yyy>\Templates or from any available project under \Projects\<STM32xxy_yyy>\Examples or \Projects\<STM32xx_yyy>\Applications (where <STM32xxx_yyy> refers to the board name, e.g. STM32091C-EVAL).

   The *Template* project is providing empty main loop function, however it's a good starting point to get familiar with project settings for STM32CubeF0. The template has the following characteristics:

   – It contains the source code of HAL, CMSIS and BSP drivers which are the minimal components required to develop a code on a given board.
   – It contains the include paths for all the firmware components.
   – It defines the STM32F0 device supported, thus allowing to configure the CMSIS and HAL drivers accordingly.
   – It provides read-to-use user files pre-configured as shown below:
     HAL initialized with default time base with ARM Core SysTick.
     SysTick ISR implemented for HAL_Delay() purpose.

Note: When copying an existing project to another location, make sure to update the include paths.

2. **Add the necessary middleware to your project (optional)**

   The available middleware stacks are: USB Device library, STMTouch touch sensing, STemWin, FreeRTOS and FatFS. To know which source files you need to add in the project files list, refer to the documentation provided for each middleware. You can also look at the Applications available under \Projects\STM32xxx_yyy\Applications\<MW_Stack> (where <MW_Stack> refers to the middleware stack, e.g. USB_Device) to know which sources files and which include paths have to be added.

3. **Configure the firmware components**

   The HAL and middleware components offer a set of build time configuration options using macros # define declared in a header file. A template configuration file is provided within each component, it has to be copied to the project folder (usually the configuration file is named xxx_conf_template.h, the word '_template' needs to be removed when copying it to the project folder). The configuration file provides enough information to know the impact of each configuration option. More detailed information is available in the documentation provided for each component.

4. **Start the HAL Library**

   After jumping to the main program, the application code must call *HAL_Init()* API to initialize the HAL Library, which do the following tasks:

   a) Configuration of the Flash prefetch and SysTick interrupt priority (through macros defined in stm32f0xx_hal_conf.h).
   b) Configuration of the SysTick to generate an interrupt each 1 msecond at the SysTick interrupt priority TICK_INT_PRIO defined in stm32f0xx_hal_conf.h, which

is clocked by the MSI (at this stage, the clock is not yet configured and thus the system is running from the internal 4 MHz MSI).

c) Setting of NVIC Group Priority to 4.

d) Call of HAL_MspInit() callback function defined in stm32f0xx_hal_msp.c user file to perform global low-level hardware initializations.

5. **Configure the system clock**

The system clock configuration is done by calling the two APIs described below:

a) HAL_RCC_OscConfig(): this API configures the internal and/or external oscillators, as well as the PLL source and factors. The user can choose to configure one oscillator or all oscillators. The PLL configuration can be skipped if there is no need to run the system at high frequency.

b) HAL_RCC_ClockConfig(): this API configures the system clock source, the Flash memory latency and AHB and APB prescalers.

6. **Initialize the peripheral**

a) First write the peripheral HAL_PPP_MspInit function. Proceed as follows:

– Enable the peripheral clock.

– Configure the peripheral GPIOs.

– Configure DMA channel and enable DMA interrupt (if needed).

– Enable peripheral interrupt (if needed).

b) Edit the stm32xxx_it.c to call the required interrupt handlers (peripheral and DMA), if needed.

c) Write process complete callback functions if you plan to use peripheral interrupt or DMA.

d) In your main.c file, initialize the peripheral handle structure then call the function HAL_PPP_Init() to initialize your peripheral.

7. **Develop your application**

At this stage, your system is ready and you can start developing your application code.

– The HAL provides intuitive and ready-to-use APIs to configure the peripheral. It supports polling, interrupts and DMA programming model, to accommodate any application requirements. For more details on how to use each peripheral, refer to the rich examples set provided in the STM32CubeF0 package.

– If your application has some real-time constraints, you can found a large set of examples showing how to use FreeRTOS and integrate it with all middleware stacks provided within STM32CubeF0. This can be a good starting point to develop your application.

Caution: In the default HAL implementation, SysTick timer is used as timebase: it generates interrupts at regular time intervals. If HAL_Delay() is called from peripheral ISR process, make sure that the SysTick interrupt has higher priority (numerically lower) than the peripheral interrupt. Otherwise, the caller ISR process will be blocked. Functions affecting timebase configurations are declared as __weak to make override possible in case of other implementations in user file (using a general purpose timer for example or other time source). For more details, refer to HAL_TimeBase example.

4.2.2 LL application

This section describes the steps needed to create your own LL application using STM32CubeF0.

1. **Create your project**

   To create a new project you can either start from the *Templates_LL* project provided for each board under \Projects\<STM32xxx_yyy>\Templates_LL or from any available project under \Projects\<STM32xxy_yyy>\Examples_LL (<STM32xxx_yyy> refers to the board name, such as STM32F072RB-Nucleo).

   The *Template* project provides an empty main loop function, however it is a good starting point to get familiar with project settings for STM32CubeF0.

   Template main characteristics are the following:

   – It contains the source codes of the LL and CMSIS drivers which are the minimal components needed to develop code on a given board.

   – It contains the include paths for all the required firmware components.

   – It selects the supported STM32F0 device and allows to configure the CMSIS and LL drivers accordingly.

   – It provides ready-to-use user files, that are pre-configured as follows:

     main.h : LED & USER_BUTTON definition abstraction layer.

     main.c : System clock configuration for maximum frequency.

2. **Port an existing project to another board**

   To port an existing project to another target board, start from the *Templates_LL* project provided for each board and available under \Projects\<STM32xxx_yyy>\Templates_LL:

   a) Select a LL example

      To find the board on which LL examples are deployed, refer to the list of LL examples STM32CubeProjectsList.html, to *Table 3: Number of examples for each board* or to application note *"STM32Cube firmware examples for STM32F0 Series"* (AN4735)

   b) Port the LL example

   – Copy/paste the Templates_LL folder - to keep the initial source - or directly update existing Templates_LL project.

   – Then porting consists principally in replacing *Templates_LL* files by the *Examples_LL* targeted project.

   – Keep all board specific parts. For reasons of clarity, board specific parts have been flagged with specific tags:

```
/* ==============   BOARD SPECIFIC CONFIGURATION CODE BEGIN    ============== */
/* ==============   BOARD SPECIFIC CONFIGURATION CODE END      ============== */
```

   Thus the main porting steps are the following:

   – Replace the stm32F0xx_it.h file

   – Replace the stm32F0xx_it.c file

   – Replace the main.h file and update it: Keep the LED and user button definition of the LL template under "BOARD SPECIFIC CONFIGURATION" tags.

– Replace the main.c file and update it:

  Keep the clock configuration of the SystemClock_Config() LL template function under "BOARD SPECIFIC CONFIGURATION" tags.

  Depending on LED definition, replace each LEDx occurrence with another LEDy available in main.h.

Thanks to these adaptations, the example should be functional on the targeted board.

4.3 Using STM32CubeMX to generate the initialization C code

An alternative to steps 1 to 6 described in *Section 4.2* consists in using the STM32CubeMX tool to generate code to initialize the system, peripherals and middleware (steps 1 to 6 above) through a step-by-step process:

1. Select the STMicroelectronics STM32 microcontroller that matches the required set of peripherals.
2. Configure each required embedded software thanks to a pinout-conflict solver, a clock-tree setting helper, a power consumption calculator, and the utility performing MCU peripheral configuration (e.g. GPIO or USART) and middleware stacks (e.g. USB).
3. Generate the initialization C code based on the configuration selected. This code is ready-to-use within several development environments. The user code is kept at the next code generation.

For more information, please refer to STM32CubeMX user manual (UM1718).

4.4 Getting STM32CubeF0 release updates

The STM32CubeF0 firmware package comes with an updater utility, STM32CubeUpdater, also available as a menu within STM32CubeMX code generation tool.

The updater solution detects new firmware releases and patches available from www.st.com and proposes to download them to the user's computer.

4.4.1 Installing and running the STM32CubeUpdater program

Follow the sequence below to install and run the STM32CubeUpdater:

1. To launch the installation, double-click the SetupSTM32CubeUpdater.exe file.
2. Accept the license terms and follow the different installation steps.
3. Upon successful installation, STM32CubeUpdater becomes available as an STMicroelectronics program under *Program Files* and is automatically launched. The STM32CubeUpdater icon appears in the system tray. Right-click the updater icon and select **Updater Settings** to configure the Updater connection and whether to perform manual or automatic checks. For more details on Updater configuration, refer to section 3 of STM32CubeMX user manual - UM1718).

5 FAQ

5.1 What is the license scheme for the STM32CubeF0 firmware?

The HAL is distributed under a non-restrictive BSD (Berkeley Software Distribution) license.

The middleware stacks made by STMicroelectronics (USB Device Libraries, STemWin) come with a licensing model allowing easy reuse, provided it runs on an STMicroelectronics device.

The middleware based on well-known open-source solutions (FreeRTOS and FatFs) have user-friendly license terms. For more details, refer to the license agreement of each middleware.

5.2 What boards are supported by the STM32CubeF0 firmware package?

The STM32CubeF0 firmware package provides BSP drivers and ready-to-use examples for the following STM32F0 boards: STM32072B-EVAL, STM32091C-EVAL, STM32F072B-DISCOVERY, STM32F0308-DISCOVERY, NUCLEO-F070RB, NUCLEO-F072RB, NUCLEO-F091RC, NUCLEO-F030R8, NUCLEO-F031K6 and NUCLEO-F042K6.

5.3 Are any examples provided with the ready-to-use toolset projects?

Yes. STM32CubeF0 provides a rich set of examples and applications. They come with the pre-configured projects for IAR, Keil and GCC toolchains.

5.4 Is there any link with Standard Peripheral Libraries?

The STM32Cube HAL and LL drivers are the replacement of the standard peripheral library:

- The HAL drivers offer a higher abstraction level compared to the standard peripheral APIs. They focus on peripheral common features rather than hardware. Their higher abstraction level allows defining a set of user-friendly APIs that can be easily ported from one product to another.
- The LL drivers offer low-level APIs at registers level. They are organized in a simpler and clearer way than direct register accesses. LL drivers also include peripheral initialization APIs, which are more optimized compared to what is offered by the SPL, while being functionally similar. Compared to HAL drivers, these LL initialization APIs allows an easier migration from the SPL to the STM32Cube LL drivers, since each SPL API has its equivalent LL API(s).

5.5 Does the HAL layer take benefit from interrupts or DMA? How can this be controlled?

Yes. The HAL layer supports three API programming models: polling, interrupt and DMA (with or without interrupt generation).

5.6 How are the product/peripheral specific features managed?

The HAL drivers offer extended APIs, i.e. specific functions as add-ons to the common API to support features available on some products/lines only.

5.7 How can STM32CubeMX generate code based on embedded software?

STM32CubeMX has a built-in knowledge of STM32 microcontrollers, including their peripherals and software, that allows to provide a graphical representation to the user and generate *.h/*.c files based on user configuration.

5.8 How can I get regular updates on the latest STM32CubeF0 firmware releases?

The STM32CubeF0 firmware package comes with an updater utility, STM32CubeUpdater, that can be configured for automatic or on-demand checks for new firmware package updates (new releases or/and patches).

STM32CubeUpdater is integrated as well within the STM32CubeMX tool. When using this tool for STM32F0 configuration and initialization C code generation, the user can benefit from STM32CubeMX self-updates as well as STM32CubeF0 firmware package updates.

For more details, refer to *Section 4.4*.

5.9 When should I use HAL versus LL drivers?

HAL drivers offer high-level and function-oriented APIs, with a high level of portability. Product/IPs complexity is hidden for end users.

LL drivers offer low-level APIs at registers level, with a better optimization but less portability. They require a deep knowledge of product/IPs specifications.

5.10 How can I include LL drivers in my environment? Is there any LL configuration file as for HAL?

There is no configuration file. Source code shall directly include the necessary stm32f0xx_ll_ppp.h file(s).

5.11 Can I use HAL and LL drivers together? If yes, what are the constraints?

It is possible to use both HAL and LL drivers. One can handle the IP initialization phase with HAL and then manage the I/O operations with LL drivers.

The major difference between HAL and LL is that HAL drivers require to create and use handles for operation management while LL drivers operates directly on peripheral registers. Mixing HAL and LL is illustrated in Examples_MIX example.

5.12 Is there any LL APIs which are not available with HAL

Yes, there are.

A few Cortex® APIs have been added in stm32f0xx_ll_cortex.h e.g. for accessing SCB or SysTick registers.

5.13 Why are SysTick interrupts not enabled on LL drivers?

When using LL drivers in standalone mode, you do not need to enable SysTick interrupts because they are not used in LL APIs, while HAL functions requires SysTick interrupts to manage timeouts.

5.14 How are LL initialization APIs enabled?

The definition of LL initialization APIs and associated resources (structure, literals and prototypes) is conditioned by the USE_FULL_LL_DRIVER compilation switch.

To be able to use LL APIs, add this switch in the toolchain compiler preprocessor.

6 Revision history

Table 4. Document revision history

Date	Revision	Changes
17-Jun-2014	1	Initial release.
30-Sep-2014	2	Added StemWin in *Section 1: STM32CubeF0 main features* and *Section 2: STM32CubeF0 architecture overview*. Updated *Figure 1: STM32CubeF0 firmware components* and *Figure 2: STM32CubeF0 firmware architecture*. Added STM32F091xx and STM32F098xx in *Table 1: Macros for STM32F0 Series*. Updated *Figure 3: STM32CubeF0 firmware package structure* and *Figure 4: STM32CubeF0 examples overview*. Added STM32091C-EVAL and NUCLEO-F091RC in *Table 2: Boards for STM32F0 Series* and *Table 3: Number of examples for each board*. Changed STM32F072RB-NUCLEO and STM32F030R8-NUCLEO into NUCLEO-F072RB and STM32F072RB-F030R8 in *Table 3: Number of examples for each board*. Replaced STM32F071RB by STM32F091RC in *Section 4.1: Running your first example*. Added STemWin in *Section 4.2: Developing your own application* and replaced STM32072B_EVAL by STM32091C_EVAL. Updated *Section 5.1: What is the license scheme for the STM32CubeF0 firmware?* and *Section 5.2: What boards are supported by the STM32CubeF0 firmware package?*, and added *Section 5.9: How do I set the HAL drivers in Debug mode to debug my application?*.
05-Dec-2014	3	Added STM32F030xC, STM32F070x6 and STM32F070xB in *Table 1: Macros for STM32F0 Series*. Added NUCLEO-F070RB in *Table 2: Boards for STM32F0 Series*, *Table 3: Number of examples for each board* and *Section 5.2: What boards are supported by the STM32CubeF0 firmware package?*.
10-Sep-2015	4	Updated *Figure 1: STM32CubeF0 firmware components*. Added NUCLEO-F031K6 and NUCLEO-F042K6 board in *Section 3.1: Supported STM32F0 devices and hardware*, *Table 3: Number of examples for each board* and *Section 5.2: What boards are supported by the STM32CubeF0 firmware package?*.
01-Feb-2016	5	Added SW4STM32 in *Section 3.2: Firmware package overview* and *Section 4.1: Running your first example*. Updated *Table 3: Number of examples for each board*.

Table 4. Document revision history (continued)

Date	Revision	Changes
22-Apr-2016	6	Added Low Layer (LL) drivers in the following sections: – *Section : Introduction* – *Section 1: STM32CubeF0 main features* – *Section 2: STM32CubeF0 architecture overview* – *Section 3: STM32CubeF0 firmware package overview:* Updated *Table 3: Number of examples for each board*. Added new Examples_LL and Examples_MIX examples in *Section 3.2: Firmware package overview* – *Updated Section 5: FAQ* to add low-layer drivers.
27-Oct-2016	7	Updated *Section 4.2: Developing your own application* to distinguish between HAL application (*Section 4.2.1: HAL application*) and LL application (*Section 4.2.2: LL application*). Updated *Figure 4* and *Table 3*.
28-Nov-2016	8	Reformatted *Table 3*.