UM1860
User manual

Getting started with STM32CubeL4 for STM32L4 Series

Introduction

STMCube™ is an STMicroelectronics original initiative to make developers' lives easier by reducing development effort, time and cost. STM32Cube covers the whole STM32 portfolio.

STM32Cube Version 1.x 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 STM32CubeL4 for STM32L4 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, STMTouch™, FatFs and Graphics.
  - All embedded software utilities delivered with a full set of examples.

This user manual describes how to get started with the STM32CubeL4 firmware package.

Section 1 describes the main features of STM32CubeL4 firmware, part of the STMCube™ initiative. *Section 2* and *Section 3* provide an overview of the STM32CubeL4 architecture and firmware package structure.

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1 STM32CubeL4 main features

STM32CubeL4 gathers, in a single package, all the generic embedded software components required to develop an application on STM32L4 microcontrollers. In line with the STMCube™ initiative, this set of components is highly portable, not only within STM32L4 Series but also to other STM32 series.

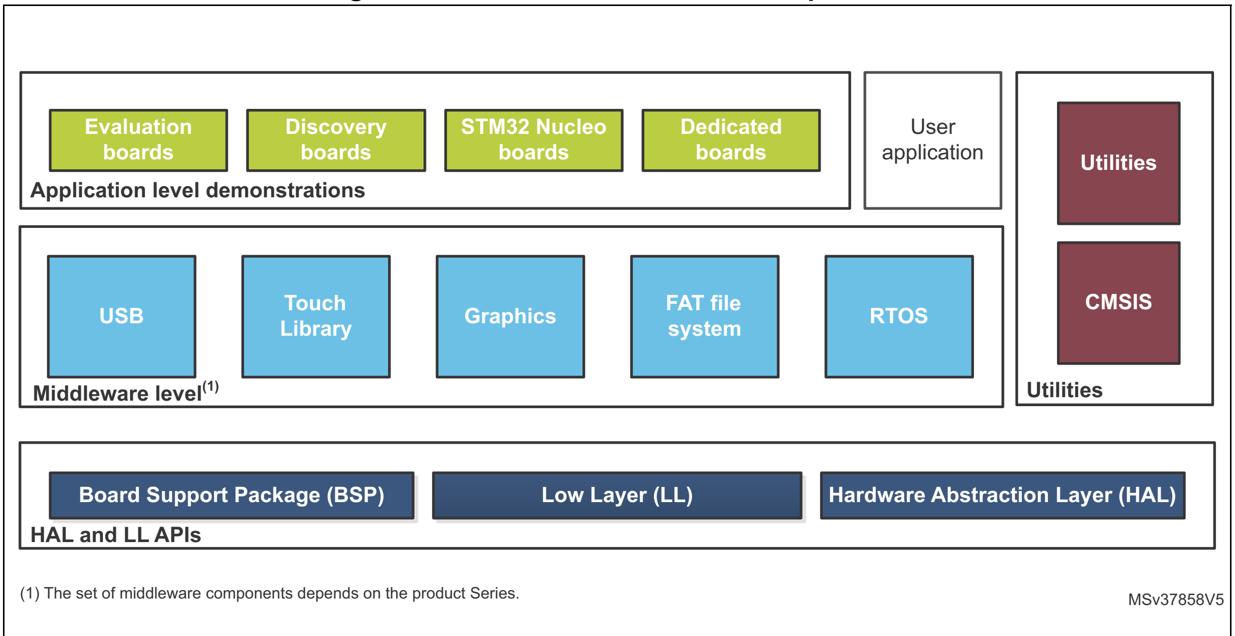
STM32CubeL4 is fully compatible with STM32CubeMX code generator that allows the generation of initialization code. The package includes Low Layer (LL) and hardware abstraction layer (HAL) APIs that cover the microcontroller hardware, together with an extensive set of examples running on STMicroelectronics boards. The HAL and LL APIs are available in open-source BSD license for user convenience.

STM32CubeL4 package also contains a set of middleware components with the corresponding examples. They come in free user-friendly license terms:

- Full USB Host and Device stack supporting many classes.
  - Host Classes: HID, MSC, CDC, Audio, MTP
  - Device Classes: HID, MSC, CDC, Audio, DFU, LPM, BCD.
- 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 STM32CubeL4 package.

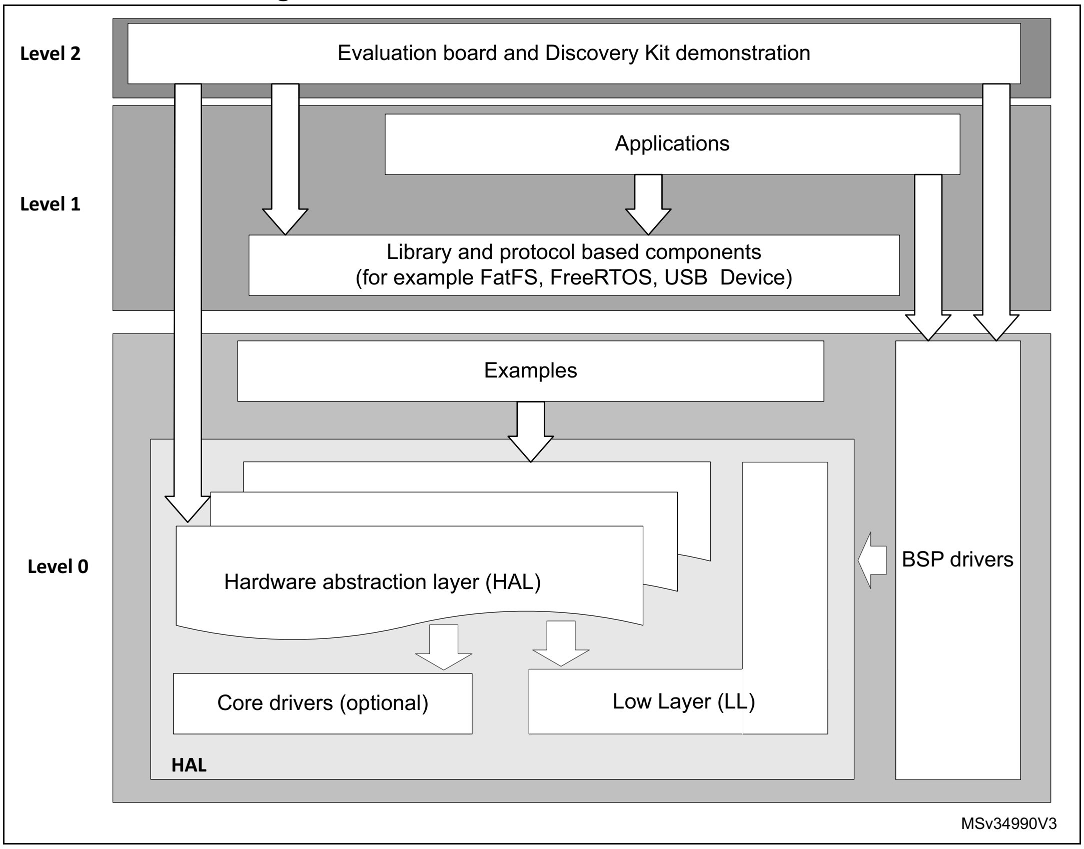
Figure 1. STM32CubeL4 firmware components



2 STM32CubeL4 architecture overview

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

Figure 2. STM32CubeL4 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 provides specific APIs to the BSP driver external components and is portable on any other board.
- BSP driver

  It allows linking of 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 easy porting to any hardware by just implementing the low-level routines.

2.1.2 Hardware abstraction layer (HAL) and Low Layer (LL)

The STM32CubeL4 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 processes. As an example, for the communication peripherals (I2S, UART…), the HAL drivers provide APIs allowing the initialization and configuration of the peripheral, the management of data transfer based on polling, the interrupt or DMA process, and the handling of communication errors that may raise. The HAL driver APIs are split in two categories:
  - Generic APIs providing common and generic functions to all the STM32 series
  - Extension APIs providing 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 FSMC, USB, or SDMMC).

  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 includes the examples built over the STM32 peripheral and which use either the HAL or/and the Low Layer drivers APIs as well as the 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 Host and Device Libraries, STMTouch touch sensing, STemWin, FreeRTOS and FatFs. Horizontal interactions between the components of this layer are 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:

- **USB Host and Device libraries**
  - Several USB classes supported (Mass-Storage, HID, CDC, DFU, LPM and BCD).
  - Support of multi-packet transfer features that allows large amounts of data to be sent 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).
  - 32-bit aligned data structures to handle DMA-based transfer in high-speed modes.
  - Support of multi USB OTG core instances from user level through configuration file. This allows the execution of operations with more than one USB host/device peripheral.
  - 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 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 STM32CubeL4 firmware package overview

3.1 Supported STM32L4 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 STM32CubeL4 offers full support of all STM32L4 Series. The user has only to define the right macro in stm32l4xx.h.

Table 1 gives the macro to be defined depending on the STM32L4 device used. This macro must also be defined in the compiler preprocessor.

Table 1. Macros for STM32L4 Series

Macro defined in stm32l4xx.h	STM32L4 devices
STM32L431xx	STM32L431CC, STM32L431KC, STM32L431RC, STM32L431VC, STM32L431CB, STM32L431KB, STM32L431RB
STM32L432xx	STM32L432KC, STM32L432KB
STM32L433xx	STM32L433CC, STM32L433RC, STM32L433VC, STM32L433CB, STM32L433RB
STM32L442xx	STM32L442KC
STM32L443xx	STM32L443CC, STM32L443RC, STM32L443VC
STM32L451xx	STM32L451CC, STM32L451RC, STM32L451VC, STM32L451CE, STM32L451RE, STM32L451VE
STM32L452xx	STM32L452CC, STM32L452RC, STM32L452VC, STM32L452CE, STM32L452RE, STM32L452VE
STM32L462xx	STM32L462CE, STM32L462RE, STM32L462VE
STM32L471xx	STM32L471RG, STM32L471JG, STM32L471VG, STM32L471QG, STM32L471ZG, STM32L471RE, STM32L471JE, STM32L471VE, STM32L471QE, STM32L471ZE
STM32L475xx	STM32L475RG, STM32L475JG, STM32L475VG, STM32L475QG, STM32L475ZG, STM32L475RE, STM32L475JE, STM32L475VE, STM32L475QE, STM32L475ZE, STM32L475RC, STM32L475VC
STM32L476xx	STM32L476RG, STM32L476JG, STM32L476VG, STM32L476QG, STM32L476ZG, STM32L476RE, STM32L476JE, STM32L476VE, STM32L476QE, STM32L476ZE, STM32L476RC, STM32L476VC
STM32L485xx	STM32L485JC, STM32L485JE
STM32L486xx	STM32L486RG, STM32L486JG, STM32L486VG, STM32L486QG, STM32L486ZG
STM32L496xx	STM32L496RG, STM32L496VG, STM32L496QG, STM32L496ZG, STM32L496AG
STM32L4A6xx	STM32L4A6RG, STM32L4A6VG, STM32L4A6QG, STM32L4A6ZG, STM32L4A6AG

STM32CubeL4 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 STMicroelectronics boards as listed in *Table 2*.

Table 2. Boards for STM32L4 Series

Board	STM32L4 devices supported
STM32L476G-EVAL	STM32L476xx
32L476GDISCOVERY	STM32L476xx
NUCLEO-L476RG	STM32L476xx
NUCLEO-L432KC	STM32L432xx
NUCLEO-L452RE	STM32L452xx
NUCLEO-L496ZG	STM32L496xx
32L496GDISCOVERY	STM32L496xx
B-L475E-IOT01	STM32L475xx

STM32CubeL4 supports Nucleo-32, Nucleo-64 and Nucleo-144 boards:

- Nucleo-64 and Nucleo-144 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 compatible with Gravitech 7-segment display Arduino™ NANO shields, which allow numbers or characters up to four digits to be displayed.

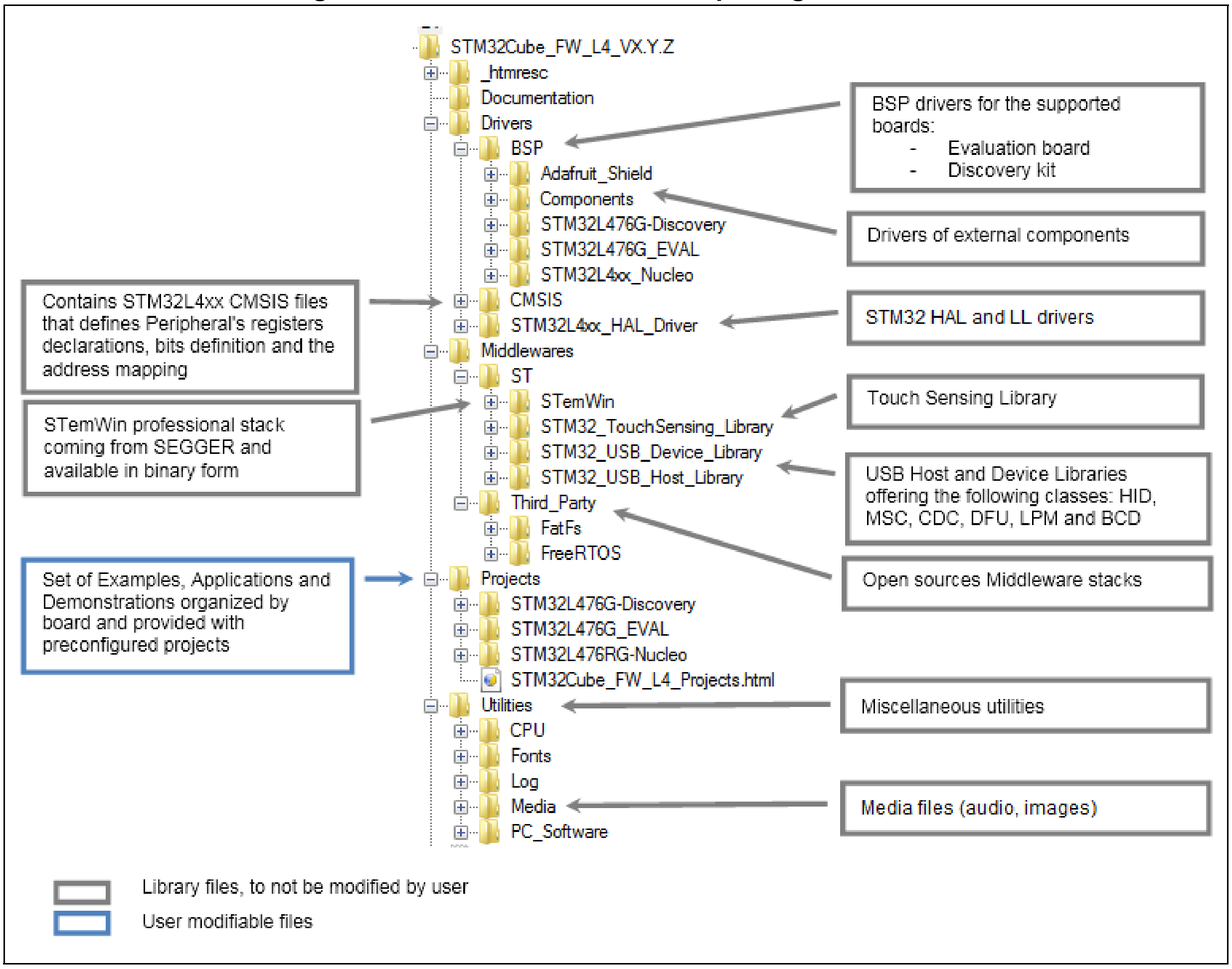
The Arduino™ shield drivers are provided within the BSP component. Their usage is illustrated by a demonstration firmware.

The STM32CubeL4 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 STM32CubeL4 firmware solution is provided in one single zip package having the structure shown in *Figure 3*.

Figure 3. STM32CubeL4 firmware package structure

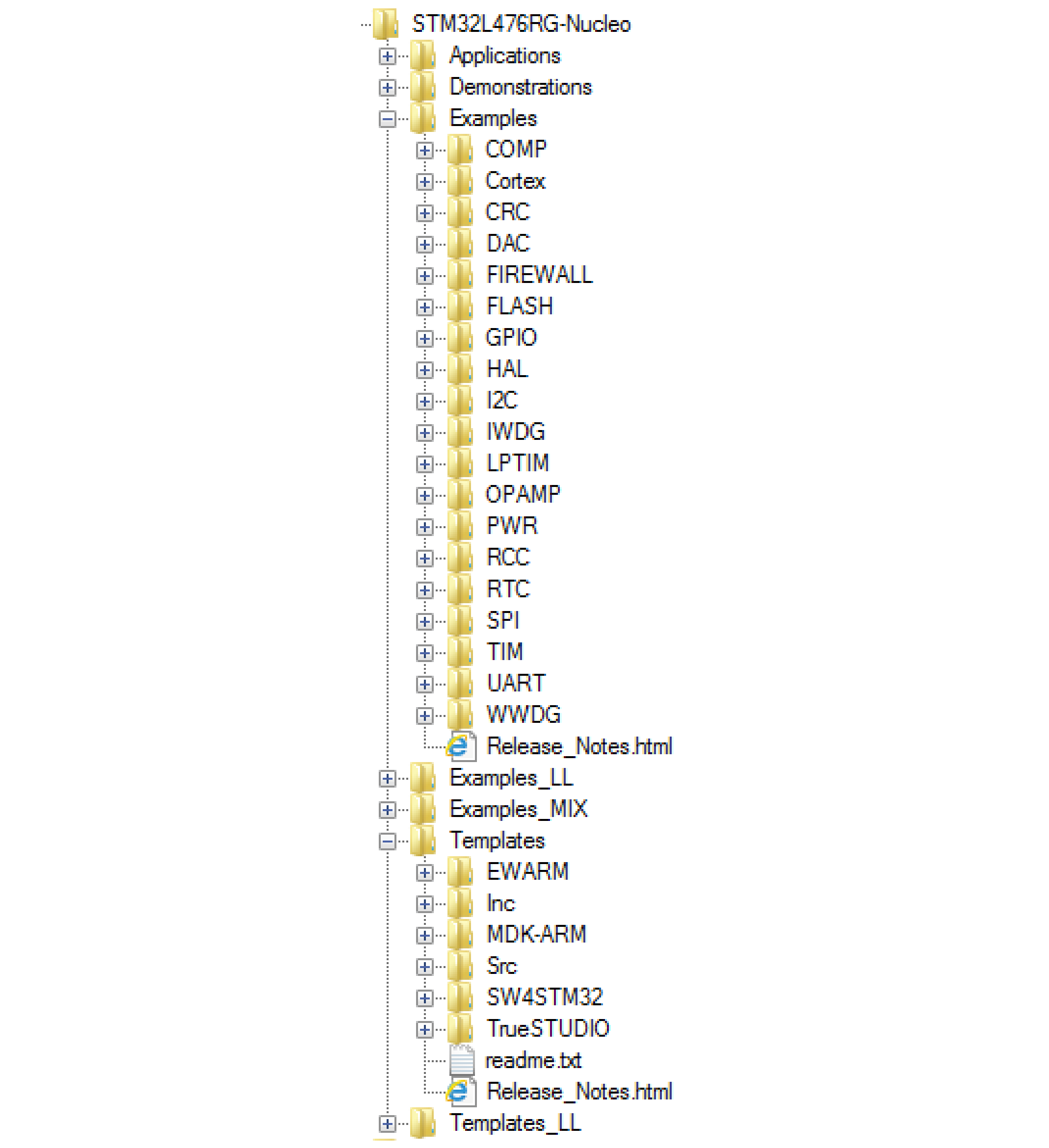


1. The library files in brown must not be modified by the user, while the files in blue can be modified.

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

Figure 4 shows the projects structure for the NUCLEO-L476RG board.

Figure 4. STM32CubeL4 examples overview



The examples are classified depending on the STM32Cube level to which they apply, 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 the quick build of 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 environment needed to make it work.

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

Table 3. Number of examples available for each board

Level	NUCLEO -L432KC	STM32 L476G _EVAL	NUCLEO -L476RG	32L476G DISCO VERY	NUCLEO -L496ZG	32L496G DISCO VERY	NUCLEO -L452RE	B-L475E-IOT01	Total
Templates_LL	1	1	1	1	1	1	1	1	8
Templates	1	1	1	1	1	1	1	1	8
Examples_MIX	0	0	12	0	10	2	0	0	24
Examples_LL	0	0	91	0	94	1	0	0	186
Examples	62	87	69	17	101	22	82	1	441
Demonstrations	1	1	1	1	1	1	1	0	7
Applications	5	29	1	5	11	11	15	11	88
Total	70	119	176	25	219	39	100	14	**762**

4 Getting started with STM32CubeL4

4.1 Running the first example

This section explains how simple is to run a first example within STM32CubeL4. It uses as an illustration the generation of a simple LED toggle running on an STM32L476RG Nucleo board:

1. Download the STM32CubeL4 firmware package. Unzip it into a directory. 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 the root volume (e.g. C\Eval or G:\Tests) to avoid some IDEs encounter problems when the path length is too long.
2. Browse to *\Projects\STM32L476RG-Nucleo\Examples*.
3. Open *\GPIO*, then *\GPIO_EXTI* folder.
4. Open the project with the 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 the image into target memory.
6. Run the example: each time the USER pushbutton is pressed, 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 user application

4.2.1 HAL application

This section describes the steps required to create user HAL application with STM32CubeL4:

1. **Create the project**

   To create a new project, the user 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. STM32L476G-EVAL).

   The *Template* project provides an empty main loop function, however it is a good starting point to get familiar with project settings for STM32CubeL4.
   The template main characteristics are the following:

   – It contains the source code of HAL, CMSIS and BSP drivers, that are the minimal components required to develop a code on a given board.

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

   – It selects the supported STM32L4 device and allows the configuration of CMSIS and HAL drivers accordingly.

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

   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 the project (optional)**

   The available middleware stacks are: USB Host and Device library, STMTouch touch sensing, STemWin, FreeRTOS and FatFs. To know which source files need to be added in the project files list, refer to the documentation provided for each middleware. or 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 to add.

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 stm32l4xx_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 stm32l4xx_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 stm32l4xx_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 chooses 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 peripheral interrupt or DMA is used.

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

7. **Develop the application**

At this stage, the system is ready and the user can start developing the 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 STM32CubeL4 package.

– If the application has some real-time constraints, the user finds a large set of examples showing how to use FreeRTOS and how integrate it with all middleware stacks provided within STM32CubeL4. This is a good starting point to develop the 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 a LL application using STM32CubeL4.

1. **Create the project**

   To create a new project, the user 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 STM32L476RG-Nucleo).

   The *Template* project provides an empty main loop function, however it is a good starting point to get familiar with project settings for STM32CubeL4.

   The template main characteristics are the following:

   – It contains the source code of LL and CMSIS drivers, that are the minimal components to develop a code on a given board.
   – It contains the include paths for all the required firmware components.
   – It selects the supported STM32L4 device and allows the configuration of 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 an LL example

   To find the board on which LL examples are deployed, refer to the list of LL examples in STM32CubeProjectsList.html, to *Table 3: Number of examples available for each board*, or to application note “*STM32Cube firmware examples for STM32L4 Series*” (AN4726).

   b) Port the LL example

   – Copy/paste the *Templates_LL* folder to keep the initial source or directly update the existing *Templates_LL* project.
   – Then LL example porting consists mainly of 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 stm32l4xx_it.h file
   – Replace stm32l4xx_it.c file
   – Replace main.h file and update it: keep the LED and user button definition of the LL template under "BOARD SPECIFIC CONFIGURATION" tags.

– Replace main.c file, and update it:

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

Depending on the LED definition, replace all LEDx occurrences 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 initialization C code

An alternative to steps 1 to 6 described in *Section 4.2* consists of 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 STM32CubeL4 release updates

The STM32CubeL4 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).

4.5 STM32 Nucleo Power GUI tool

The STM32CubeL4 firmware package comes with a Windows® graphical user interface (GUI) tool available under *Utilities\PC_Software* folder. This tool allows connection via the USB ST-Link virtual COM port, to any STM32 Nucleo hardware boards supported by the firmware package. It allows the selection of various low-power modes and benchmarking codes thanks to the available binary files. Users therefore quickly assess STM32L4 low-power performance.

5 FAQ

5.1 What is the license scheme for the STM32CubeL4 firmware?

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

The middleware stacks made by STMicroelectronics (USB Host and 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 STM32CubeL4 firmware package?

The STM32CubeL4 firmware package provides BSP drivers and ready-to-use examples for the following STM32L4 boards: STM32L476G-EVAL, 32L476GDISCOVERY, NUCLEO-L476RG, NUCLEO-L432KC, 32L496GDISCOVERY and NUCLEO-L496ZG.

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

Yes. STM32CubeL4 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 the definition of 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 drivers take benefit from interrupts or DMA? How can this be controlled?

Yes, they do. 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 provides a graphical representation to the user and generates *.h/*.c files based on the user configuration.

5.8 How can I get regular updates on the latest STM32CubeL4 firmware releases?

The STM32CubeL4 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 STM32L4 configuration and initialization C code generation, the user benefits from STM32CubeMX self-updates as well as STM32CubeL4 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 stm32l4xx_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 handles 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 stm32l4xx_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, there is no 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
16-Feb-2015	1	Initial release.
15-Sep-2015	2	Added STM32L475xx and STM32L485xx in *Table 1: Macros for STM32L4 Series*. Added Low Layer (LL) drivers in *Section : Introduction*, *Section 1: STM32CubeL4 main features*, *Section 2: STM32CubeL4 architecture overview* and *Section 3: STM32CubeL4 firmware package overview*. Added new Examples_LL and Examples_MIX examples in *Section 3.2: Firmware package overview*/ Added SW4STM32 toolchain in *Section 3.2: Firmware package overview* and in *Section 4.1: Running the first example*. Updated *Section 5: FAQ* to add low-layer drivers.
28-Jan-2016	3	Updated *Table 3: Number of examples available for each board*. Updated LL driver features in *Section 2.1.2: Hardware abstraction layer (HAL) and Low Layer (LL)*. Updated *Section 5.4: Is there any link with Standard Peripheral Libraries?* and added *Section 5.14: How are LL initialization APIs enabled?*.
25-Feb-2016	4	Added STM32L431xx, STM32L432xx, STM32L433xx, STM32L442xx and STM32L443xx macros in *Table 1: Macros for STM32L4 Series*. Added NUCLEO-L432KC board in *Table 2: Boards for STM32L4 Series*, *Table 3: Number of examples available for each board* and *Section 5.2: What boards are supported by the STM32CubeL4 firmware package?*.
17-Oct-2016	5	Added STM32L451xx, STM32L452xx and STM32L462xx in *Table 1: Macros for STM32L4 Series*. Added NUCLEO-L452RE in *Table 2: Boards for STM32L4 Series*, *Table 3: Number of examples available for each board* and *Section 5.2: What boards are supported by the STM32CubeL4 firmware package?* Updated *Section 4.2: Developing user application* to distinguish between HAL application (*Section 4.2.1: HAL application*) and LL application (*Section 4.2.2: LL application*).
13-Dec-2016	6	Removed STM32L451xx, STM32L452xx and STM32L462xx part numbers, as well as NUCLEO-L452RE.

Table 4. Document revision history (continued)

Date	Revision	Changes
20-Feb-2017	7	Updated *Figure 1: STM32CubeL4 firmware components*. Added STM32L496xx and STM32L4A6xx in *Table 1: Macros for STM32L4 Series*. Added NUCLEO-L496ZG and 32L496GDISCOVERY in *Table 2: Boards for STM32L4 Series*, *Table 3: Number of examples available for each board* and *Section 5.2: What boards are supported by the STM32CubeL4 firmware package?*. Added *Section 4.5: STM32 Nucleo Power GUI tool*.
19-Apr-2017	8	Added: – STM32L451xx, STM32L452xx and STM32L462xx in *Table 1: Macros for STM32L4 Series* – NUCLEO-L452RE and B-L475E-IOT01 in *Table 2: Boards for STM32L4 Series*, *Table 3: Number of examples available for each board* and *Section 5.2: What boards are supported by the STM32CubeL4 firmware package?*