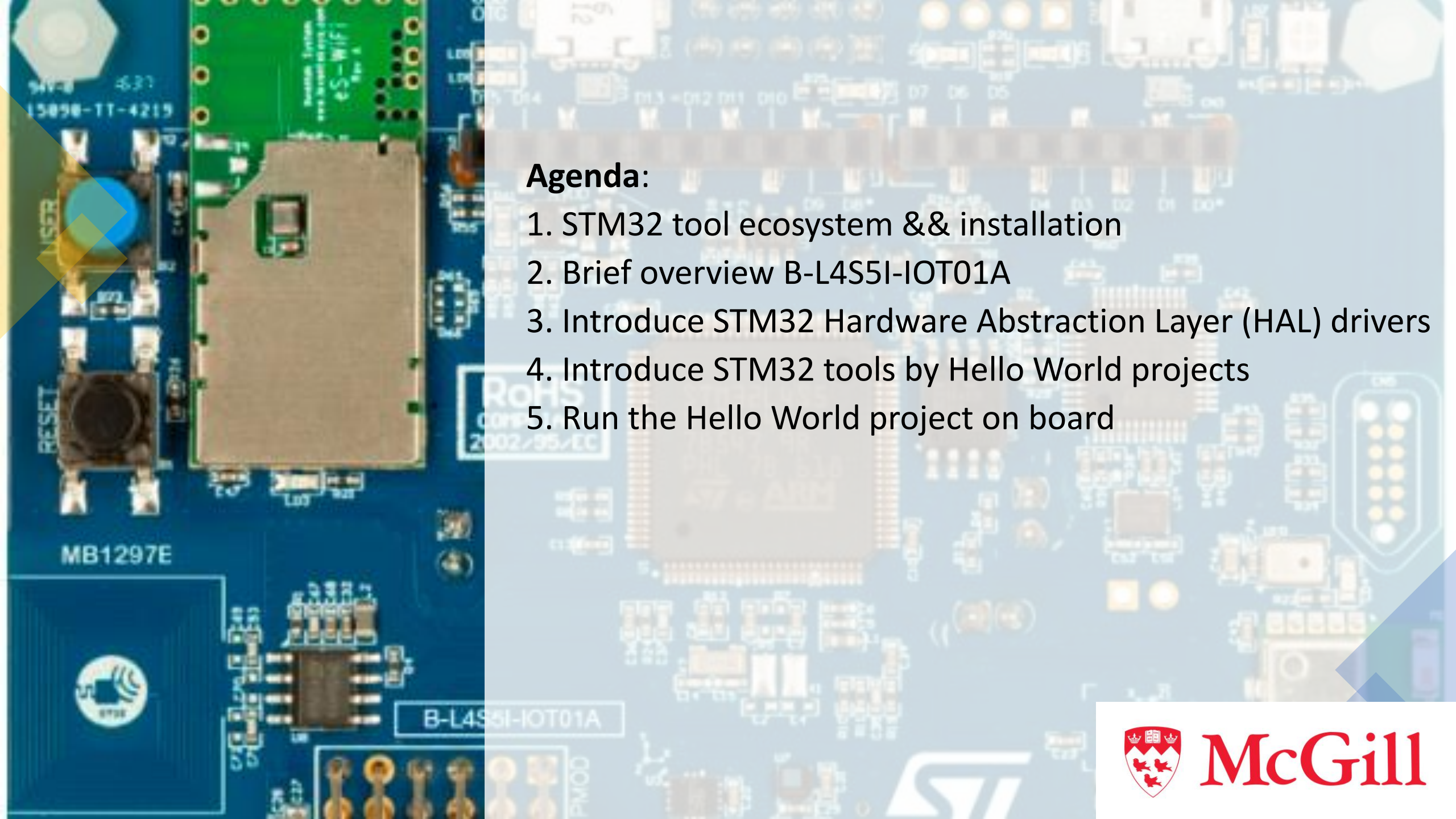# Tutorial First Session

Lecturer :
Shahab Mahmoudi Sadaghiani

Email : shahab.mahmoudisadaghiani@mcgill.ca

ECSE 444 - Microprocessor -Winter 2023

McGill

Agenda:
1. STM32 tool ecosystem && installation
2. Brief overview B-L4S5I-IOT01A
3. Introduce STM32 Hardware Abstraction Layer (HAL) drivers
4. Introduce STM32 tools by Hello World projects
5. Run the Hello World project on board

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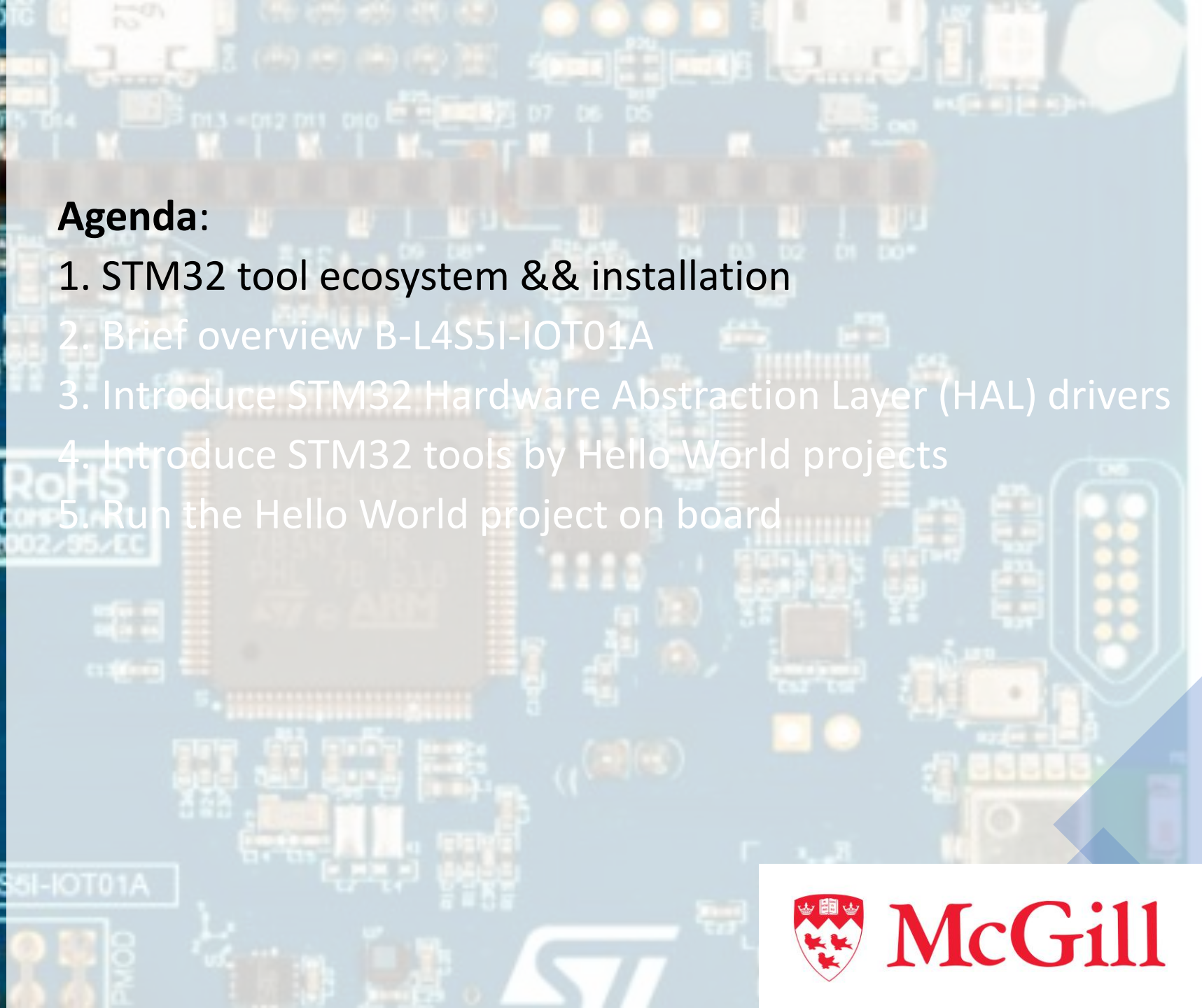5. Run the Hello World project on board

STM32 IDE Ecosystem ref[1]

➢ STM32 CubeMX program can be used to customize any STM32 device configuration and peripherals. By using its graphical user interface, you can generate C-code for STM32 CubeIDE tool.

➢ STM32CubeIDE is an Integrated Development Environment for STM32 processors. It is based on open-source solutions like Eclipse or the GNU C/C++ toolchain. CubeMX allows us to add and modify generated code. After compiling and build our project, we program our chip through the CubeIDE programer. Finally, there are advanced tools for debugging our application.
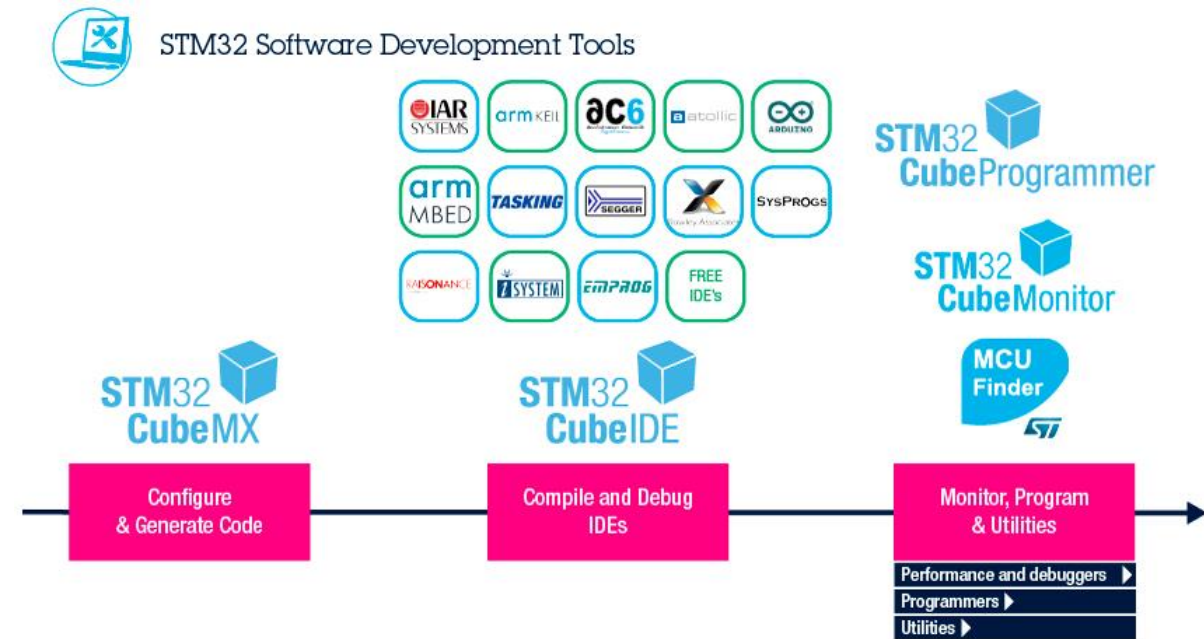
➢ STM32CubeMonitor
➢ STM32CubeProgrammer
➢ Other tools

Fig. 1 ref[1]

1 https://www.st.com/content/st_com/en.html

2

3

New user?

myST brings you a set of personalized features:

○ Participate to ST Events
○ Stay informed with ST eNewsletters
○ Get help with ST Online Support
○ Discuss on the ST Community
○ Benefit from our Online Design Tools
○ Download Software
○ Order free samples
○ Manage your weekly product updates
○ Buy ST Products & Tools

Create Account

4

Your Profile

Salutation: Select one

First name*:

Last name*:

Email*:

Email Confirmation*:

Function*:   Select one

Company/University*:

Industry*:   ADAS

Country/Region*:   Select one

Links :

1.STMCubeMX :
   https://www.st.com/en/development-tools/stm32cubemx.html

2. STMCubeIDE :
   https://www.st.com/en/development-tools/stm32cubeide.html

3. STM Link Server :
https://www.st.com/en/development-tools/st-link-server.html#overview

Get Software

	Part Number	General Description	Supplier	Download	All versions
+	Patch-CubeMX	Patch for STM32CubeMX	ST	Get latest	
+	STM32CubeMX-Lin	STM32Cube init code generator for Linux	ST	Get latest	Select version ∨
+	STM32CubeMX-Mac	STM32Cube init code generator for macOS	ST	Get latest	Select version ∨
+	STM32CubeMX-Win	STM32Cube init code generator for Windows	ST	Get latest	Select version ∨

➢ Although it is better to work with the latest version, if you want to import your project into the lab PC, your tools versions should match.

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Key messages of STM32L4+ series

More performance and still ULP leader

ST has stretched the STM32L4 architecture to reach 150 MIPS based on its Arm Cortex-M4 core with FPU and ST ART Accelerator™ at 120 MHz while keeping best-in-class, ultra-low-power (ULP) figures.

More Graphics and Innovation

Enhanced graphics acceleration and innovative peripherals are embedded to optimize the BOM cost.

More Integration

2 MB of Flash and 640 KB of SRAM with safety and security features, smart and numerous peripherals, advanced and low power analog circuits in packages as small as 4.62 x 4.14 mm.
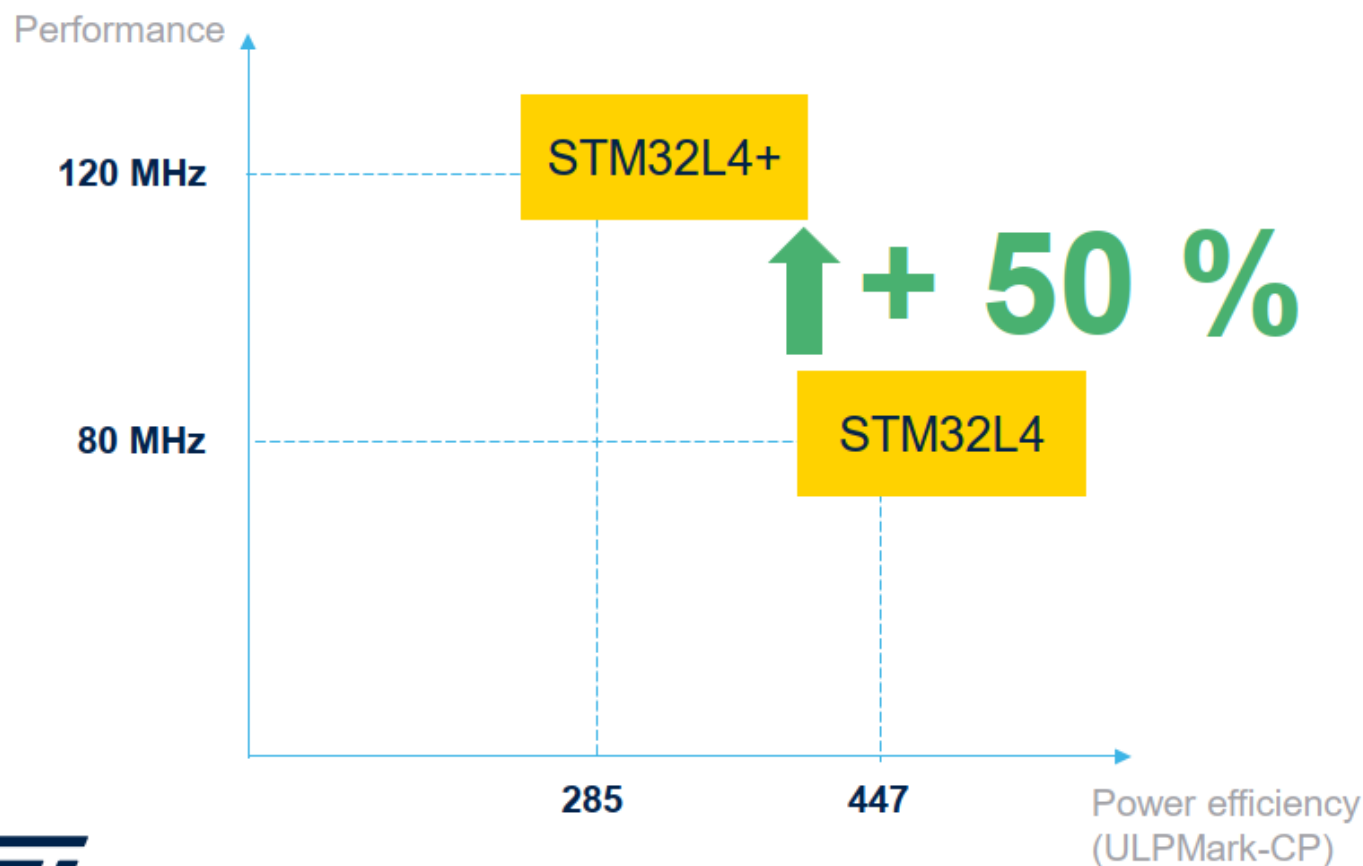
Great Investment

Great Investment This new STM32 member benefits from the pin-to-pin compatibility of the STM32 family and the STM32 Ecosystem.

Ref : "en.stm32l4plus_pres" document

Providing more performance

Stretching the performance and still excellent in Power consumption

- **Up to 120** MHz/ **150 DMIPS** with ART Accelerator™
- **Up to 409** CoreMark Result
- Arm® Cortex® -M4 with DSP instructions and floating-point unit (FPU)
- 2 x DMA (14 channels)
- SPI up to 60 Mbit/s, Octo-SPI up to 86 MHz USART up to 10 Mbit/s

Ref : "en.stm32l4plus_pres" document

Ultra-low-power modes

Best power consumption numbers with full flexibility

Wake-up time		
	V_BAT	3 nA / 300 nA*
250 µs	Shutdown	22 nA / 180 nA*
14 µs	Standby	42 nA / 190 nA*
14 µs	Standby + 8-Kbyte RAM	242 nA / 390 nA*
5 µs	Stop 2 (retention: 256-Kbyte RAM)	2.5 µA / 2.9 µA *
5 µs	Stop 2 (full retention: 640-Kbyte RAM)	3.9 µA / 4.3 µA*
6 cycles	Sleep	13 µA/MHz **
	Run up to 120 MHz	Down to 43 µA/MHz **

Tamper detection: 3 I/Os, RTC

Wake-up sources: reset pin, 5 I/Os, RTC

Wake-up sources: + BOR, IWDG

Wake-up sources: + all I/Os, PVD, LCD, COMPs, I²C, LPUART, LPTIM

Wake-up sources: + all I²C, UART

Wake-up sources: any interrupt or event

ULPBENCH™ An EEMBC Benchmark 285 ULPMark-CP

ULPBENCH™ An EEMBC Benchmark 60 ULPMark-PP

Note : * without RTC / with RTC
       ** with external SMPS

Ref : "en.stm32l4plus_pres" document

Smart peripherals metering

Digital Filter for Sigma Delta Modulators
8 x parallel inputs
with up to 24-bit data output resolution

ADC ΣΔ 24-bit

V_{BAT} **with RTC**
for battery backup
300 nA in V_{BAT} mode for RTC and
32x 32-bit backup registers

TRNG & AES
for Security
128-/256-bit AES
key encryption hardware accelerator

STM32L4+

Electricity/Gas / Water Smart Meter

LCD Display
SPI, Parallel or TFT Interface

Anti Tamper pin
3 x tamper pins
for battery domain

SPI / UART/ SDIO
for Wireless
3x SPIs (4x SPIs with the Quad SPI)
6x USARTs (ISO 7816, LIN, IrDA, modem)
1 x SDIO

FSMC
External memory interface
for static memories supporting SRAM,
PSRAM, NOR and NAND

I/Os
Up to 114 fast I/Os for buttons & relays

Ref : "en.stm32l4plus_pres" document

8

Smart peripherals
fitness tracker - wristband

Digital Filter for Sigma Delta Modulators
with PDM (Pulse Density Modulation) microphone input support

Batch Acquisition Mode (BAM)

Sensors

I²C
3x I²C FM+(1 Mbit/s), SMBus/PMBus

SPI / UART
3x SPIs (4x SPIs with the Quad SPI)
6x USARTs (ISO 7816, LIN, IrDA, modem)

STM32L4+

fitness tracker wristband

Display

FSMC
Parallel interface to TFT
SPI
Up to 60 MHz speed
MIPI DSI
Direct connection
Chrom-ART Accelerator™
Graphic Acceleration
Chrom-GRC™
SRAM needs reduction

USB
USB OTG 2.0
full-speed,
LPM and BCD

SAI
2x serial audio interfaces

DAC
2x 12-bit DAC,
low-power sample
and hold

ADC
2× 12-bit ADC 5 MSPS,
up to 16-bit with
hardware oversampling,
200 µA/MSPS

OPAMP
2x op amp
with
built-in PGA

Ref : "en.stm32l4plus_pres" document

9

Ref : "en.stm32l4plus_pres" document

Ref : "en.stm32l4plus_pres" document

Links :

STM32L4+ Discovery kit IoT node, low-power wireless
https://www.st.com/en/evaluation-tools/b-l4s5i-iot01a.html

STM32L4S5VI
https://www.st.com/en/microcontrollers-microprocessors/stm32l4s5vi.html

Schematic

https://www.st.com/en/evaluation-tools/b-l4s5i-iot01a.html#cad-resources

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wiki.st.com/stm32mpu

UM1884

https://www.st.com/resource/en/user_manual/dm00173145-description-of-stm32l4l4-hal-and-lowlayer-drivers-stmicroelectronics.pdf
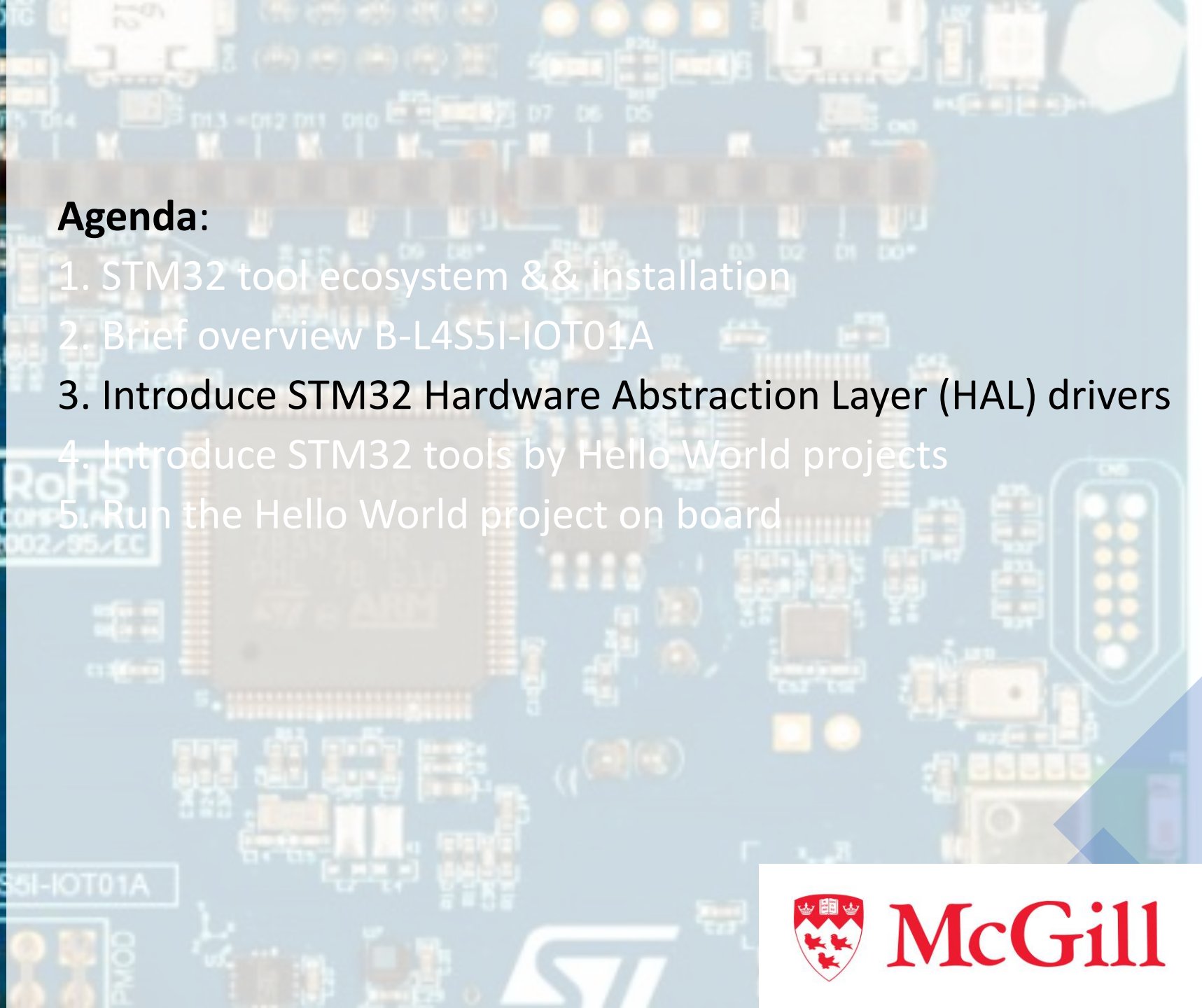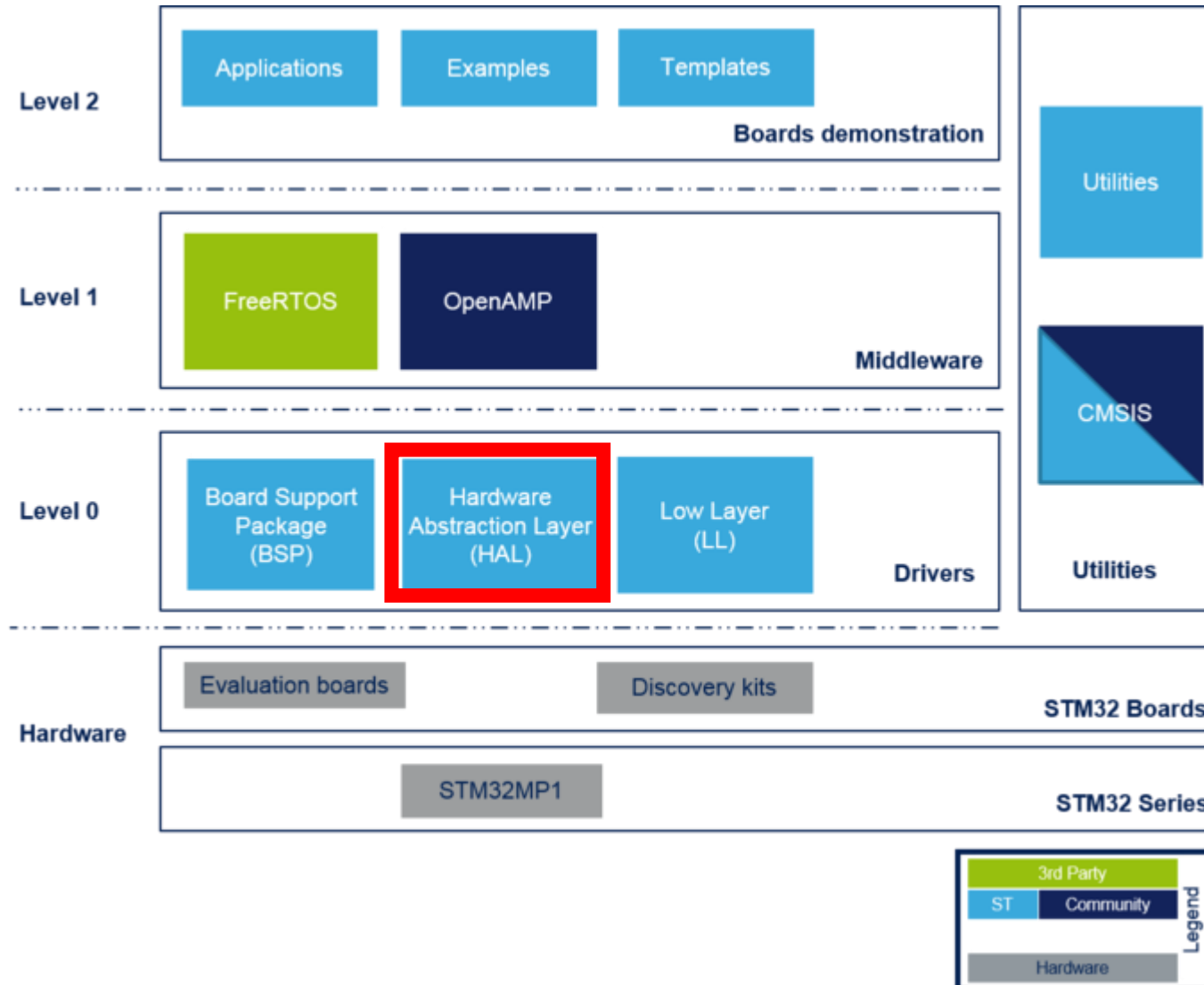
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STM32 CubeMX

File   Window   Help

Home > STM32L4S5VITx - B-L4S5I-IOT01A > Untitled - Pinout & Configuration >   GENERATE CODE

Pinout & Configuration   Clock Configuration   Project Manager   Tools

Software Packs   Pinout

Undo Mode and pinout   Ctrl-Z
Redo Mode and pinout   Ctrl-Y

Categories   A->Z   ☐ Keep Current Signals Placement   Ctrl-K
☑ Show User Label

System Core

Analog   Clear Pinouts   Ctrl-P

Timers   Pins/Signals Options...   Ctrl-O

Connectivity   List Pinout Compatible MCUs   Alt-L

Multimedia   Export pinout with Alt. Functions
Export pinout without Alt. Functions   Ctrl-U

Security   Reset used GPIOs   Alt-G
Set unused GPIOs   Ctrl-G

Computing   Pinout View Colors

Middleware   Layout reset

STM32L4S5VITx
LQFP100
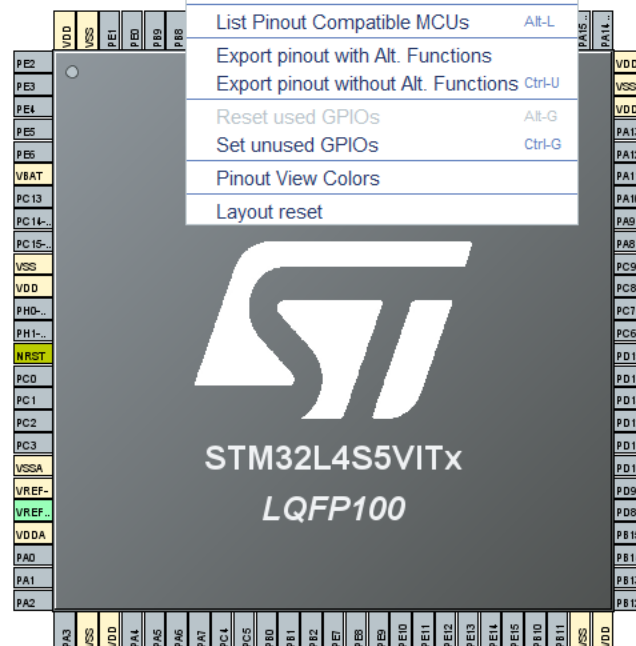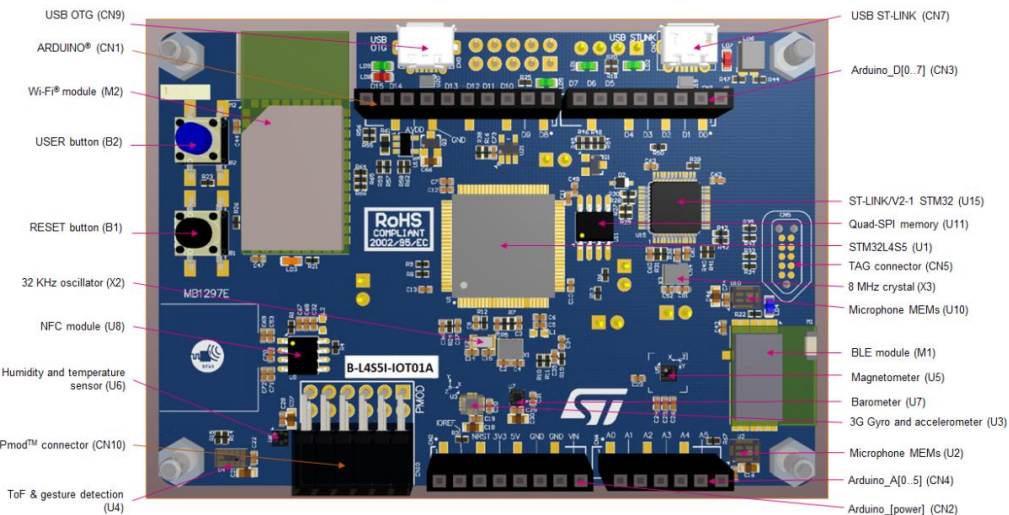
Table 4. Button and LED control port

Reference	Color	Name	Comment
B1	Black	Reset	-
B2	Blue	Wake-up	Wake-up alternate function
LD1	Green	LED1	PA5 (Alternate with ARD.D13)
LD2	Green	LED2	PB14
LD3	Yellow	LED3 (Wi-Fi®)	PC9, Wi-Fi® activity
LD4	Blue	LED4 (BLE)	PC9, Bluetooth® activity
LD5	Green	5V Power	5 V available
LD6	Bicolor (Red and green)	ST-LINK COM	Green during communication
LD7	Red	Fault Power	Current higher than 750 mA
LD8	Red	V_{BUS} OCRCR	PE3
LD9	Green	V_{BUS} OK	5 V USB available

STM32CubeMX LED_Button.ioc: STM32L4S5VITx B-L4S5I-IOT01A

File   Window   Help

STM32
CubeMX

Home   STM32L4S5VITx - B-L4S5I-IOT01A   LED_Button.ioc - Pinout & Configuration   GENERATE CODE
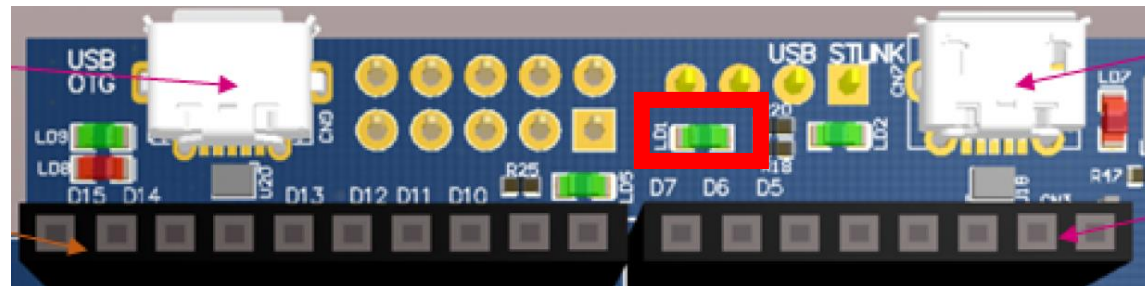
Pinout & Configuration   Clock Configuration   Project Manager   Tools

∨ Software Packs   ∨ Pinout

GPIO Mode and Configuration

Pinout view   System view

Configuration

Categories   A->Z

System Core

Group By Peripherals

GPIO

DMA
GPIO
IWDG
NVIC
RCC
SYS
TSC
WWDG

Search Signals

Search (Crtl+F)   ☐ Show only Modified Pins

Pi...	Signal...	GPIO ...	GPIO ...	GPIO ...	Maxi...	Fast ...	User L...	Modified
PA5	n/a	Low	Outpu...	No pu...	Low	n/a	myLed	☑
PC13	n/a	n/a	Input ...	No pu...	n/a	n/a	myBu...	☑
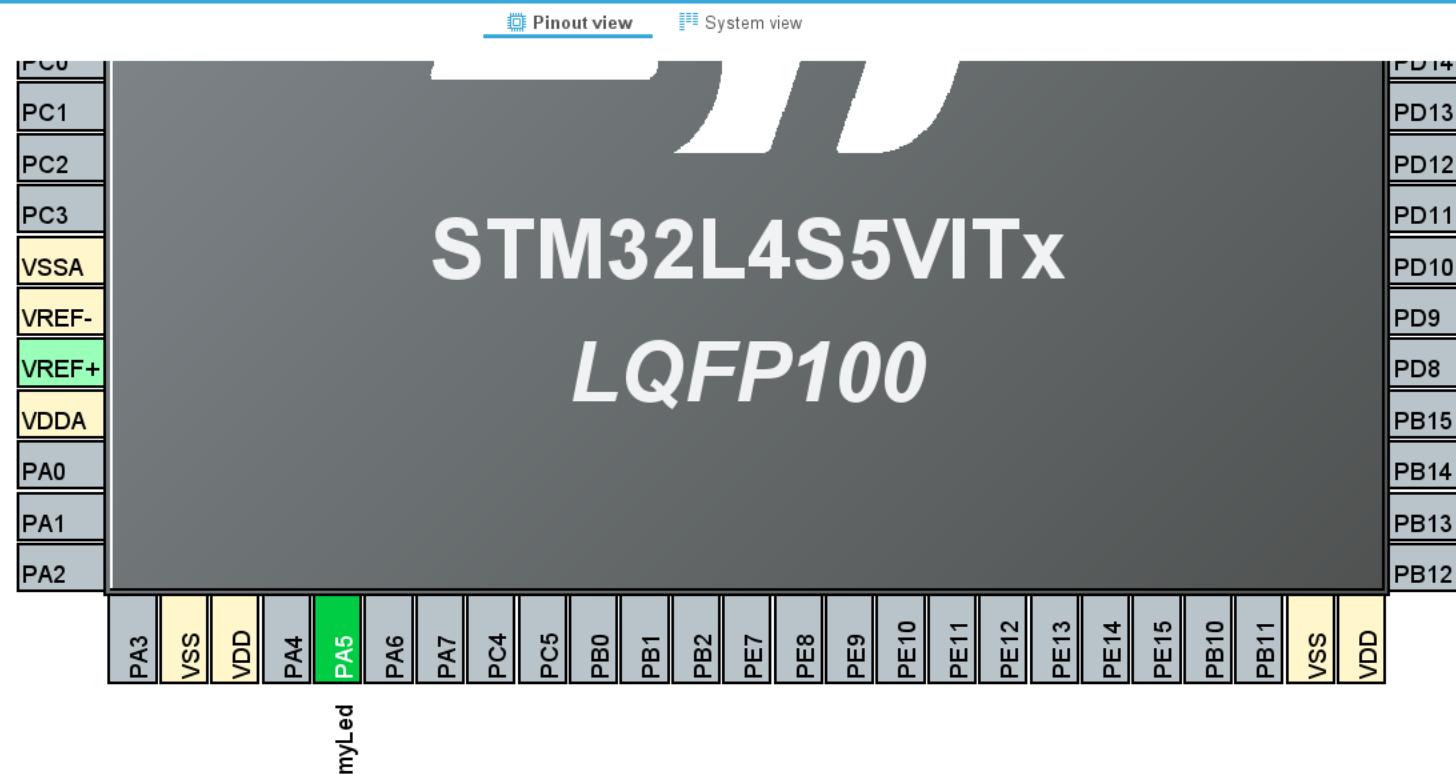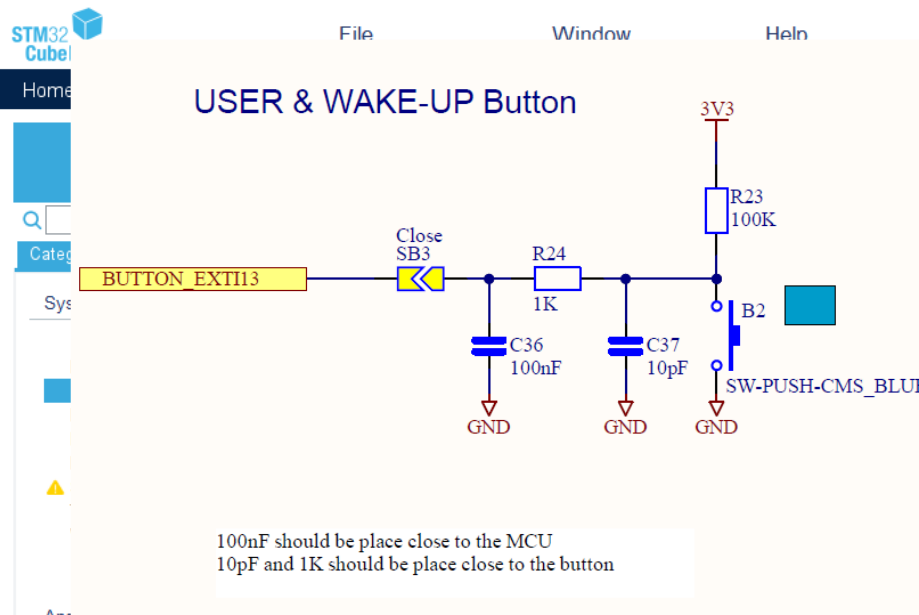
Analog

Timers

Connectivity

Multimedia

Security

Computing

Middleware

Select Pins from table to configure them. Multiple selection is Allowed.

PC0
PC1
PC2
PC3
VSSA
VREF-
VREF+
VDDA
PA0
PA1
PA2

STM32L4S5VITx
LQFP100

PD14
PD13
PD12
PD11
PD10
PD9
PD8
PB15
PB14
PB13
PB12

PA3 VSS VDD PA4 PA5 PA6 PA7 PC4 PC5 PB0 PB1 PB2 PE7 PE8 PE9 PE10 PE11 PE12 PE13 PE14 PE15 PB10 PB11 VSS VDD

myLed

STM32 Cube

File   Window   Help

Home

Configuration

Software Packs

USER & WAKE-UP Button

3V3

R23
100K

Close
SB3

BUTTON_EXTI13

R24
1K

C36
100nF

C37
10pF

B2

SW-PUSH-CMS_BLUE

GND   GND   GND

100nF should be place close to the MCU
10pF and 1K should be place close to the button

Table 13. B-L4S5I-IOT01A Discovery kit for the IoT node I/O assignment

Pin number	Pin name	Feature / comment	Signal / label
1	PE2	GPIO_Output	ST25DV04K RF_DISABLE
2	PE3	GPIO_EXTI3	USB_OTG_OVRCR_EXTI3
3	PE4	GPIO_EXTI4	ST25DV04K GPO
4	PE5	GPIO_EXTI5	SPSGRF-915-GPIO3_EXTI5
5	PE6	GPIO_EXTI6	SPBTLE-RF-IRQ_EXTI6
7	PC13	GPIO_EXTI13	BUTTON_EXTI13
9	PC15 / OSC32_OUT	RTC CLK	RCC_OSC32_OUT
10	V_SS	GND	GND

PD3 PD2

PE4
PE5
PE6
VBAT
myButton PC13
PC14..
PC15..
VSS
VDD
PH0-..
PH1-..

Analog
Timers
Connectivity
Multimedia
Security
Computing
Middleware

Select Pins from table to configure them. **Multiple selection is Allowed.**

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ECSE 444 - Microprocessor -Winter 2023

STM32 CubeMX

File   Window   Help

Home > STM32L4S5VITx - B-L4S5I-IOT01A > Untitled - Project Manager > **GENERATE CODE**

Pinout & Configuration	Clock Configuration	Project Manager	Tools

Project

Project Settings
Project Name
LED_Button

Project Location
C:\Users\shahab\Desktop\TA winter 2022\Lab   Browse

Application Structure
Basic   ☐ Do not generate the main()

Toolchain Folder Location
C:\Users\shahab\Desktop\TA winter 2022\Lab\LED_Button\

Code Generator

Toolchain / IDE
STM32CubeIDE

Linker Settings
Minimum Heap Size   0x200
Minimum Stack Size   0x400

Advanced Settings

Thread-safe Settings
Cortex-M4NS
☐ Enable multi-threaded support
Thread-safe Locking Strategy
Default – Mapping suitable strategy depending on RTOS selection.

Mcu and Firmware Package
Mcu Reference
STM32L4S5VITx

Firmware Package Name and Version
STM32Cube FW_L4 V1.17.1   ☑ Use latest available version

☑ Use Default Firmware Location
C:/Users/shahab/STM32Cube/Repository/STM32Cube_FW_L4_V1.17.1   Browse

---

Code Generation   ✕

ⓘ   The Code is successfully generated under :

C:/Users/shahab/Desktop/TA winter 2022/Lab/LED_Button

Project language : C

Open Folder   Open Project   Close

ECSE 444 - Microprocessor -Winter 2023

File   Edit   Source   Refactor   Navigate   Search   Project   Run   Window   Help

Project Explorer

- B-L475E-IOT01
- blinky
- Lab1
- Lab2
- Lab2_1
- lab3
- lab4
- lab5
- lab6
- Lab7
- LED_Button
  - Includes
  - Drivers
  - Src
    - main.c
    - stm32l4xx_hal_msp.c
    - stm32l4xx_hal_timebase_tim.c
    - stm32l4xx_it.c
    - syscalls.c
    - sysmem.c
    - system_stm32l4xx.c
  - Startup
  - Inc
  - LED_Button.ioc
  - STM32L4S5VITX_FLASH.ld
  - STM32L4S5VITX_RAM.ld
- project0
- uart_project

main.c

```c
1  /* USER CODE BEGIN Header */
2  /**
3   ******************************************************************
4   * @file           : main.c
5   * @brief          : Main program body
6   ******************************************************************
7   * @attention
8   *
9   * <h2><center>&copy; Copyright (c) 2022 STMicroelectronics.
10  * All rights reserved.</center></h2>
11  *
12  * This software component is licensed by ST under BSD 3-Clause license,
13  * the "License"; You may not use this file except in compliance with the
14  * License. You may obtain a copy of the License at:
15  *                        opensource.org/licenses/BSD-3-Clause
16  *
17  ******************************************************************
18  */
19  /* USER CODE END Header */
20  /* Includes ------------------------------------------------------*/
21  #include "main.h"
22
23  /* Private includes ----------------------------------------------*/
24  /* USER CODE BEGIN Includes */
25
26  /* USER CODE END Includes */
27
28  /* Private typedef -----------------------------------------------*/
29  /* USER CODE BEGIN PTD */
30
31  /* USER CODE END PTD */
32
33  /* Private define ------------------------------------------------*/
34  /* USER CODE BEGIN PD */
35  /* USER CODE END PD */
36
37  /* Private macro -------------------------------------------------*/
38  /* USER CODE BEGIN PM */
39
40  /* USER CODE END PM */
41
42  /* Private variables ---------------------------------------------*/
43
```

Outline   Build Targets

- main.h
- SystemClock_Config(void) : void
- MX_GPIO_Init(void) : void
- main(void) : int
- SystemClock_Config(void) : void
- MX_GPIO_Init(void) : void
- HAL_TIM_PeriodElapsedCallback(TIM_HandleTypeDef*) : void
- Error_Handler(void) : void
- assert_failed(uint8_t*, uint32_t) : void

Problems   Tasks   Console   Properties

No consoles to display at this time.

B...   St...   S...   S...   S...   In...   C...   Se...

No search results available. Start a search from the search dialog...

Writable   Smart Insert   25 : 1 : 1008

```c
/* USER CODE BEGIN 2 */
  char status = 0;
 /* USER CODE END 2 */
 /* Infinite loop */
 /* USER CODE BEGIN WHILE */
 while (1)
 {
    /* USER CODE END WHILE */

    /* USER CODE BEGIN 3 */
 status = HAL_GPIO_ReadPin(myButton_GPIO_Port, myButton_Pin);
 if (status == 0)
 HAL_GPIO_WritePin(myLed_GPIO_Port, myLed_Pin, GPIO_PIN_SET);
 else
 HAL_GPIO_WritePin(myLed_GPIO_Port, myLed_Pin, GPIO_PIN_RESET);
 }
 /* USER CODE END 3 */
}
```
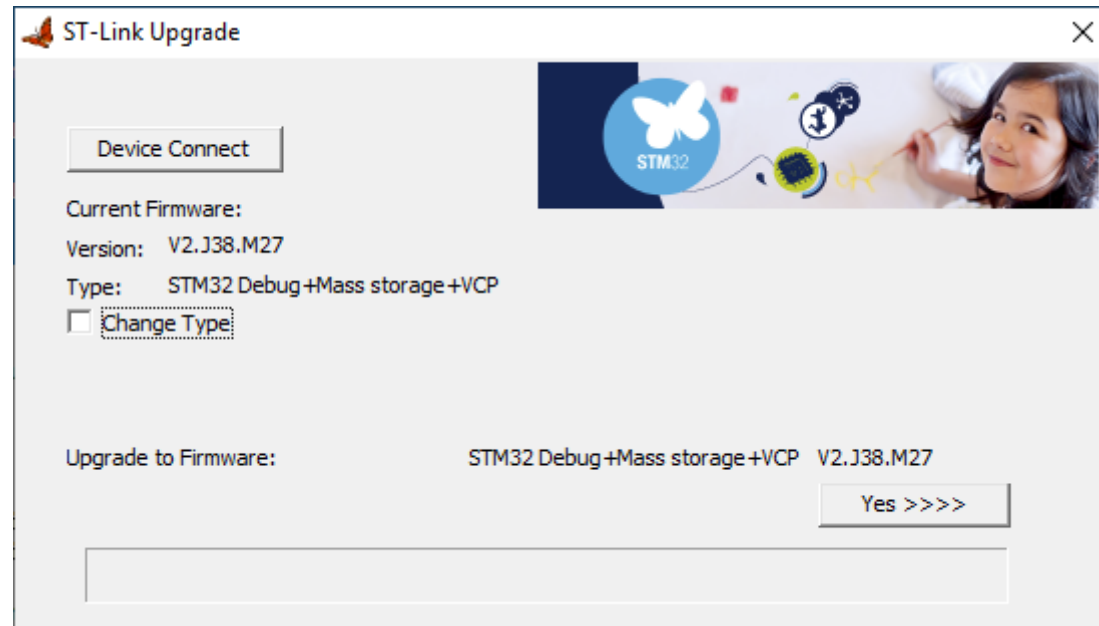
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File   Edit   Source   Refactor   Navigate   Search   Project   Run   Window   Help

Project Explorer

- B-L475E-IOT01
- blinky
- Lab1
- Lab2
- Lab2_1
- lab3
- lab4
- lab5
- lab6
- Lab7
- LED_Button
  - Binaries
  - Includes
  - Drivers
  - Src
    - main.c
    - stm32l4xx_hal_msp.c
    - stm32l4xx_hal_timebase_tim.c
    - stm32l4xx_it.c
    - syscalls.c
    - sysmem.c
    - system_stm32l4xx.c
  - Startup
  - Debug
  - Inc
  - LED_Button.ioc
  - LED_Button Debug.launch
  - STM32L4S5VITX_FLASH.ld
  - STM32L4S5VITX_RAM.ld
- project0
- uart_project

```c
 80     SystemClock_Config();
 81
 82     /* USER CODE BEGIN SysInit */
 83
 84     /* USER CODE END SysInit */
 85
 86     /* Initialize all configured peripherals */
 87     MX_GPIO_Init();
 88     /* USER CODE BEGIN 2 */
 89     char status = 0;
 90     /* USER CODE END 2 */
 91     /* Infinite loop */
 92     /* USER CODE BEGIN WHILE */
 93     while (1)
 94     {
 95       /* USER CODE END WHILE */
 96
 97       /* USER CODE BEGIN 3 */
 98         status = HAL_GPIO_ReadPin(myButton_GPIO_Port, myButton_Pin);
 99         if (status == 0)
100             HAL_GPIO_WritePin(myLed_GPIO_Port, myLed_Pin, GPIO_PIN_SET);
101         else
102             HAL_GPIO_WritePin(myLed_GPIO_Port, myLed_Pin, GPIO_PIN_RESET);
103     }
104     /* USER CODE END 3 */
105 }
106
107 /**
108   * @brief System Clock Configuration
109   * @retval None
110   */
111 void SystemClock_Config(void)
112 {
113   RCC_OscInitTypeDef RCC_OscInitStruct = {0};
114   RCC_ClkInitTypeDef RCC_ClkInitStruct = {0};
115
116   /** Configure the main internal regulator output voltage
117   */
118   if (HAL_PWREx_ControlVoltageScaling(PWR_REGULATOR_VOLTAGE_SCALE1_BOOST) != HAL_OK)
119   {
120     Error_Handler();
121   }
122   /** Initializes the RCC Oscillators according to the specified parameters
```

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- main.h
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- MX_GPIO_Init(void) : void
- main(void) : int
- SystemClock_Config(void) : void
- MX_GPIO_Init(void) : void
- HAL_TIM_PeriodElapsedCallback(TIM_HandleTypeDef*) : void
- Error_Handler(void) : void
- assert_failed(uint8_t*, uint32_t) : void

Problems   Tasks   Console   Properties

<terminated> LED_Button Debug [STM32 Cortex-M C/C++ Application] ST-LINK (ST-LINK GDB server) (Terminated Jan 16, 2022, 5:02:44 PM)

Verifying ...

Download verified successfully

ger connection lost.
ing down...

No search results available. Start a search from the search dialog...

Writable   Smart Insert   87 : 18 : 2512

GOODBYE

Image source : www.mtlblog.com/