

Simplifying Motion MEMS and Environmental Sensors Design Using the STM32CubeMX and the X-CUBE-MEMS1 Software Pack (Hands-On Workshop)

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Technology Tour 2019

Vancouver, BC | September 24



Required HW

2

- **Laptop with USB type A**
- **64 bit OS** Win (7, 10), MacOS, Linux (Generic, Debian, RPM)
 - Virtual Machine is also OK (example: Parallel, VM Fusion...)
 - **Administration rights** are required for SW tools installation

Developing with Sensors Made Simple

Hands-On

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- USB Flash drive with relevant material for the hands-on
- **Please copy** the content of the USB drive on your laptop




**Please return it at the
end of the workshop**



Agenda

4

- Introduction
 - Products & Ecosystem
 - Hands-on Training Session
 - Installation Process
 - STM32CubeMX libraries installation
 - STM32CubeIDE installation
 - Tera Term installation
 - Hardware Description
 - Lab Examples: 
- **Lab 0** - Read all sensors in polling mode
 - **Lab 1** - LIS2DW12 accelerometer orientation change detection
 - **Lab 2** - LPS22HH barometer read from internal FIFO
 - **Lab 3** - LSM6DSO accelerometer embedded step counter
 - **Lab 4** - LIS2DW12 accelerometer acceleration detection
 - **Lab 5** - LSM6DSO accelerometer single/double tap detection
 - **Lab 6** - LSM6DSO accelerometer 6.6 kHz data rate read at 100 Hz

ST Addresses Four End Markets

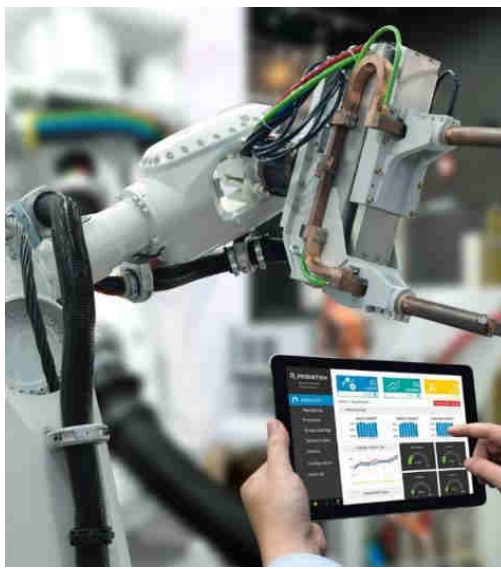
5

Automotive

Industrial

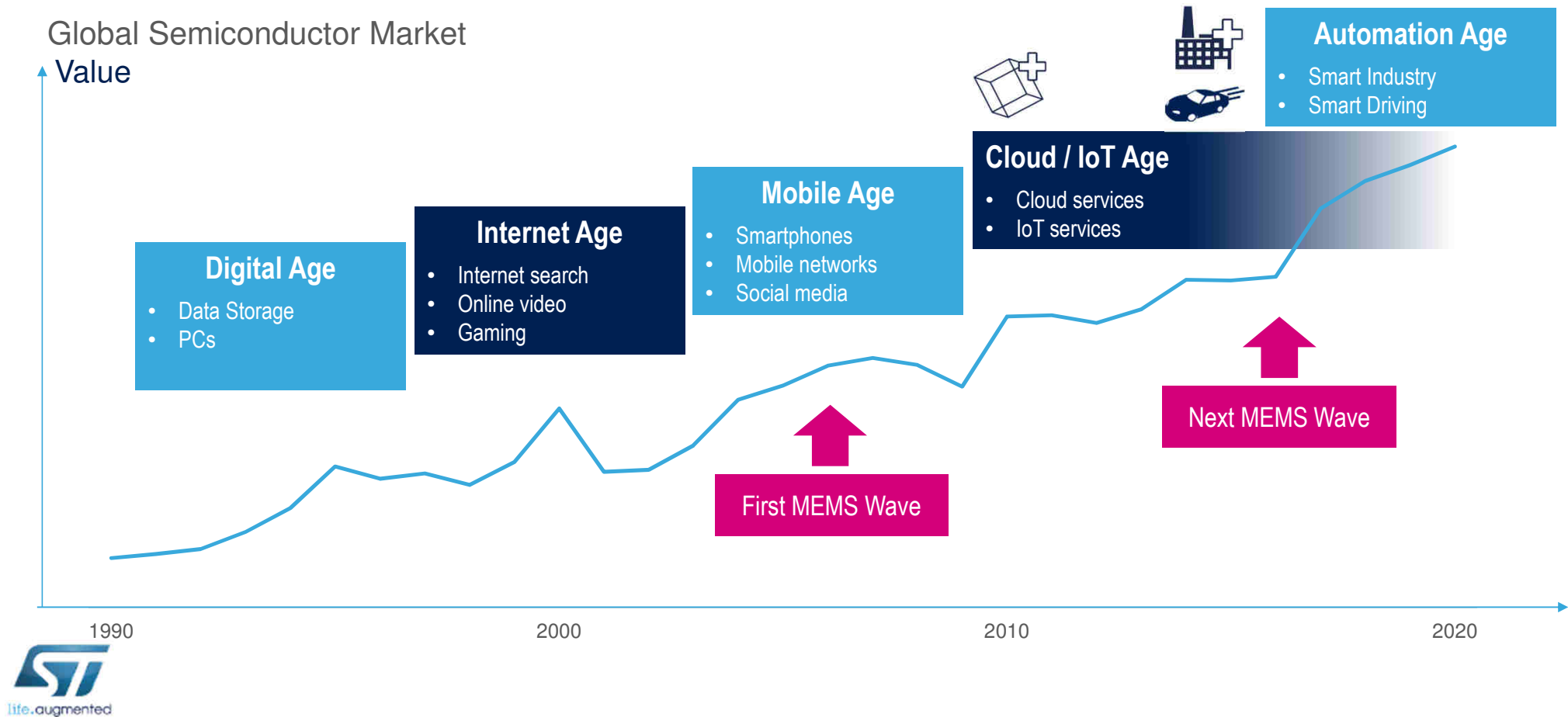
Personal Electronics

Communications
Equipment,
Computers & Peripherals



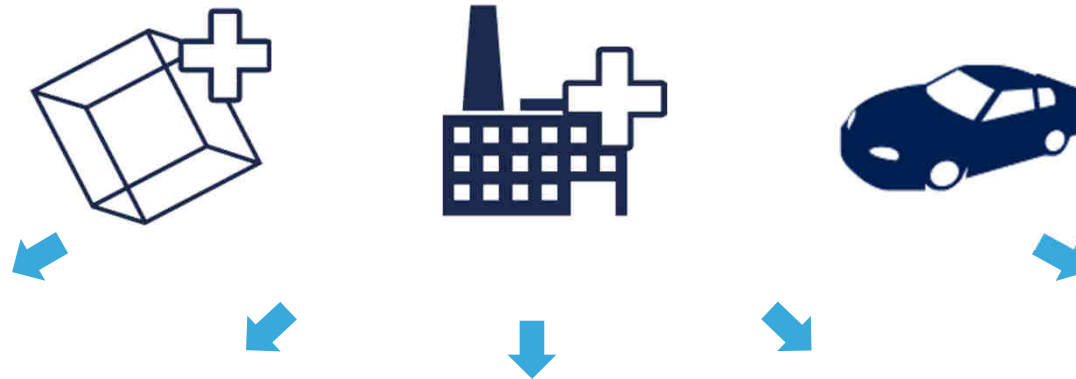
Sensors Trends

6



Sensors Evolution

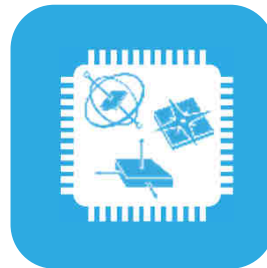
7



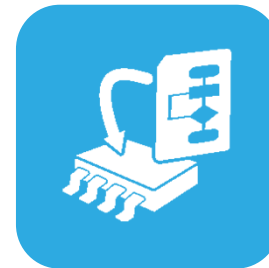
Technologies
Manufacturing



Accuracy
Stability



Multi Sensors
Integration



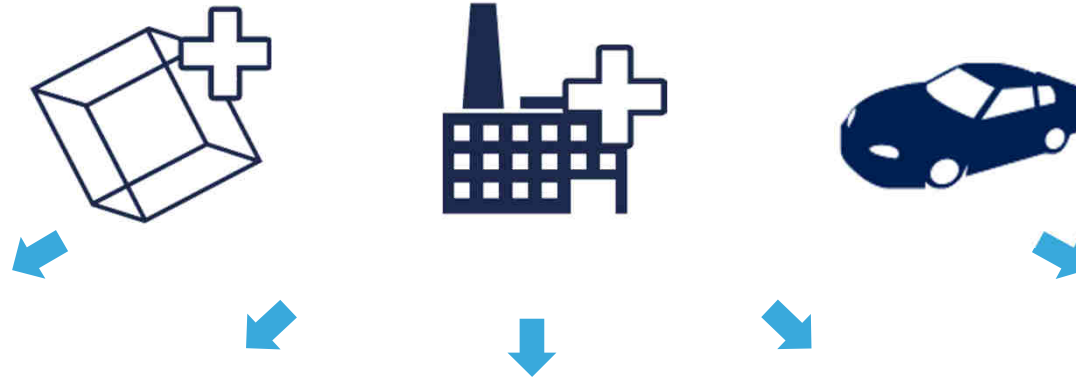
Embedded
Smart Functions



Low Power
Always ON

Sensors Evolution

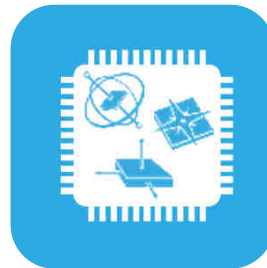
8



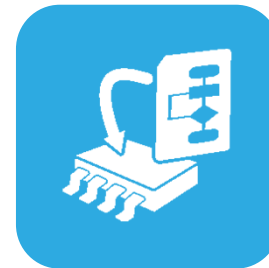
17 Billion Units
Shipped



+83%
Temp. Stability



-70%
size reduction



Embedded
FSM and Dec. Tree



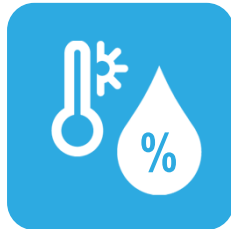
-91%
Current Consumption

Broad Sensors Portfolio

9



Motion



Environment



Interactivity



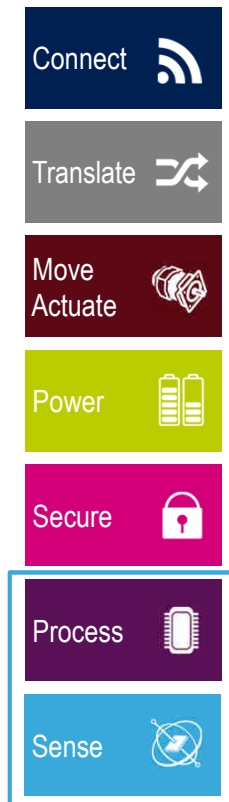
Micro-Actuators



Optical

ST: Products & Ecosystem

10



Sensor Tile



ProfiMEMS



STM32 Nucleo Development & Expansion boards

Pre-integrated SW for vertical applications



Smart Things



Smart Home



Smart City



Smart Industry

Development Ecosystem



Code generators



Prototyping software



Development environments



Debug solutions



Simulation and analysis tools



On-line design tools



Developing with Sensors

11

Complicated

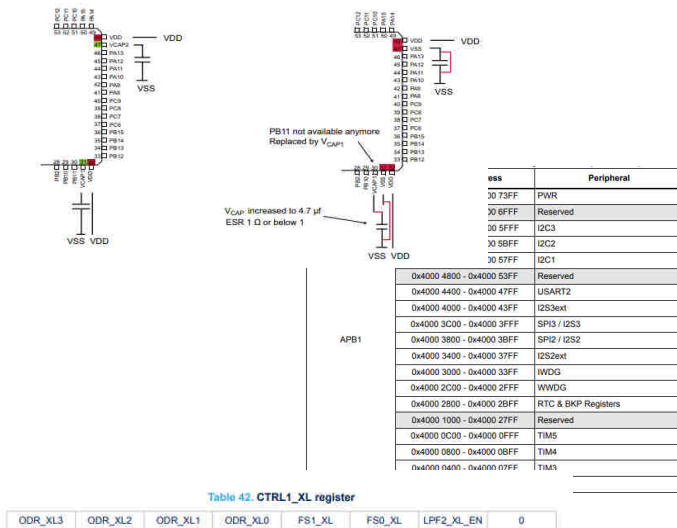


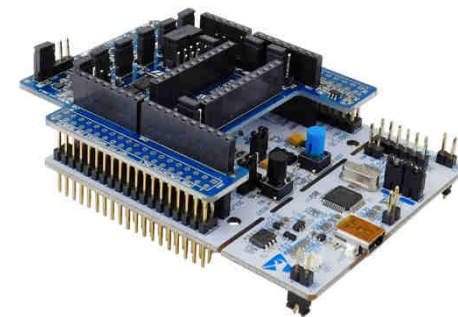
Table 42. CTRL1_XL register

ODR_XL3	ODR_XL2	ODR_XL1	ODR_XL0	FS1_XL	FS0_XL	LPF2_XL_EN	0
---------	---------	---------	---------	--------	--------	------------	---

Table 43. CTRL1_XL register description

ODR_XL[3:0]	Accelerometer ODR selection (see Table 44)
FS1[1:0]_XL	Accelerometer full-scale selection (see Table 45)
	Accelerometer high-resolution selection
LPF2_XL_EN	(0: output from first stage digital filtering selected (default); 1: output from LPF2 second filtering stage selected)

Simple

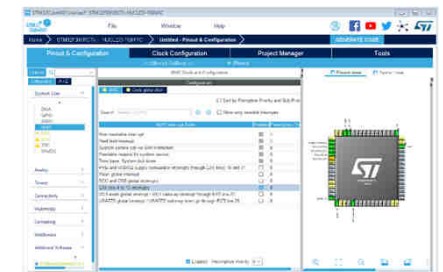
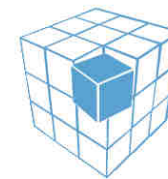


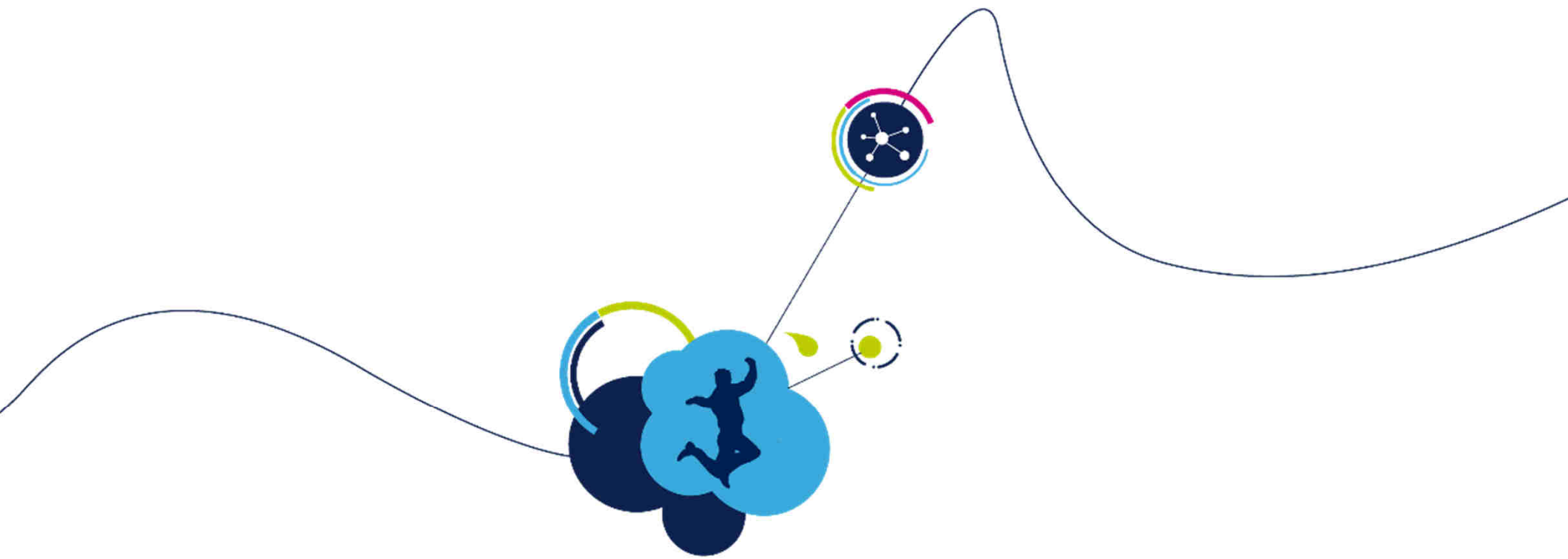
HW

Nucleo + X-Nucleo

SW

STM32CubeIDE + STM32CUBEMX + X-CUBE-MEMS1



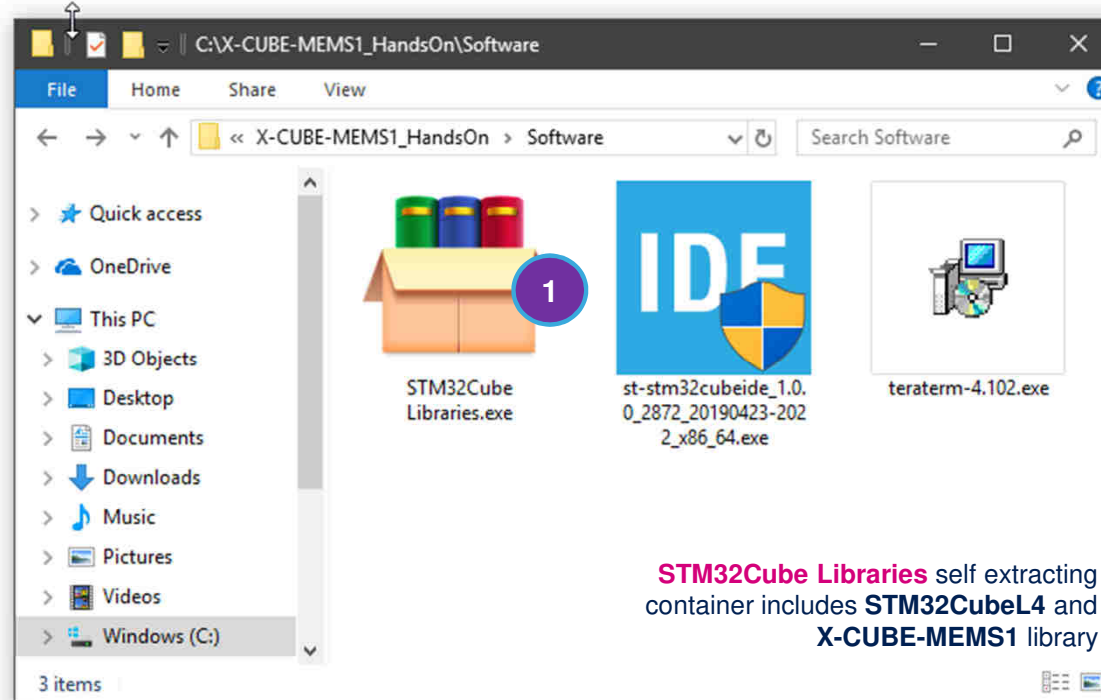


STM32CubeMX Libraries Installation

STM32CubeMX Libraries Installation

13

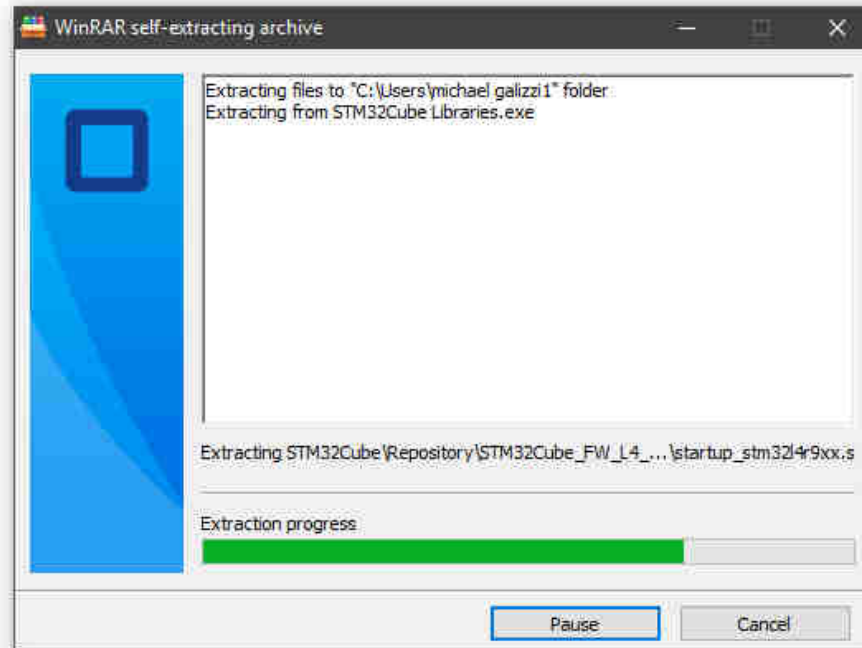
1. Run the **STM32Cube Libraries.exe** self-extracting archive located in **X-CUBE-MEMS1_HandsOn\Software**



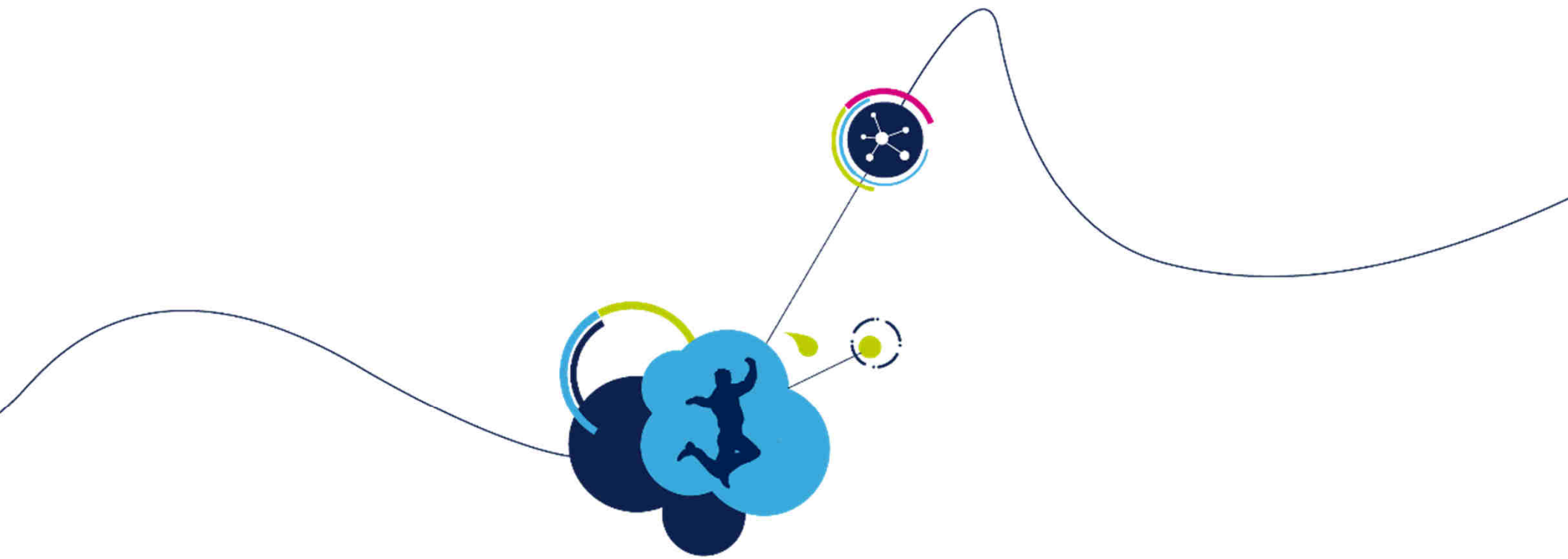
STM32CubeMX Libraries Installation

14

1. Library extraction may take few minutes.
Please wait the library to be fully extracted before proceed any further.



Meantime we'll proceed to install and configure STM32CubeIDE

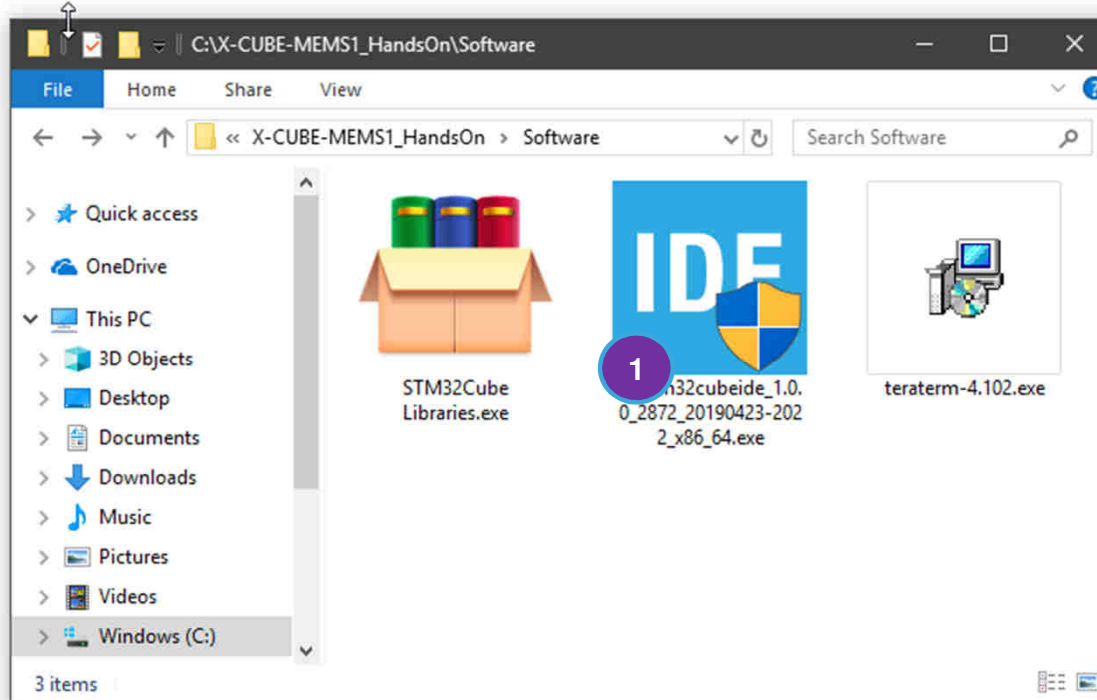


STM32CubeIDE Installation

STM32CubeIDE Installation

16

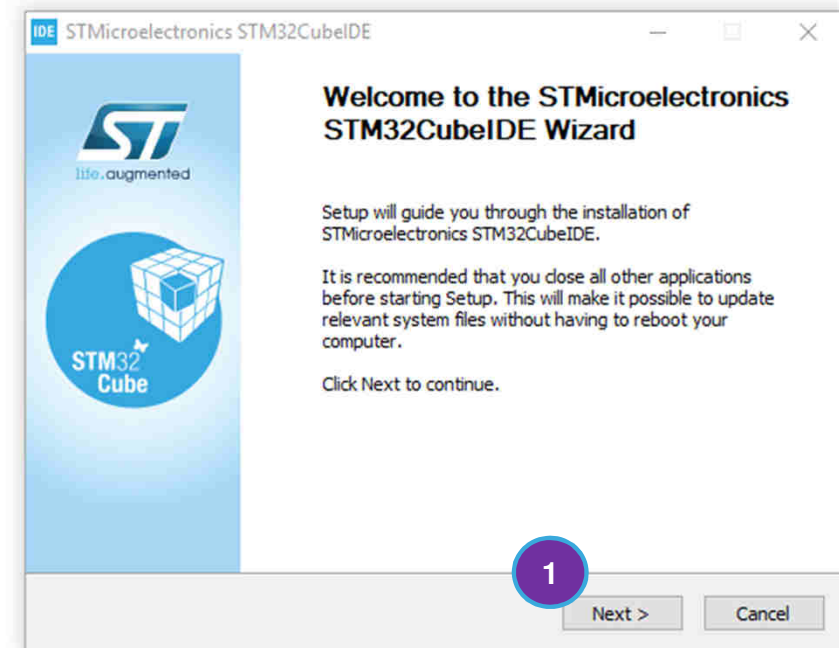
1. Run the **STM32CubeIDE** installer located in **X-CUBE-MEMS1_HandsOn\Software**



STM32CubeIDE Installation

17

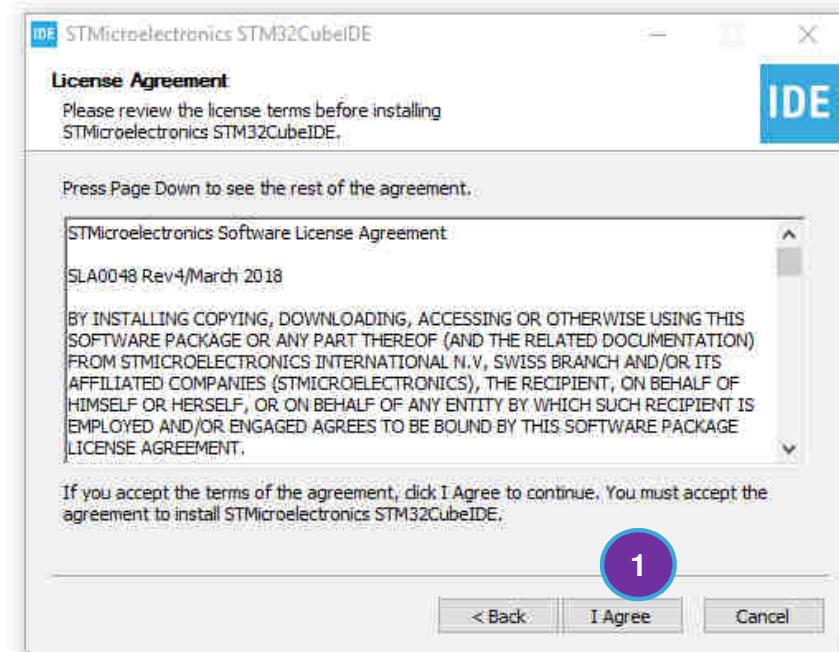
1. Click **Next >**



STM32CubeIDE Installation

18

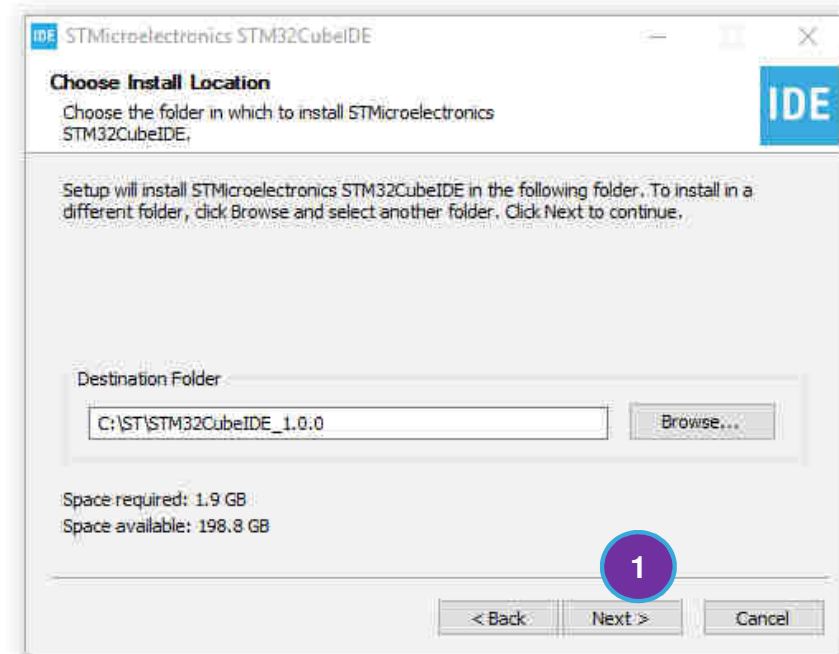
1. Click **I Agree**



STM32CubeIDE Installation

19

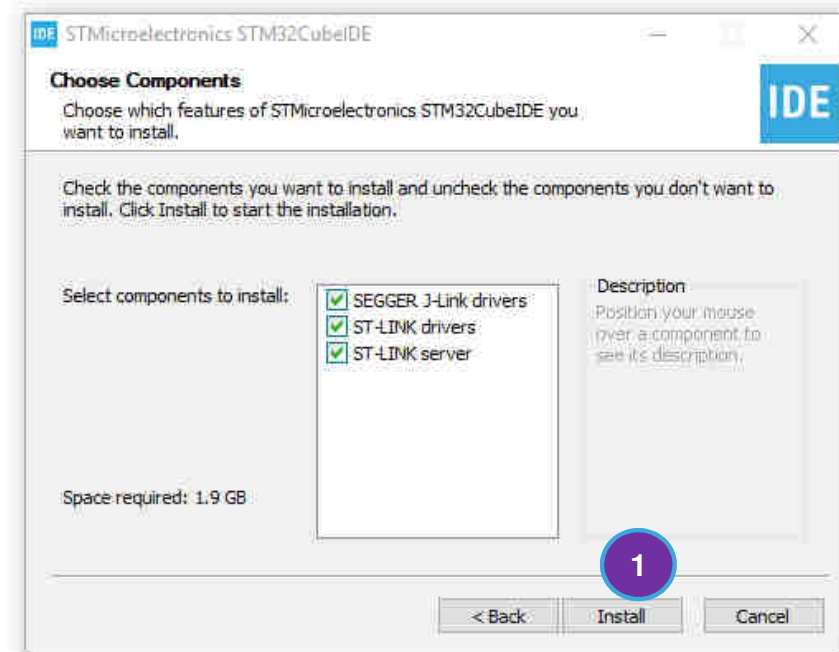
1. Click **Next >**



STM32CubeIDE Installation

20

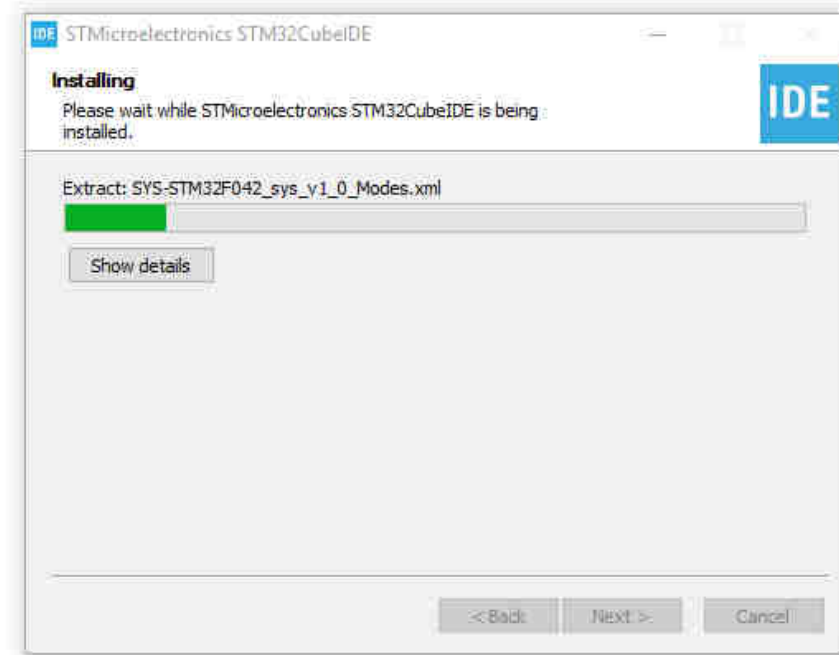
1. Click **Install**

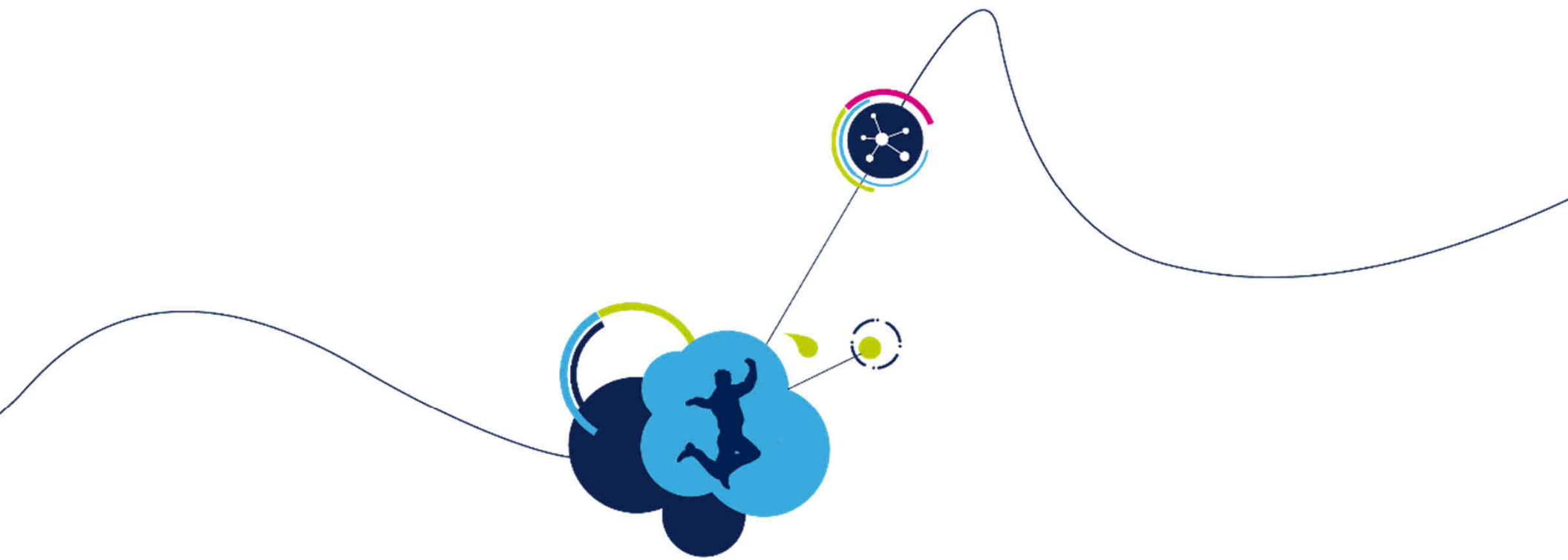


STM32CubeIDE Installation...

21

1. Wait until installation is completed



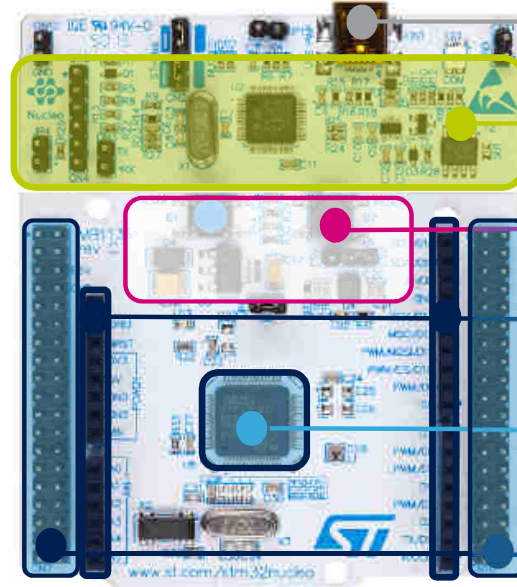
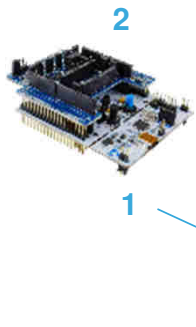


STM32 Nucleo Expansion

HW #1: STM32 NUCLEO Board

Microcontroller

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Flexible board power supply :
through USB or external source

Integrated ST-Link/V2-1:
mass storage device flash programming

2 push buttons, 2 color Leds

Arduino extension connectors :
easy access to add-ons

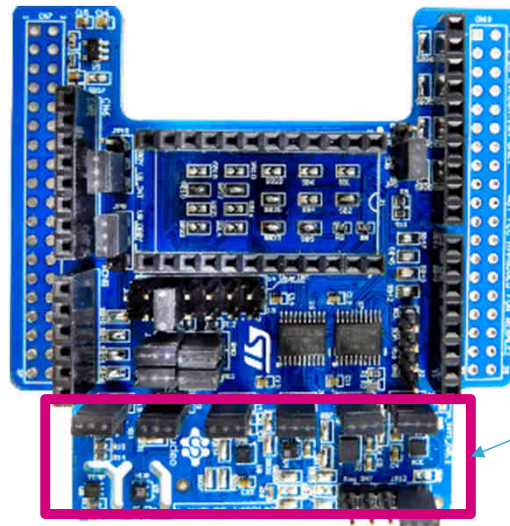
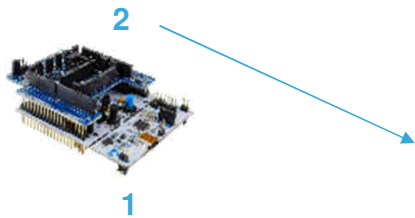
STM32 MCU (NUCLEO-L476RG)

Morpho extension headers :
direct access to all MCU I/Os

HW #2: X-NUCLEO-IKS01A3 Board

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Motion MEMS and environmental sensor



Accelerometer:
LIS2DW12



Accel. + Gyro:
LSM6DSO



Pressure:
LPS22HH



Temperature:
STTS751



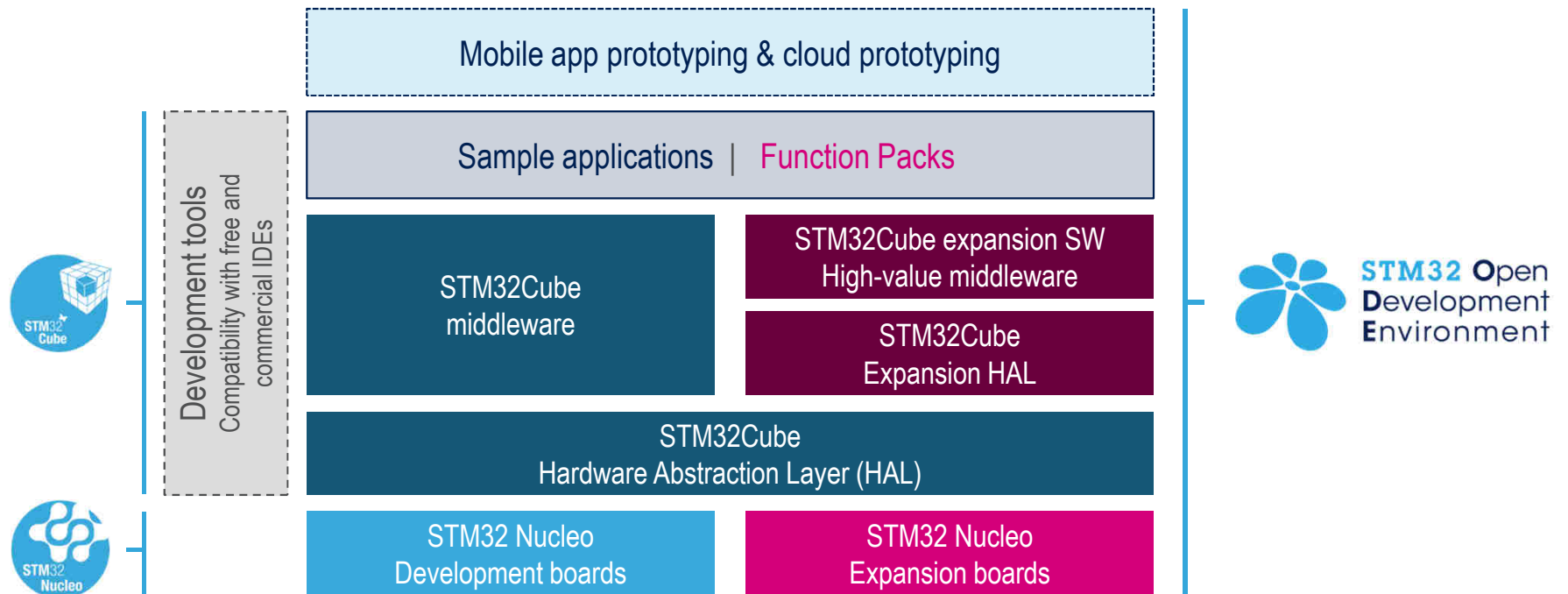
Humidity:
HTS221



Magnetometer:
LIS2MDL

Development Software Architecture

25



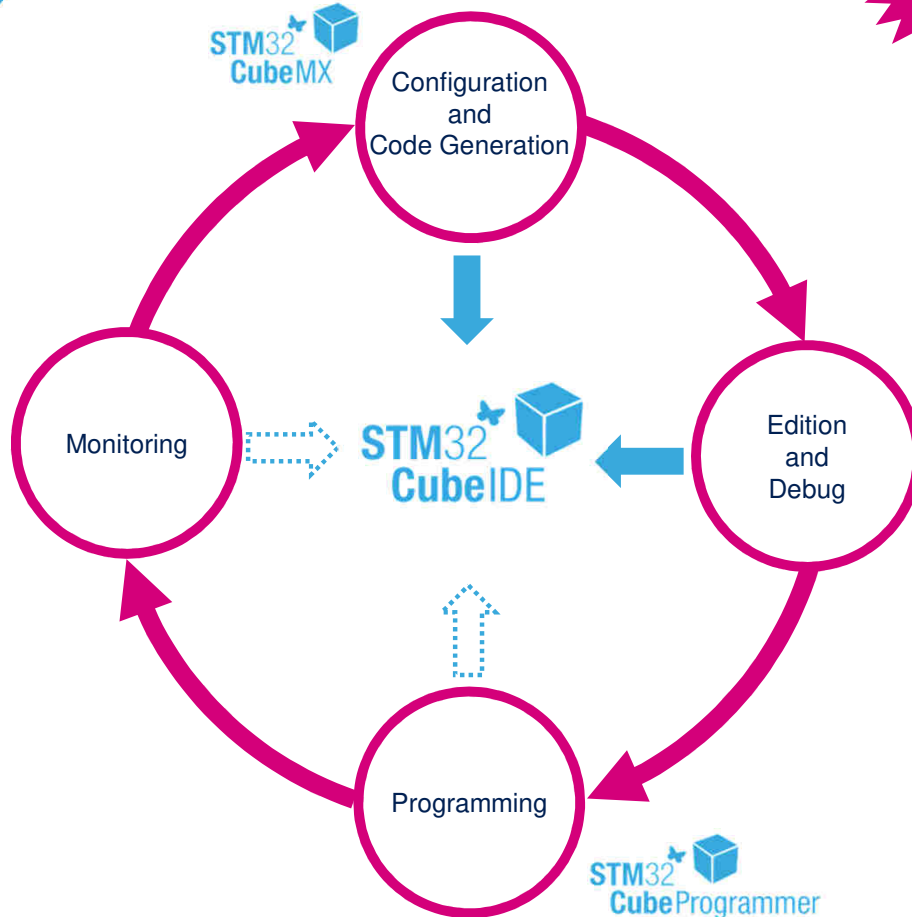
STM32 Supported IDEs

26



STM32 IDEs





STM32CubeIDE

as **FREE** turn-1 Development Tool

27

Complete multi platform family tools

Cover full development cycle

Integrated solution



Software Development Tools

28



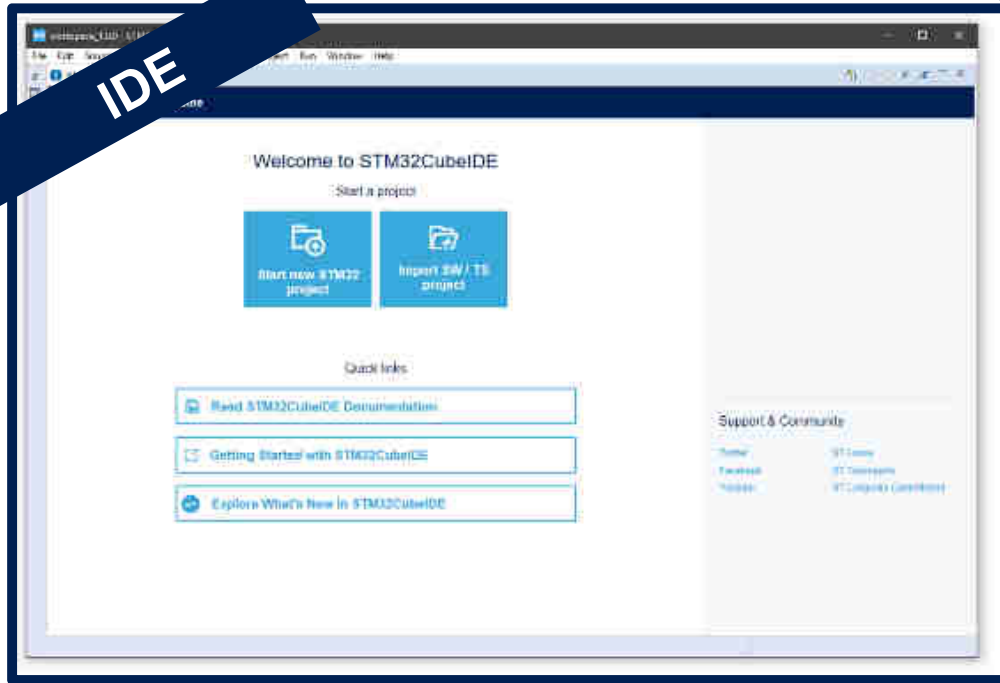
“STM32CubeIDE”
development environment

↳ **“STM32CubeMX”**
initialization code generator

↳ **“X-CUBE-MEMS1”**
application code and drivers for sensors

STM32CubeIDE

an All-in-1 Development Tool



Dedicated IDE for all STM32 microcontrollers

STM32CubeMX is natively integrated as code generator

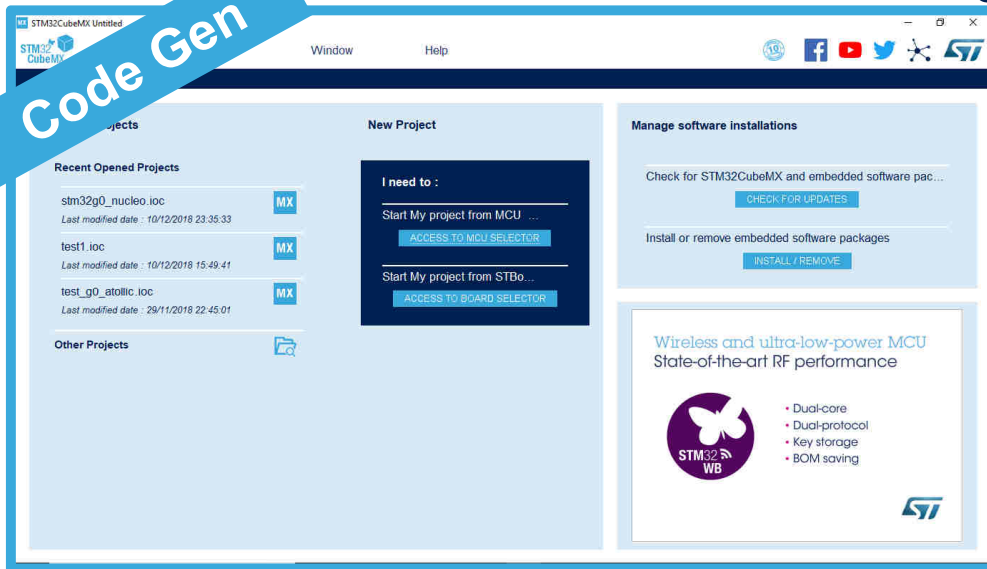
Based on Eclipse (Text editor), GCC (compiler) and GDB (debugger)



STM32CubeMX

an All-in-1 Development Tool

Code Gen



Very powerful configuration and code generation

Support all STM32 MCU and MPU, with integrated powerful Finder

Pinouts, clock tree, peripherals and middleware configuration.

Expandable to support wireless connectivity, sensors and much more!



STM32CubeL0



STM32CubeL1



STM32CubeL4



STM32CubeF1



STM32CubeF3



STM32CubeF2



STM32CubeF4



STM32CubeG0



STM32CubeF0



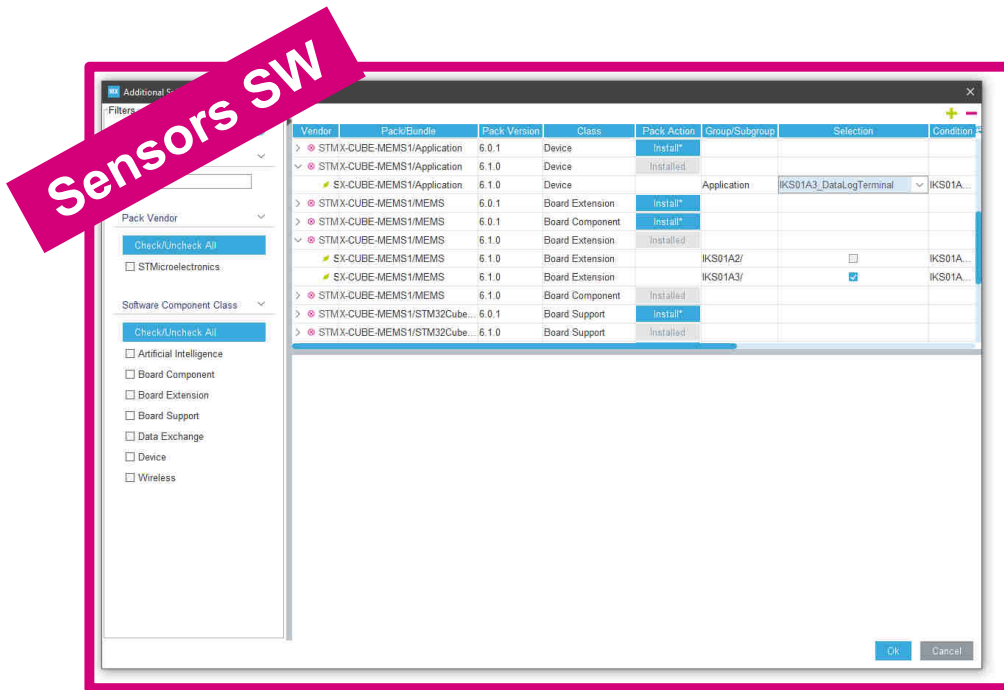
STM32CubeF7



STM32CubeH7



STM32 X-CUBE-MEMS1 an All-in-1 Development Tool



Drivers for sensors

Board Support Package firmware architecture

Include Sample Applications



Accelerometer



Inertial module



Magnetometer



Gyroscope



Pressure Sensor



Temperature Sensor



Humidity sensor

X-CUBE-MEMS1

an All-in-1 Development Tool

Sample Applications

- Data Logging on Terminal All Sensors



Accelerometer

6D Orientation, Wake Up, Self Test



Magnetometer

Self Test



Pressure
Sensor

FIFO Mode



Inertial
module

6D, FIFO Modes, FreeFall, Pedometer,
Tap, Tilt, Wake Up, Self Test



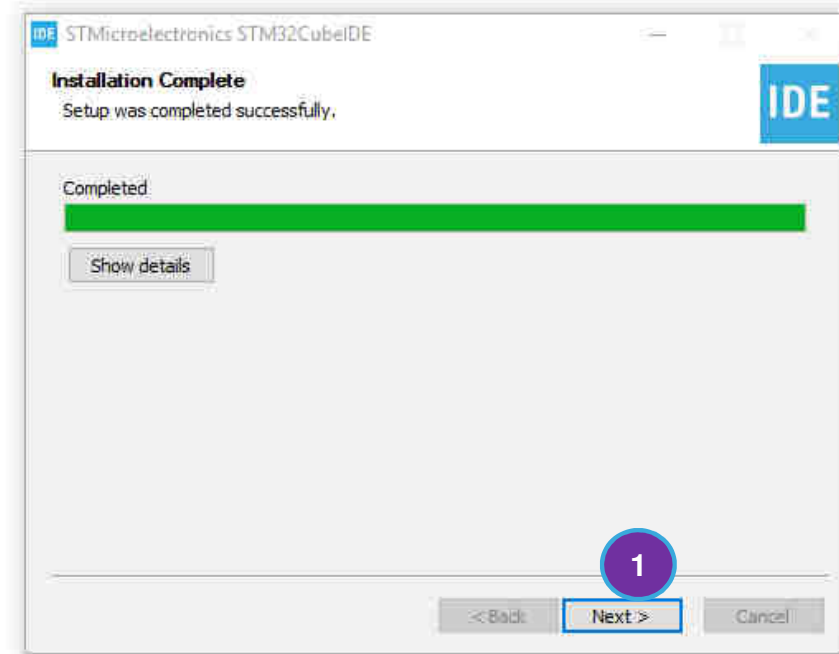
Temperature
Sensor

Temperature Limit

...STM32CubeIDE Installation

33

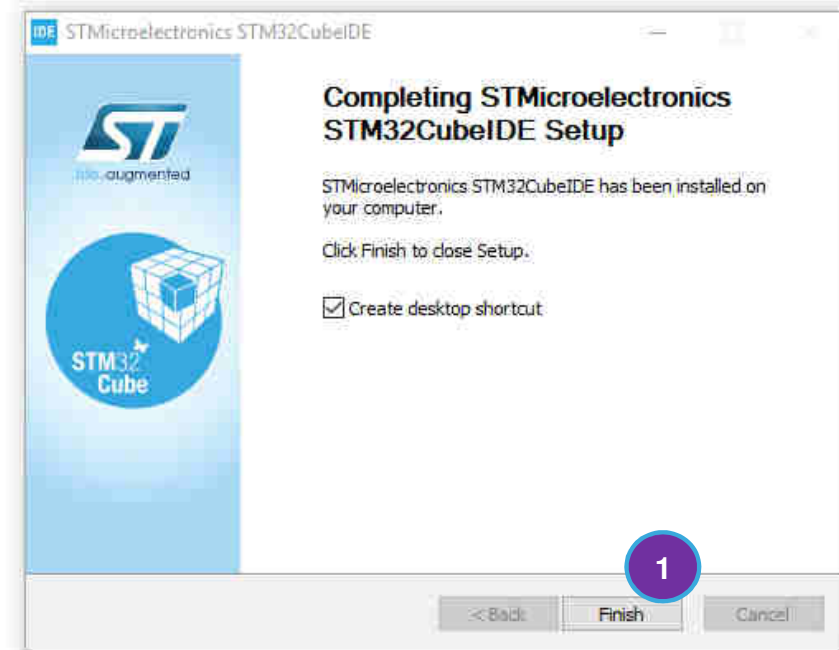
1. Click **Next >**



STM32CubeIDE Installation

34

1. Click **Finish**



STM32CubeIDE Configuration

35

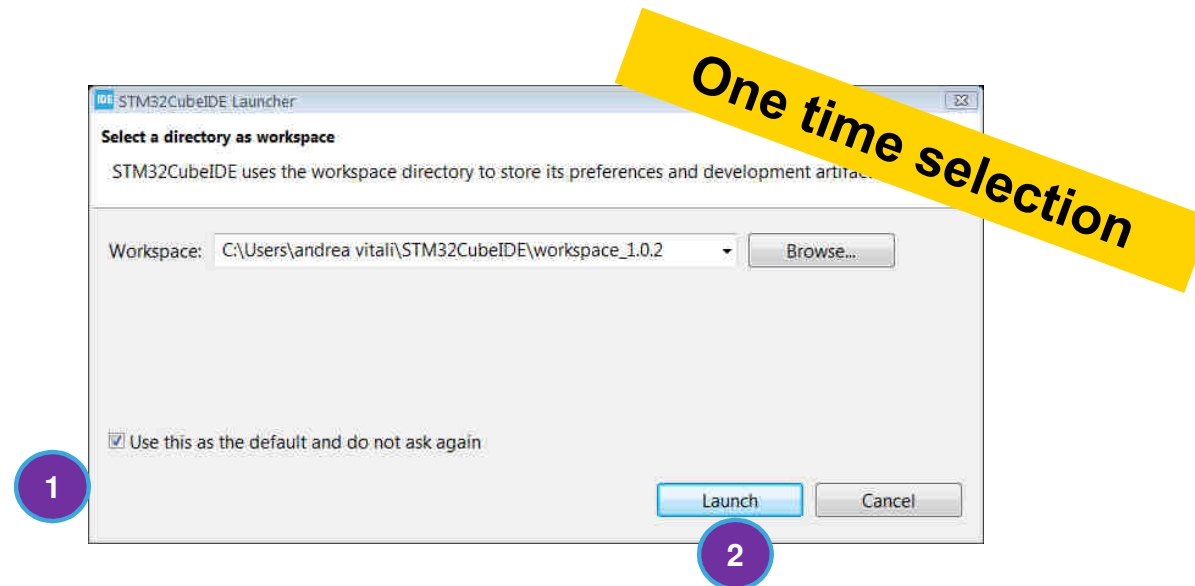
1. Open **STM32CubeIDE** by double clicking the icon on your desktop
2. Wait until **STM32CubeIDE** is loading



STM32CubeIDE Configuration

36

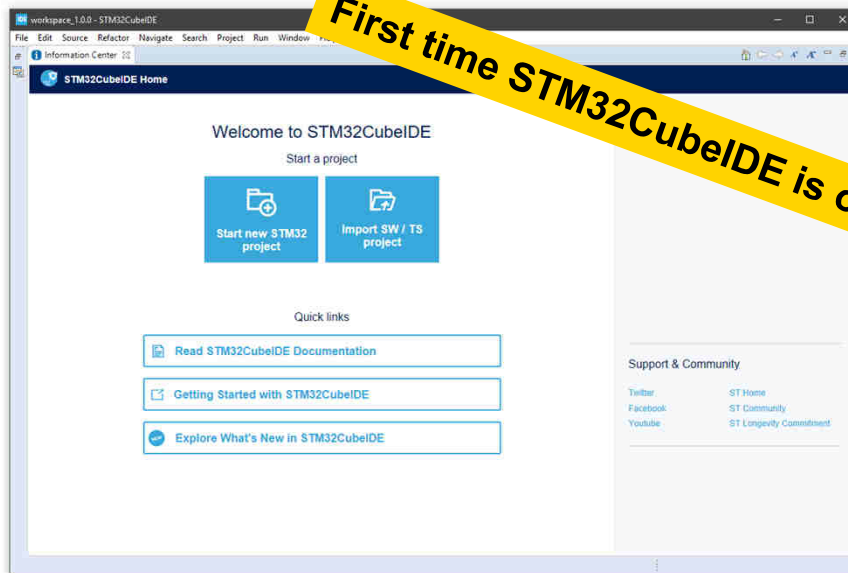
1. Check **Use this as the default and do not ask again**
2. Click **Launch**



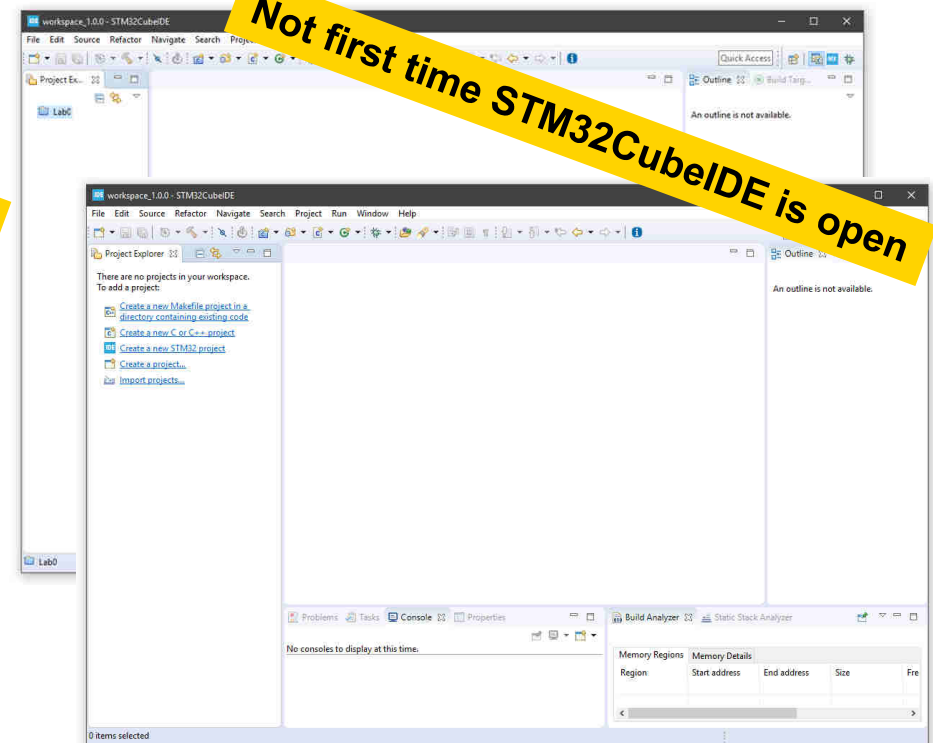
STM32CubeIDE Configuration

37

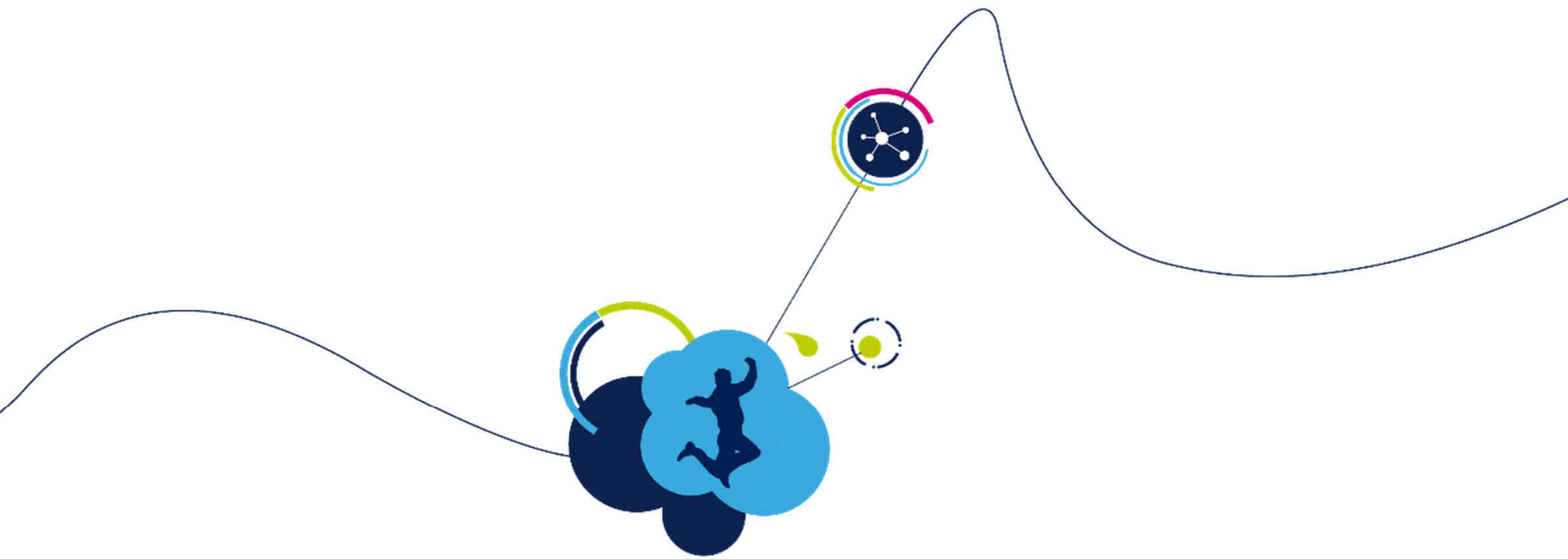
The main interface of STM32CubeIDE will appear differently, depending if it is the first time it has been run or not:



First time STM32CubeIDE is open



Not first time STM32CubeIDE is open

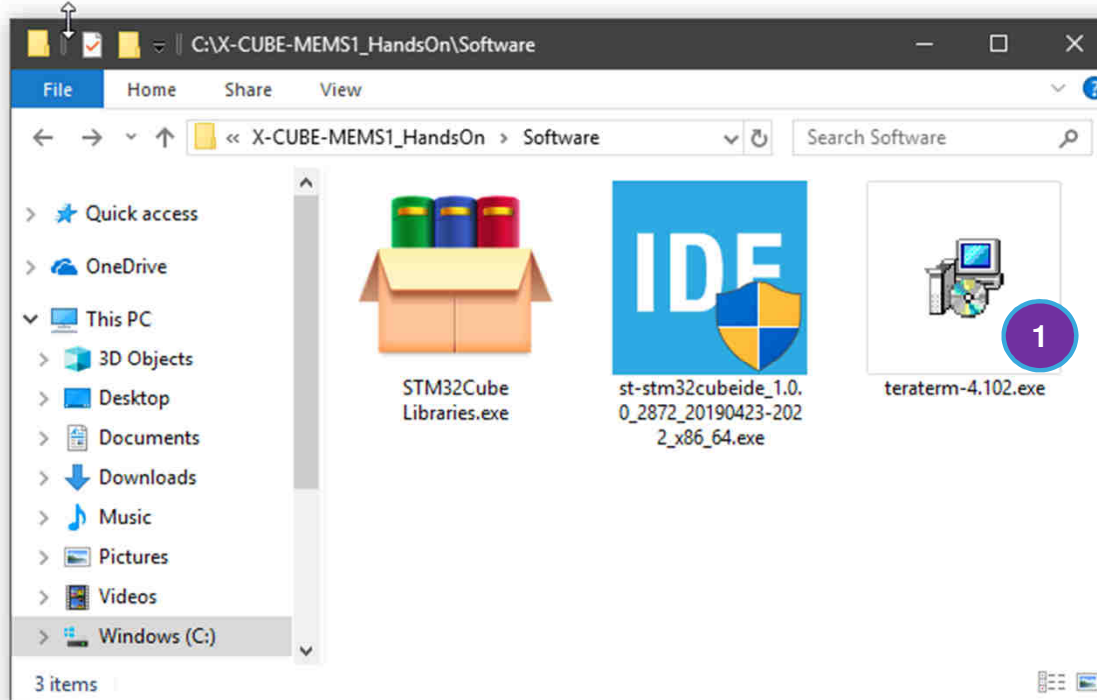


Tera Term Installation

Tera Term Setup 1/9

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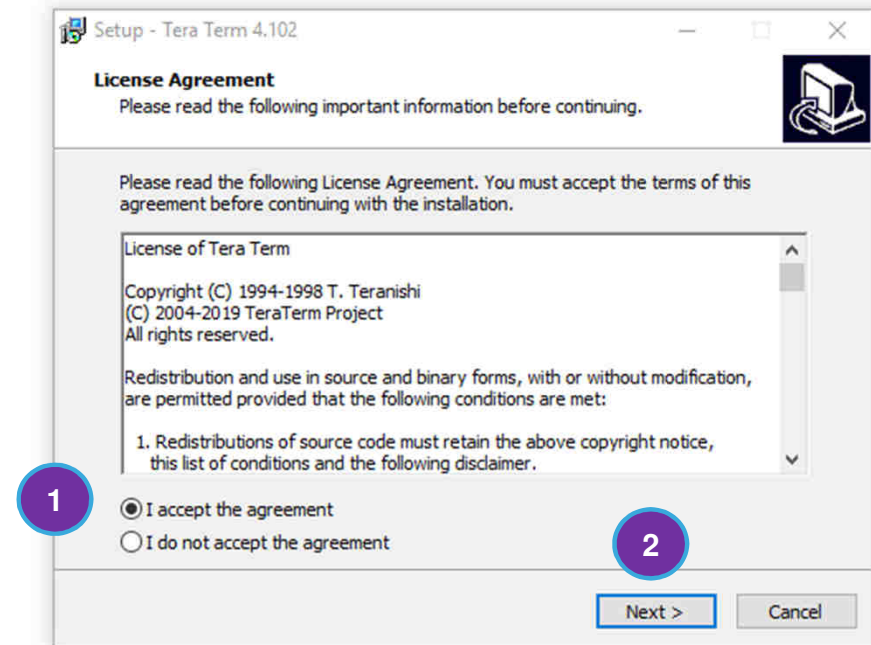
1. Launch the **teraterm-4.102.exe** installer inside the **X-CUBE-MEMS1_HandsOn\Software** directory



Tera Term Setup 2/9

40

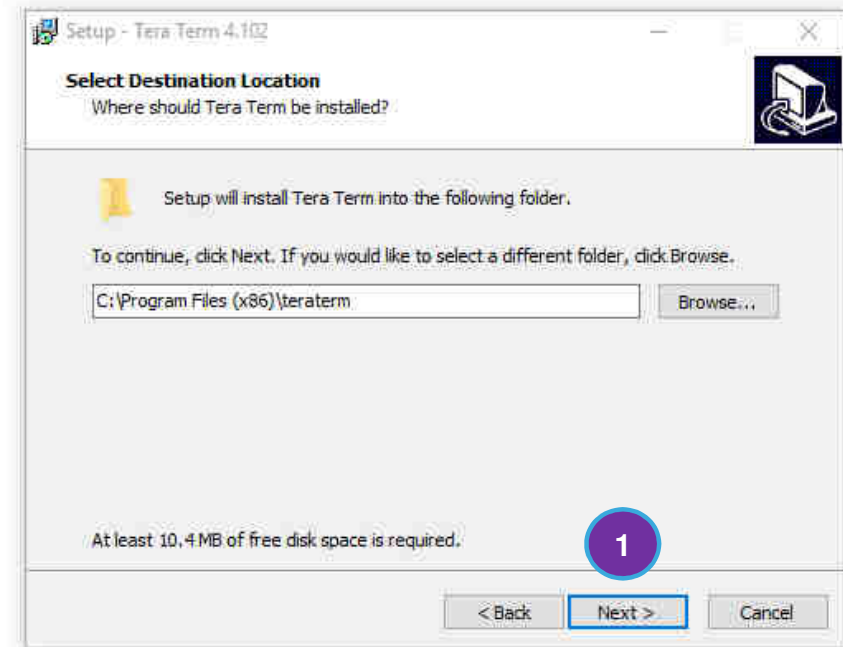
1. **Accept the agreement**
2. Click on **Next**



Tera Term Setup 3/9

41

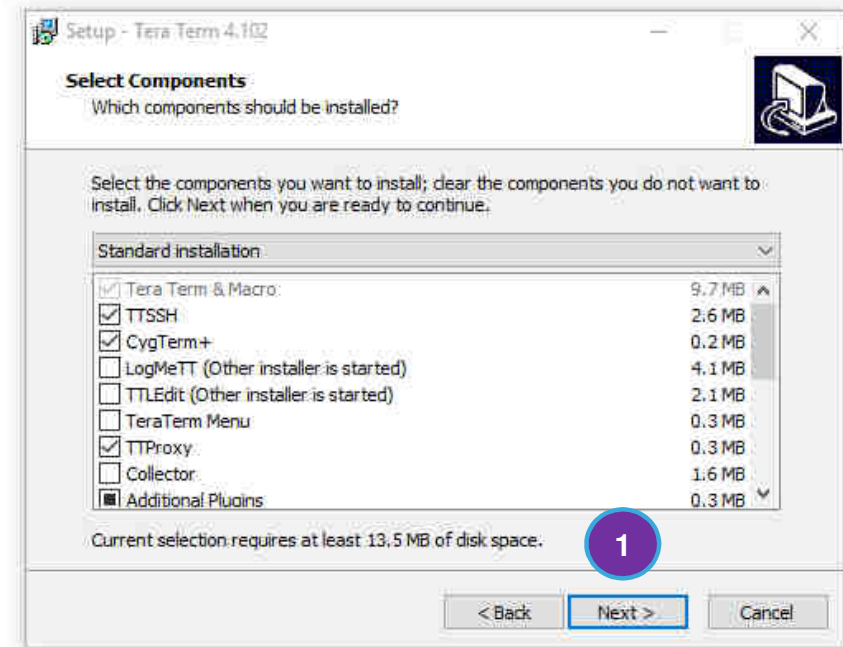
1. Click on **Next**



Tera Term Setup 4/9

42

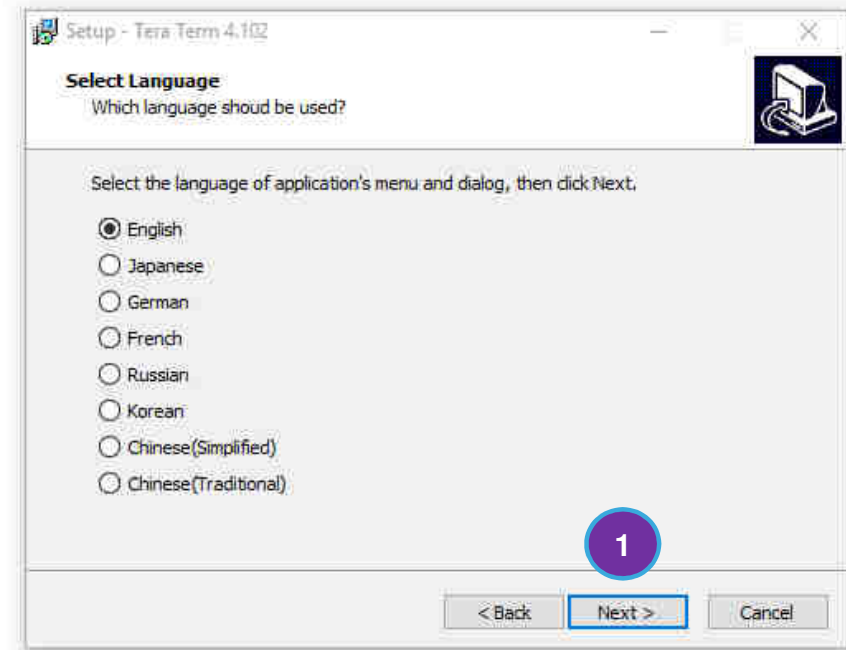
1. Click on **Next**



Tera Term Setup 5/9

43

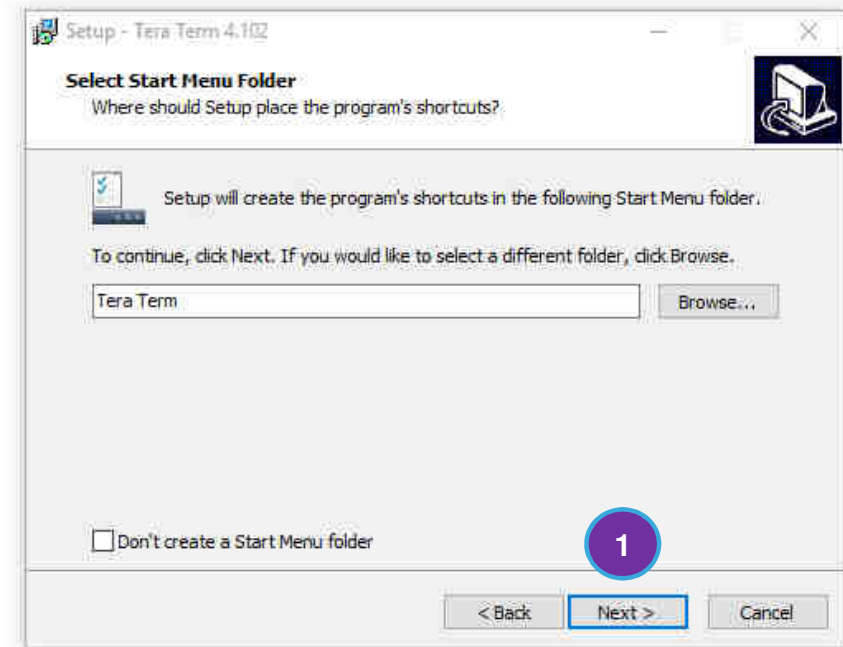
1. Click on **Next**



Tera Term Setup 6/9

44

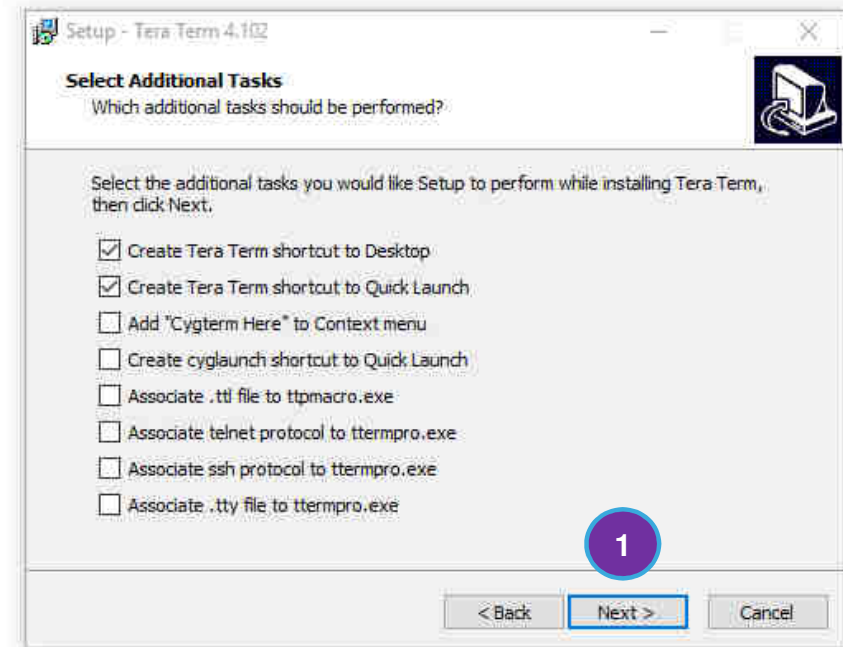
1. Click on **Next**



Tera Term Setup 7/9

45

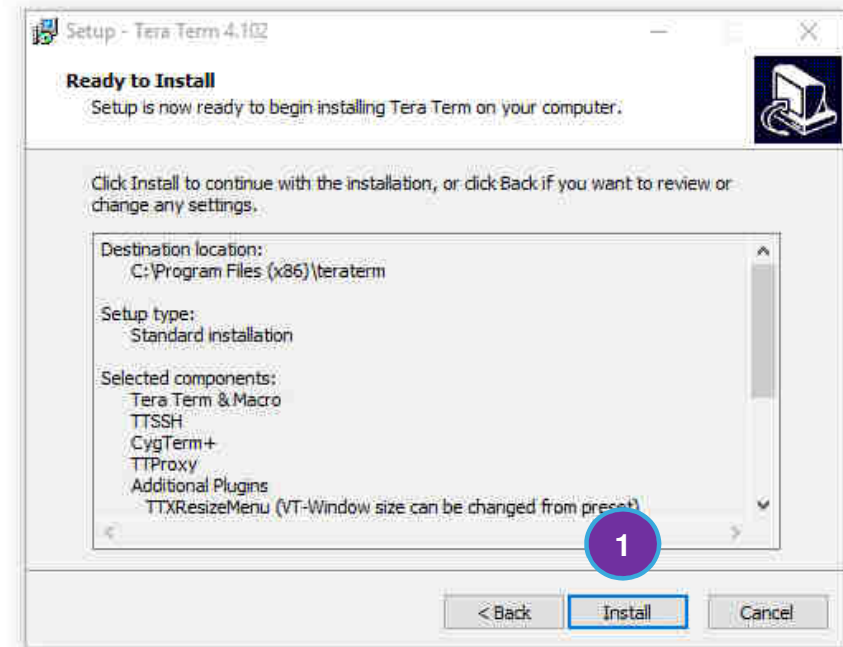
1. Click on **Next**



Tera Term Setup 8/9

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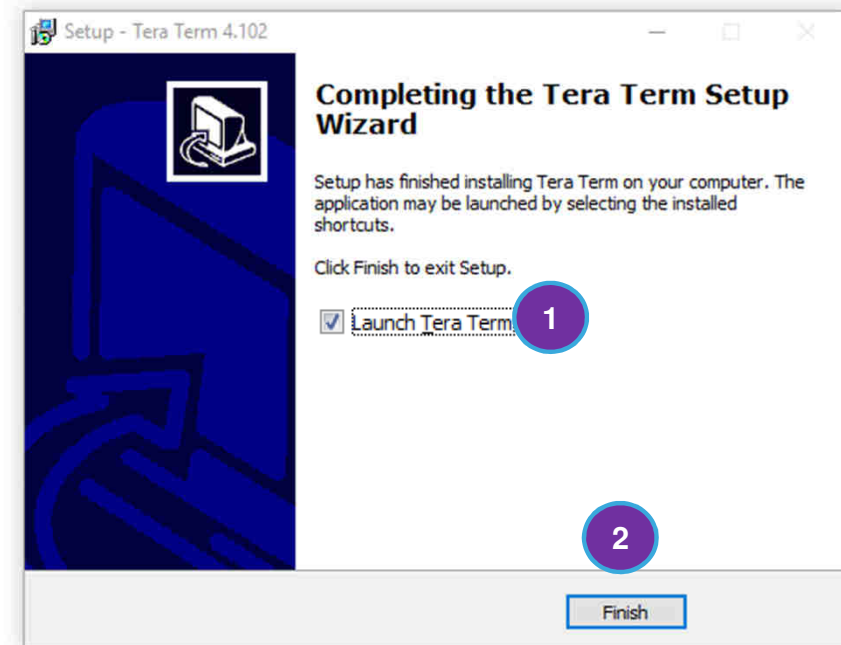
1. Click on **Install**

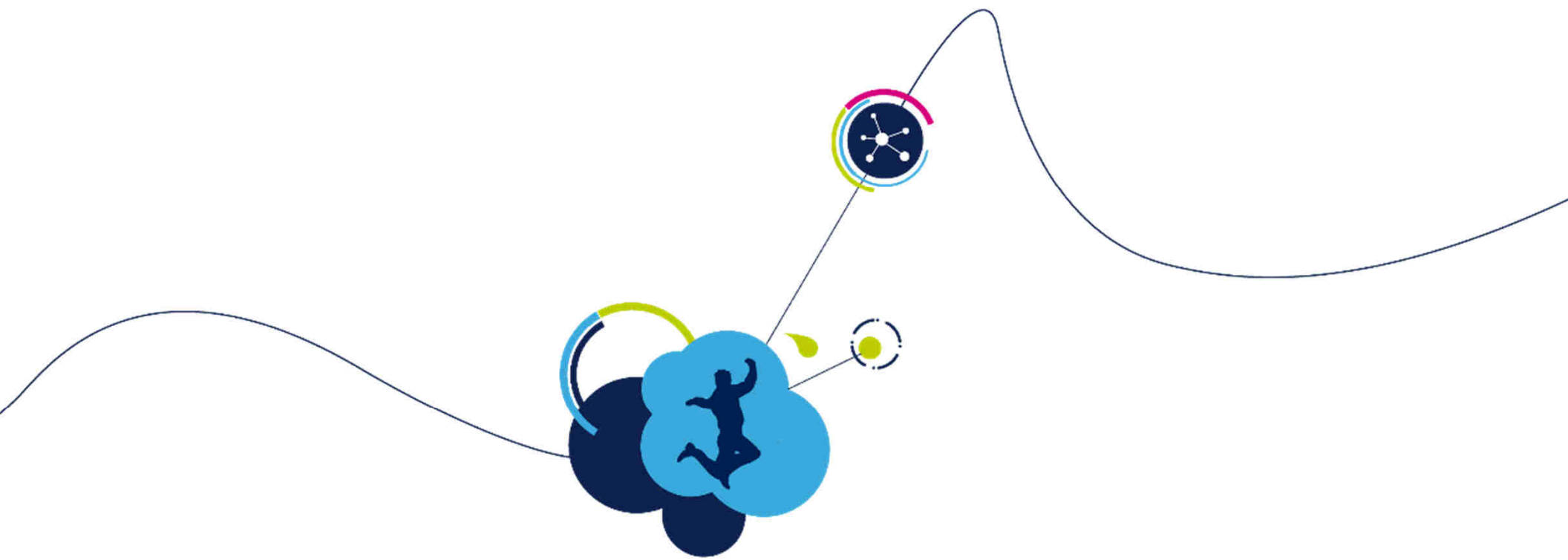


Tera Term Setup 9/9

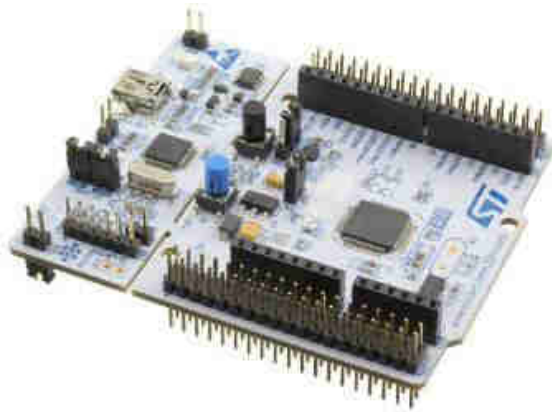
47

1. Select **Launch Tera Term**
2. Click on **Finish**



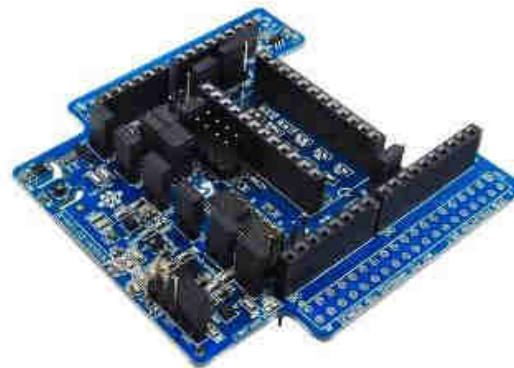


Preparing the Hardware



NUCLEO-L476RG

Development board with STM32L476RG MCU, supports Arduino and ST morpho connectivity



X-NUCLEO-IKS01A3

Motion MEMS and environmental sensor evaluation board system



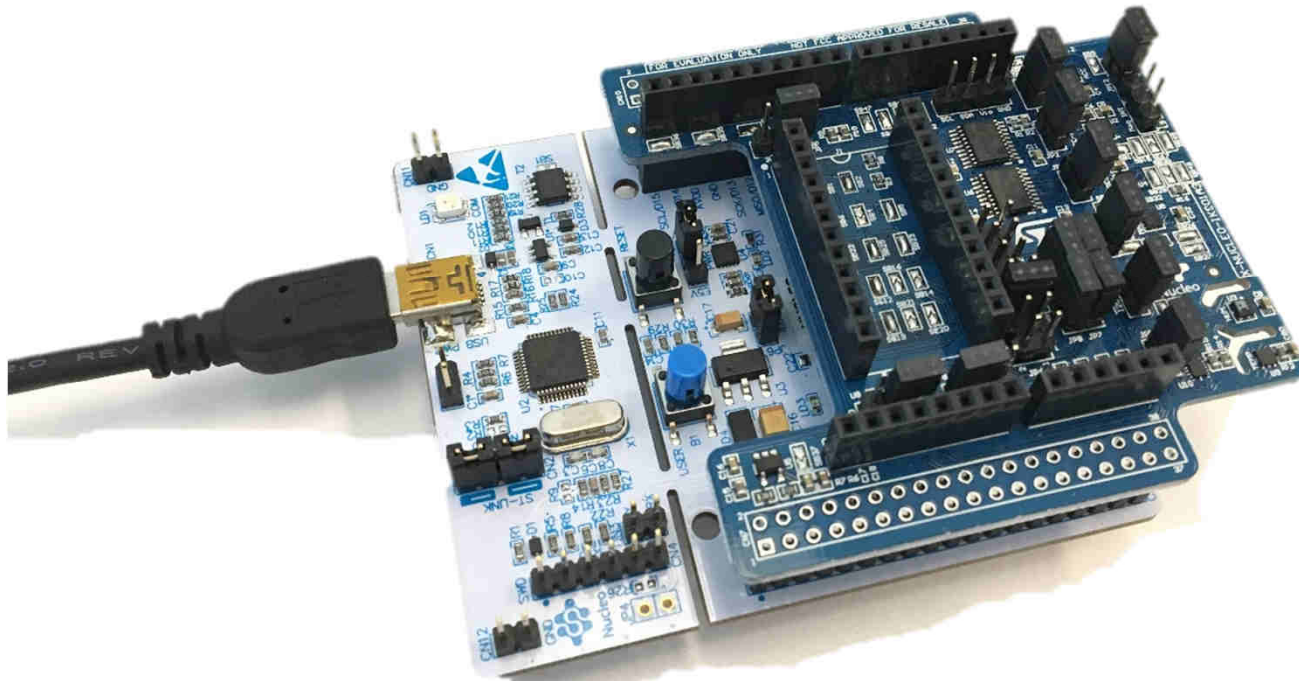
MINI USB CABLE

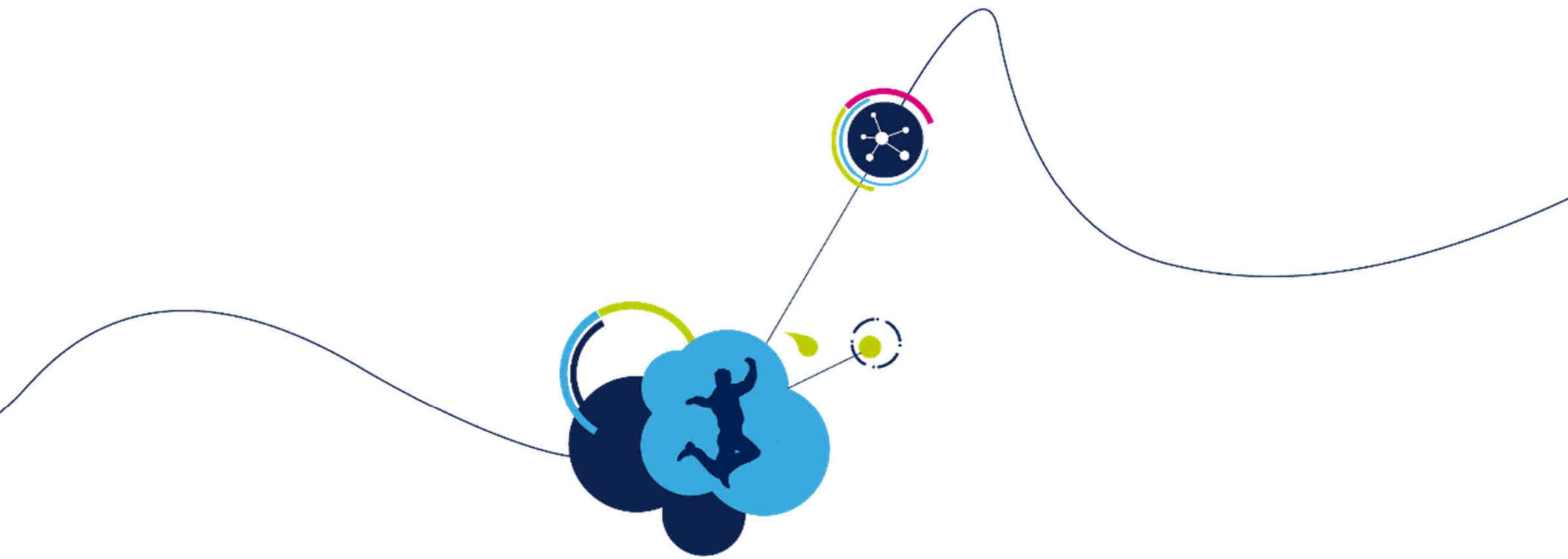
Enable USB communication to the laptop

Preparing the Hardware

50

1. Stack **NUCLEO-L476RG** and **X-NUCLEO-IKS001A3** and connect it to the PC





Tera Term Configuration

This can only be done when the board is connected via USB

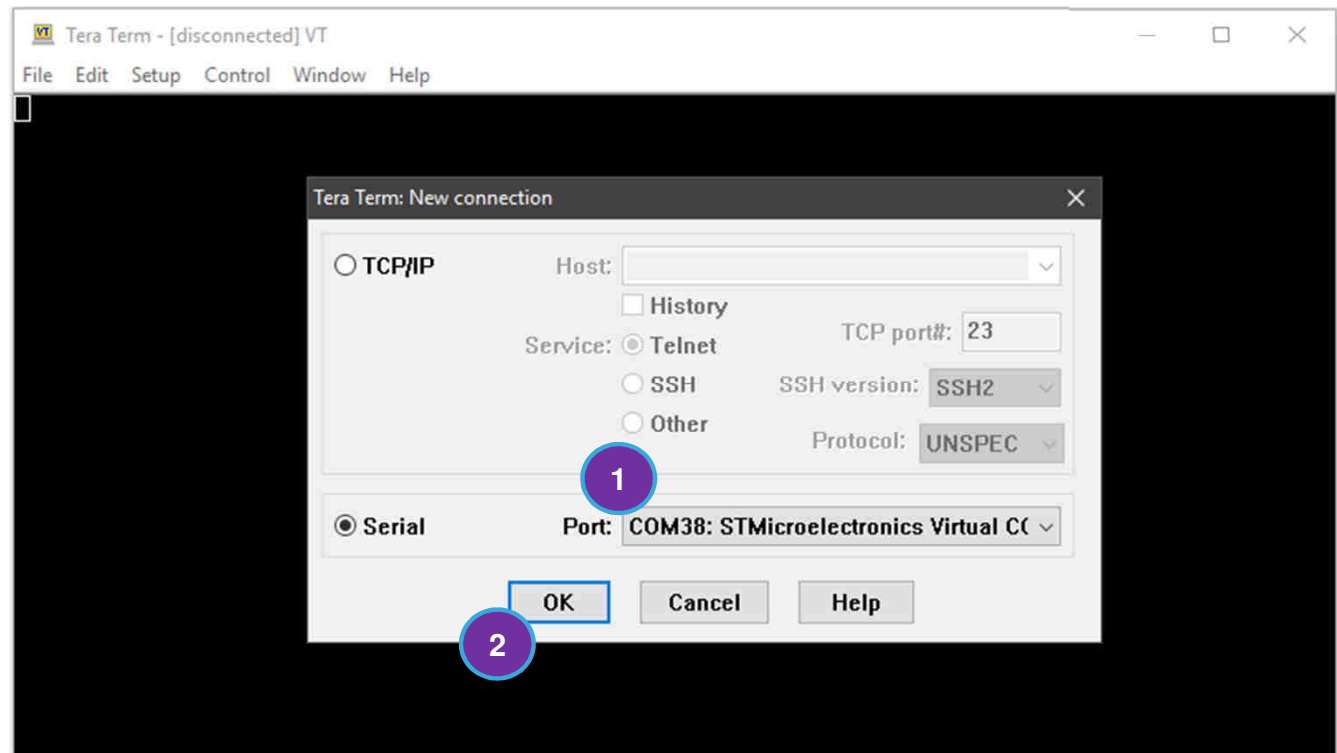
Tera Term Configuration 1/5

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Plug the board to the PC using the micro USB cable provided



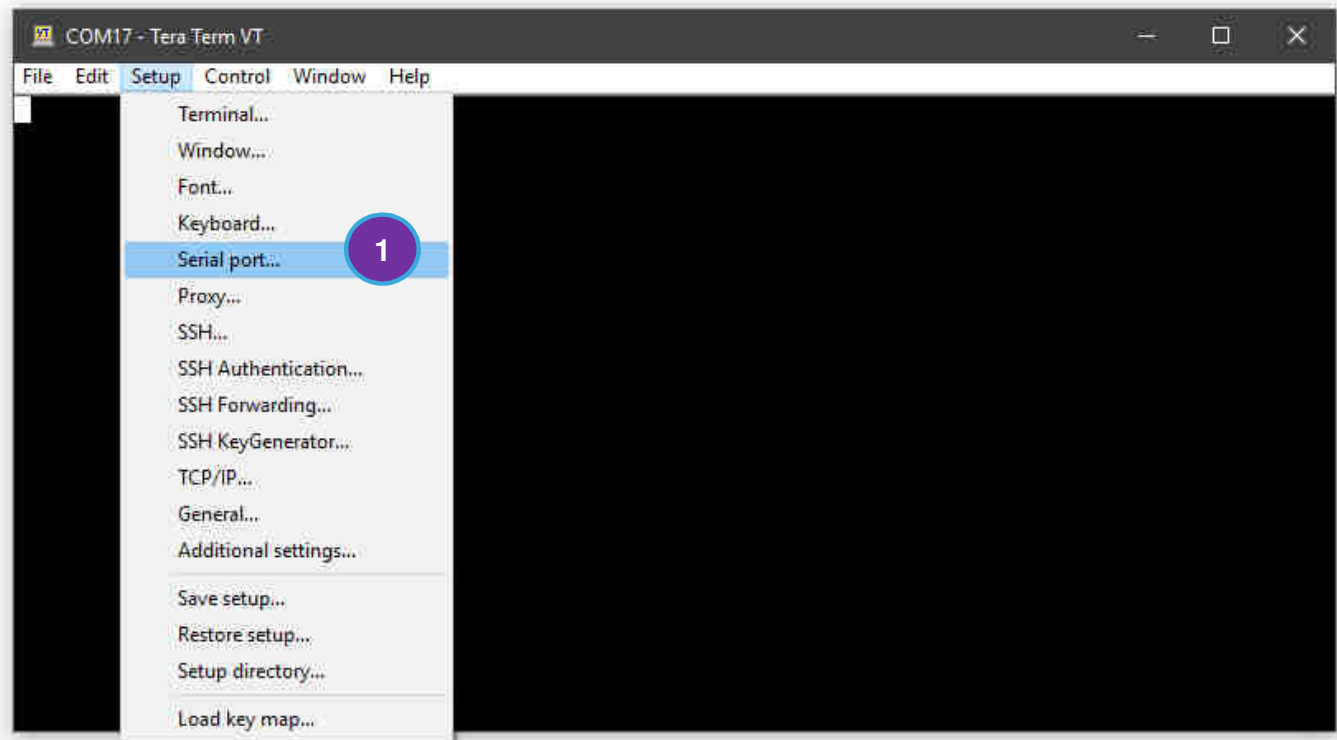
1. Select the **STMicroelectronics Virtual COM Port**
2. Click **OK**



Tera Term Configuration 2/5

53

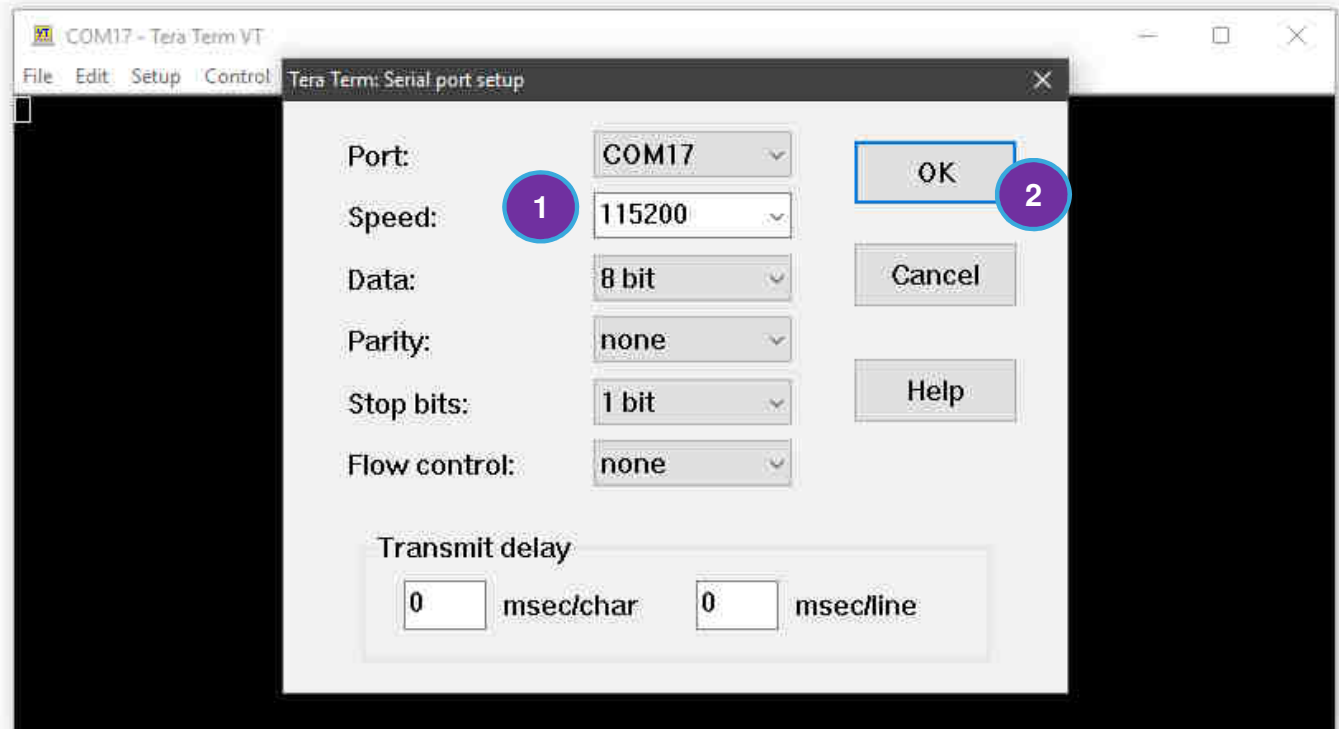
1. Click **Setup** -> **Serial port...**



Tera Term Configuration 3/5

54

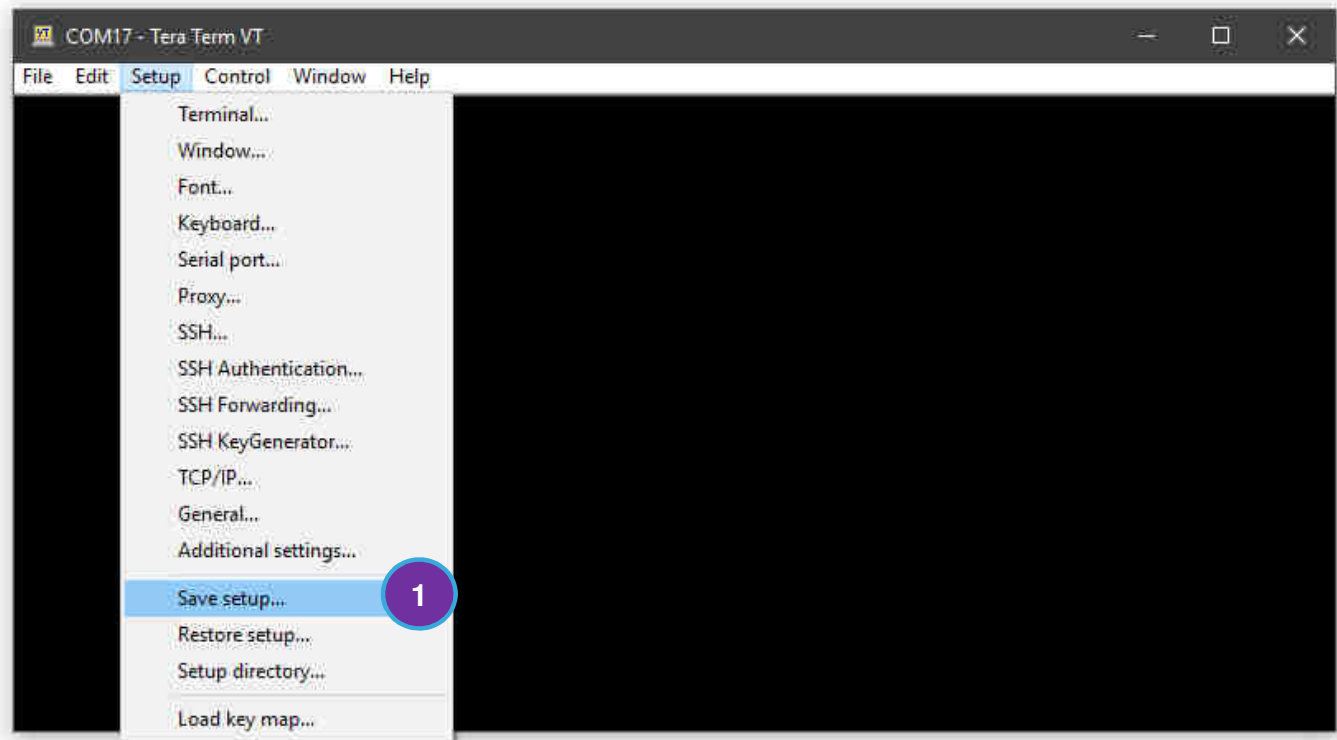
1. Set the following:
Baud Rate: **115200**
Data: **8 bit**
Parity: **none**
Stop: **1 bit**
Flow control: **none**
2. Click **OK**



Tera Term Configuration 4/5

55

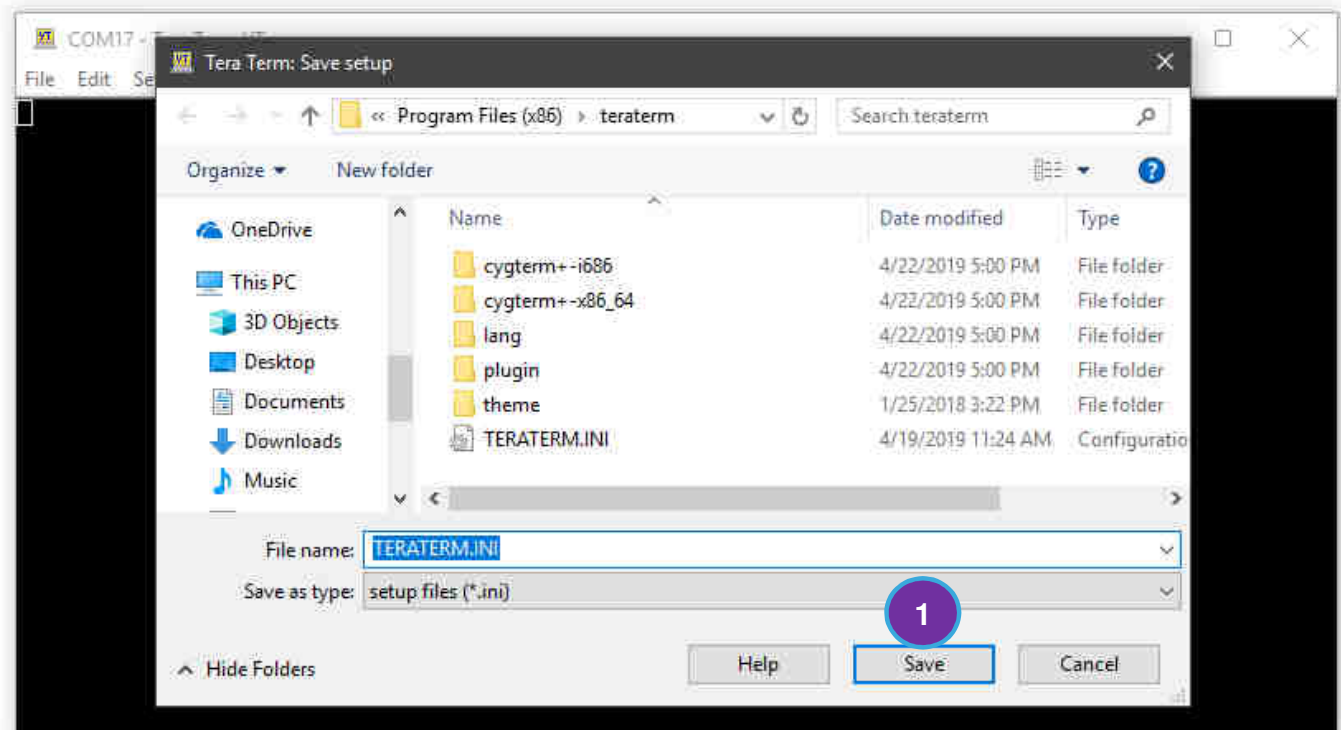
1. Click **Setup** -> **Save setup...**



Tera Term Configuration 5/5

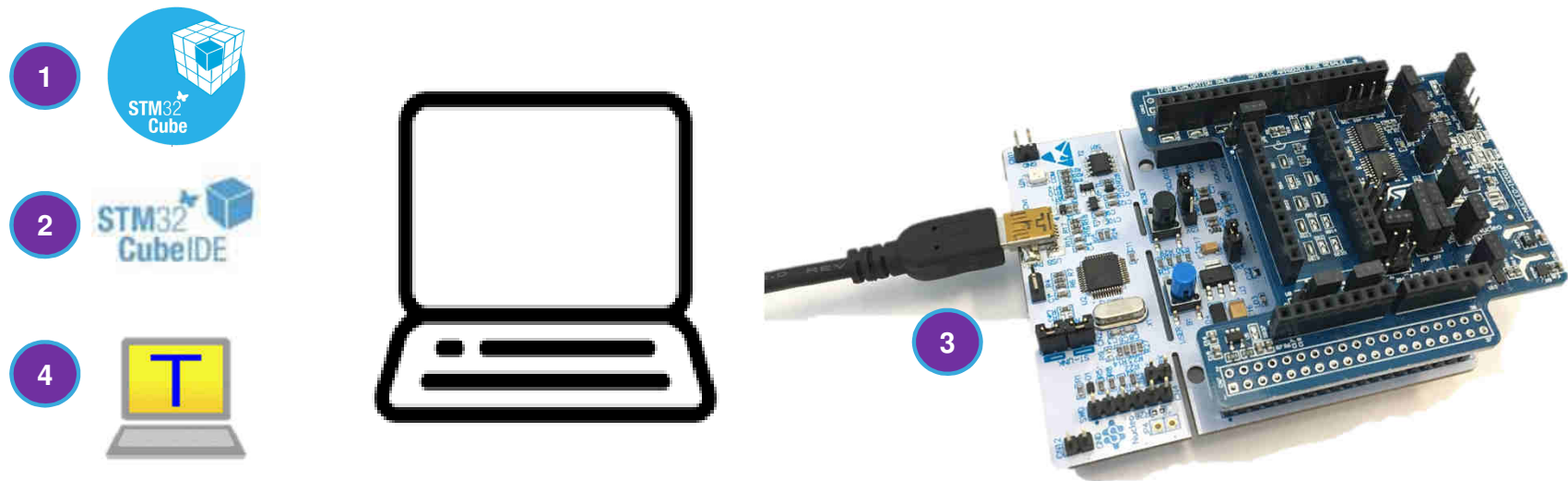
56

1. Click **Save**



Hardware and Software Check

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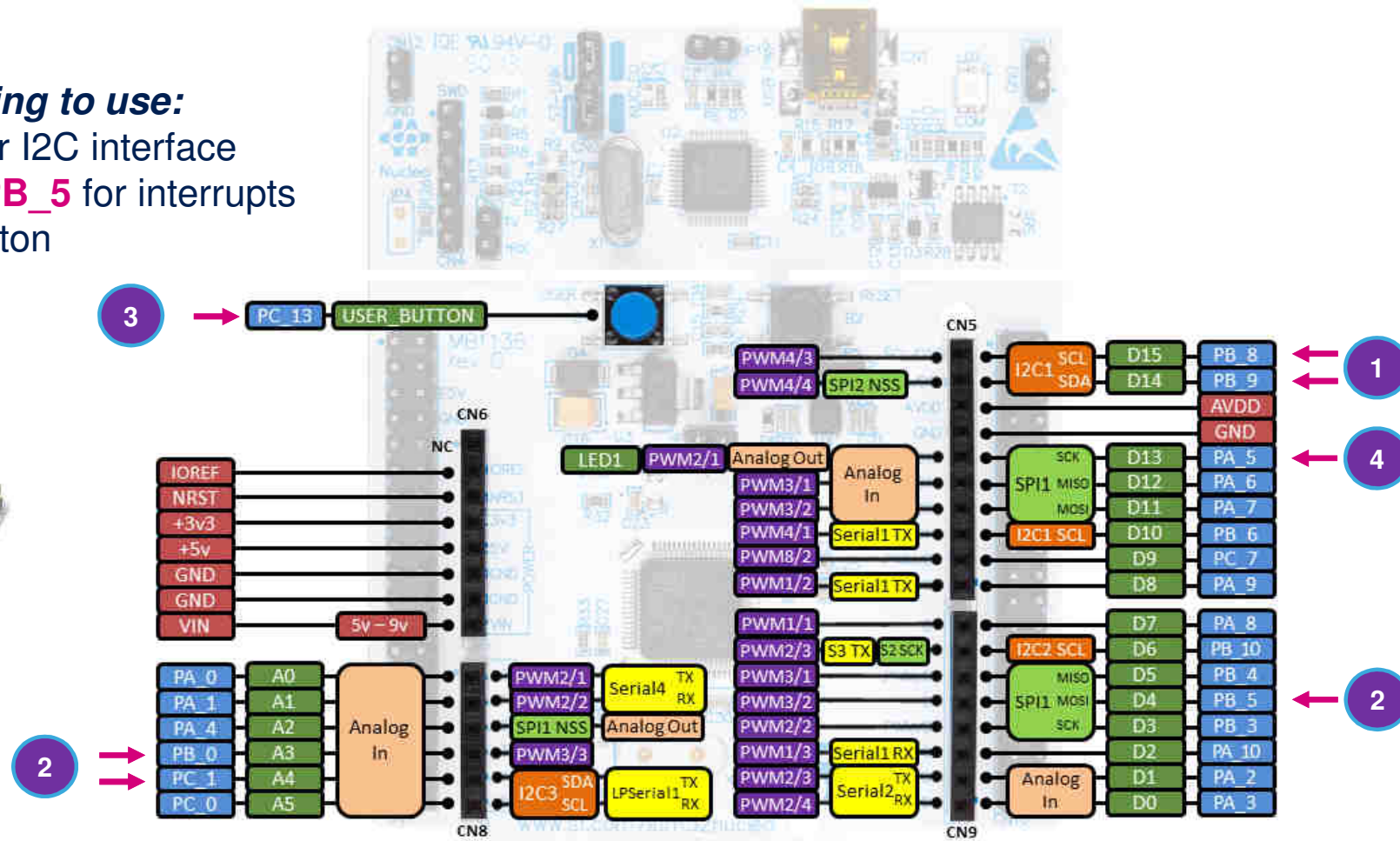
- At this point you should all have:
 1. *Installed* STM32Cube libraries
 2. *Installed* STM32CubeIDE
 3. *Stacked* the Nucleo-L476 with X-Nucleo-IKS01A3 and plug it to the PC
 4. *Installed and configured* Tera Term

NUCLEO-L476RG Header Pinout

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In our labs we are going to use:

1. **PB_8** and **PB_9** for I2C interface
2. **PB_0**, **PC_1** and **PB_5** for interrupts
3. **PC_13** for user button
4. **PA_5** for the LED

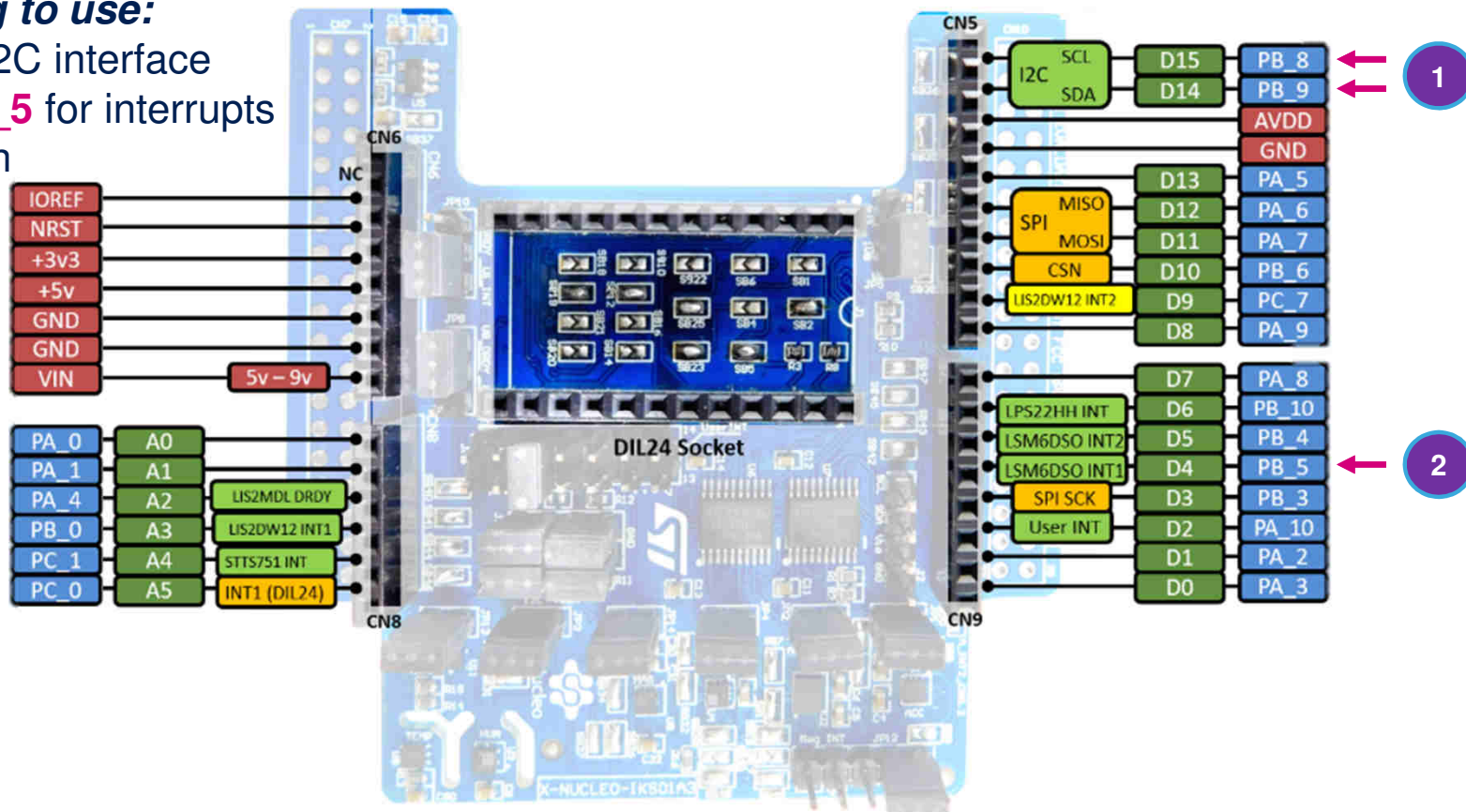


X-NUCLEO-IKS01A3 Header Pinout

59

In our labs we are going to use:

1. **PB_8** and **PB_9** for I2C interface
2. **PB_0**, **PC_1** and **PB_5** for interrupts
3. **PC_13** for user button
4. **PA_5** for the LED



LAB0

Goals:

- Configure a new project using X-CUBE-MEMS1
- **Configure all sensors and read data in polling mode**
- Visualizing sensor data on Tera Term

Leading Sensors for IoT

61

ACCELEROMETER & GYROSCOPE **6-AXIS IMU**

LSM6DSO

Wearables,
Smartphones, IoT,
AR/VR



- Best in class for Power/Noise
- Embedded Digital Features including: New Pedometer, FSM
- High speed I3C interface
- Real dual core

ULTRA LOW POWER **ACCELEROMETER**

LIS2DW12

IoT, wearable,
anti-tampering,
security



- Flexibility Power Consumption vs. Noise
- Ecosystem (SW, libraries, ref design, Nucleo boards ...)

HIGH ACCURACY **PRESSURE SENSOR**

LPS22HH

Compact, low
power, water
resistant



- LPS22HH: high accuracy,
- Low Power Consumption
- Skip One Point Cal. post Soldering

MAGNETOMETER **COMPASS**

LIS2MDL

Accuracy,
Temperature
Stability



- Power Consumption
- Thermal Stability & Precision
- The LIS2MDL has a magnetic field dynamic range of ± 50 gauss.

LOCAL **TEMPERATURE SENSOR**

STTS751

Low Voltage,
Low Power



- Ultra low power with one shot mode for superior power savings
- SMBus 2.0 compliant supporting ALERT command
- Very small package

HUMIDITY AND TEMPERATURE COMBO

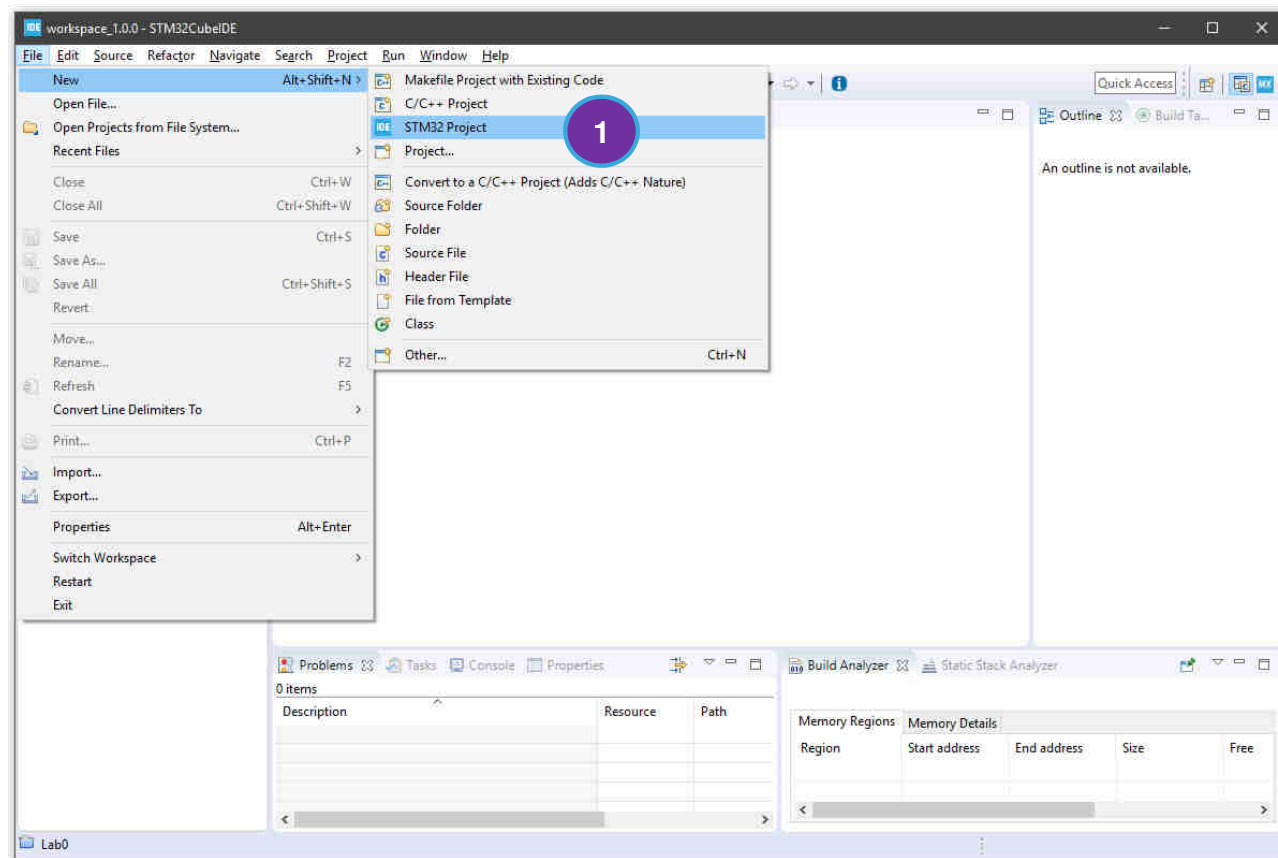
HTS221

Compact
Low Power



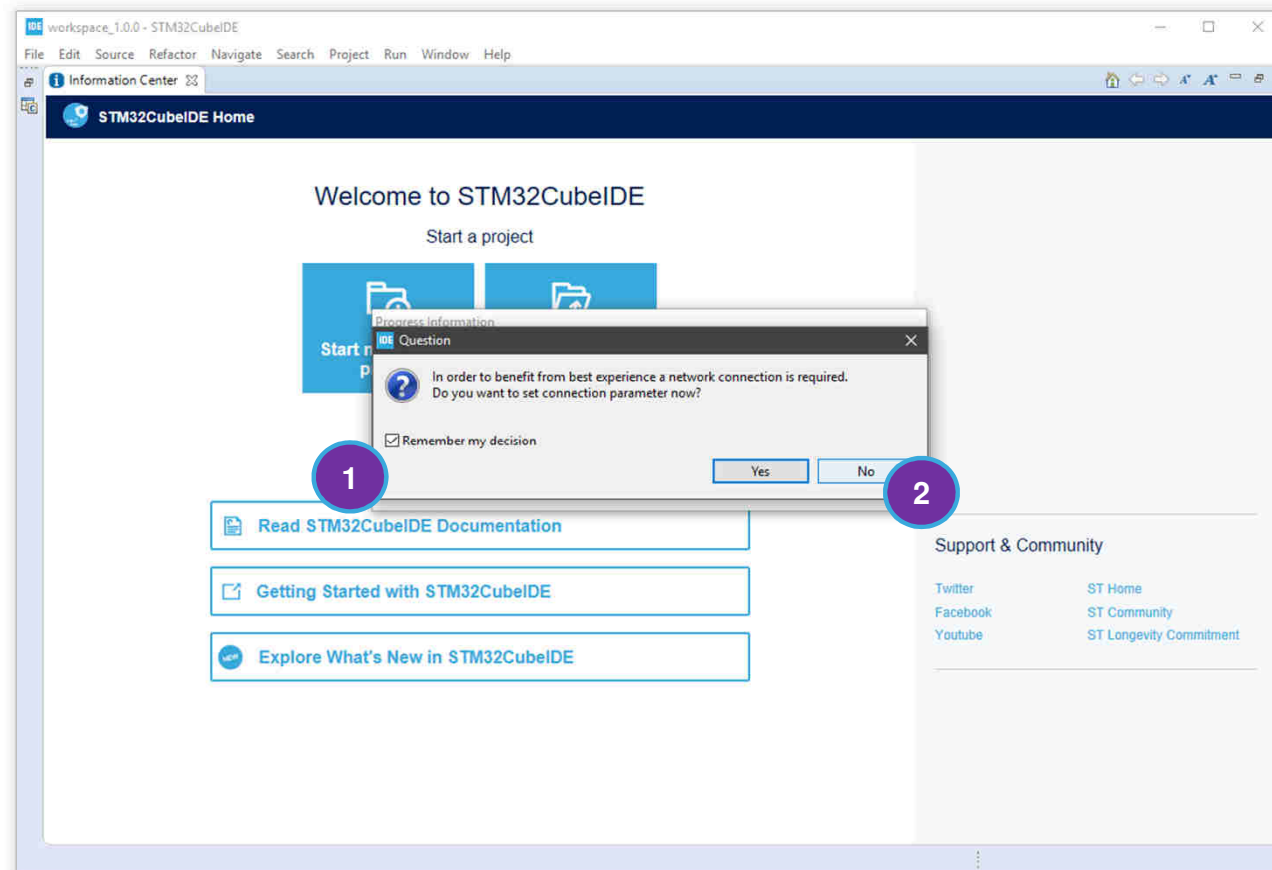
- Direct H and T data readout
- Low current consumption (3.5uA)
- Industrial temperature operating range

1. Click on **File > New > STM32 Project**

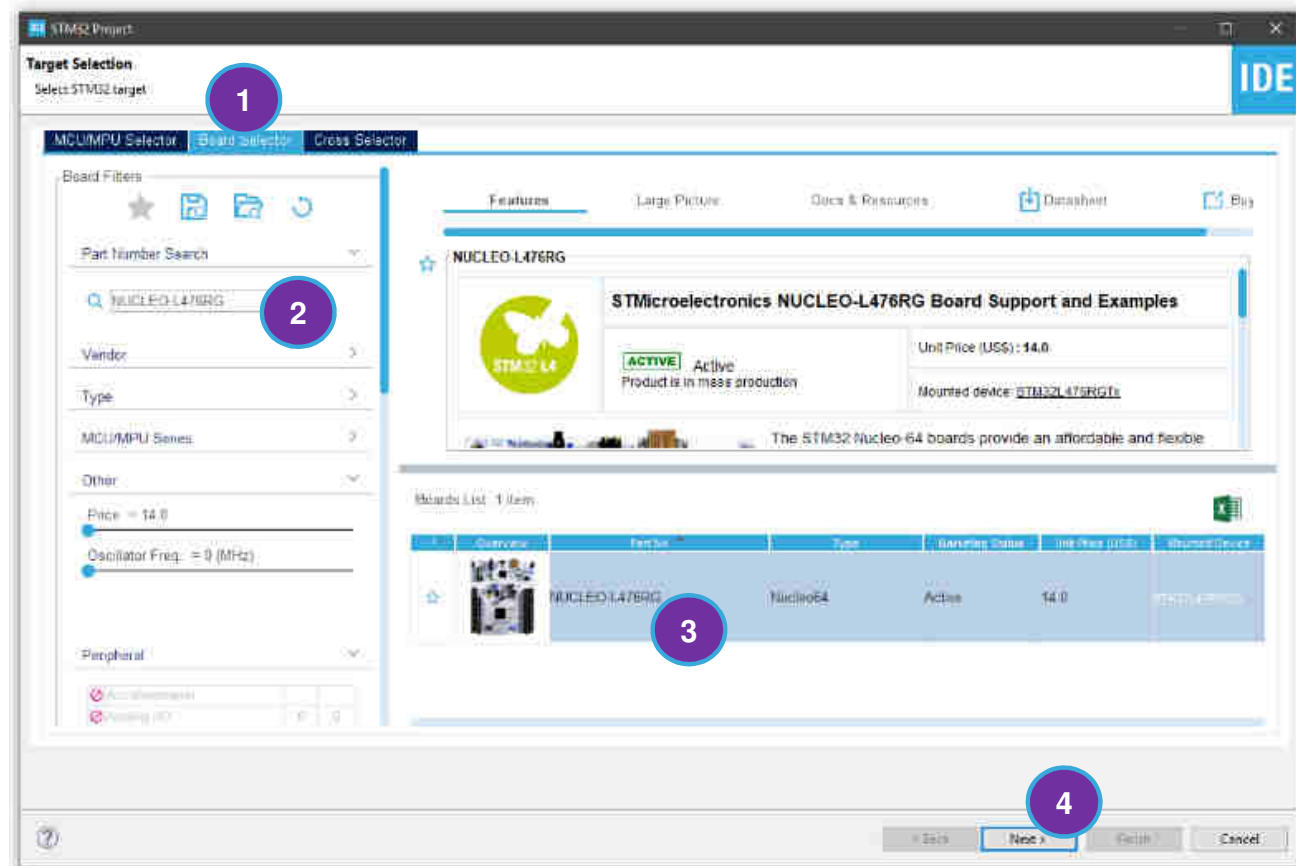


1. Check **Remember my decision***
2. Click on **No**

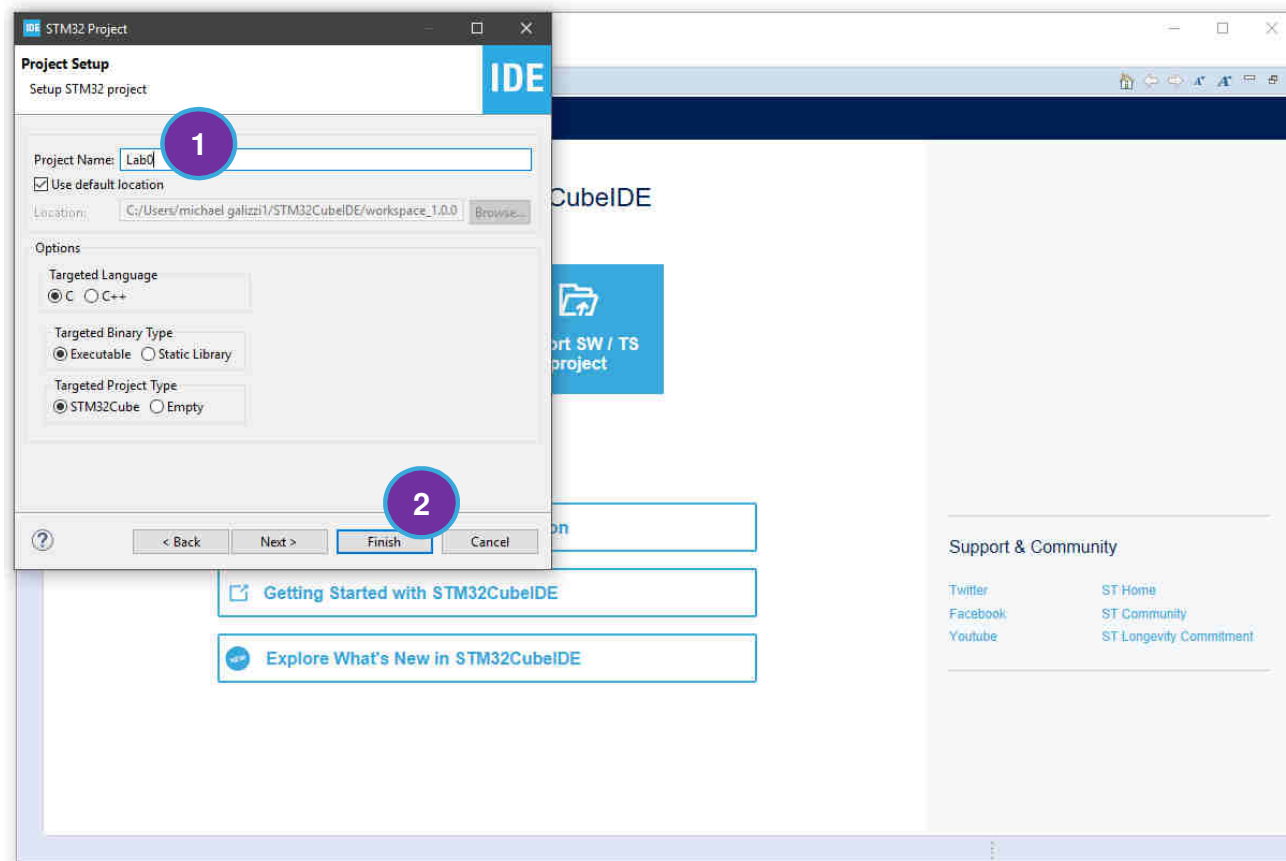
* It is always possible to reconfigure internet connection parameter in **Window > Preferences** then in **General > Network Connections**



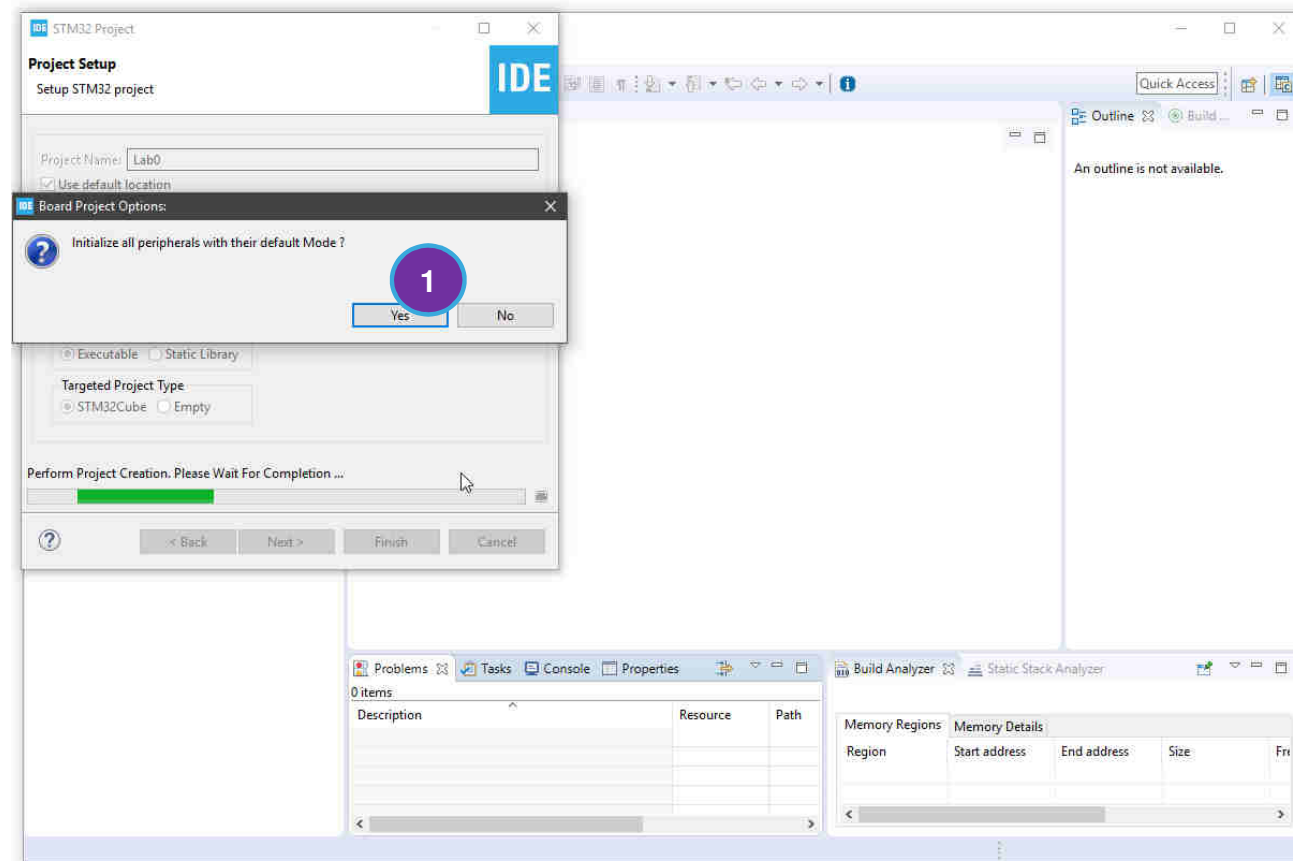
1. Click on **Board Selector**
2. Type **NUCLEO-L476RG**
3. Click on the board
4. Click **Next >**



1. Project Name **Lab0**
2. Click **Finish**

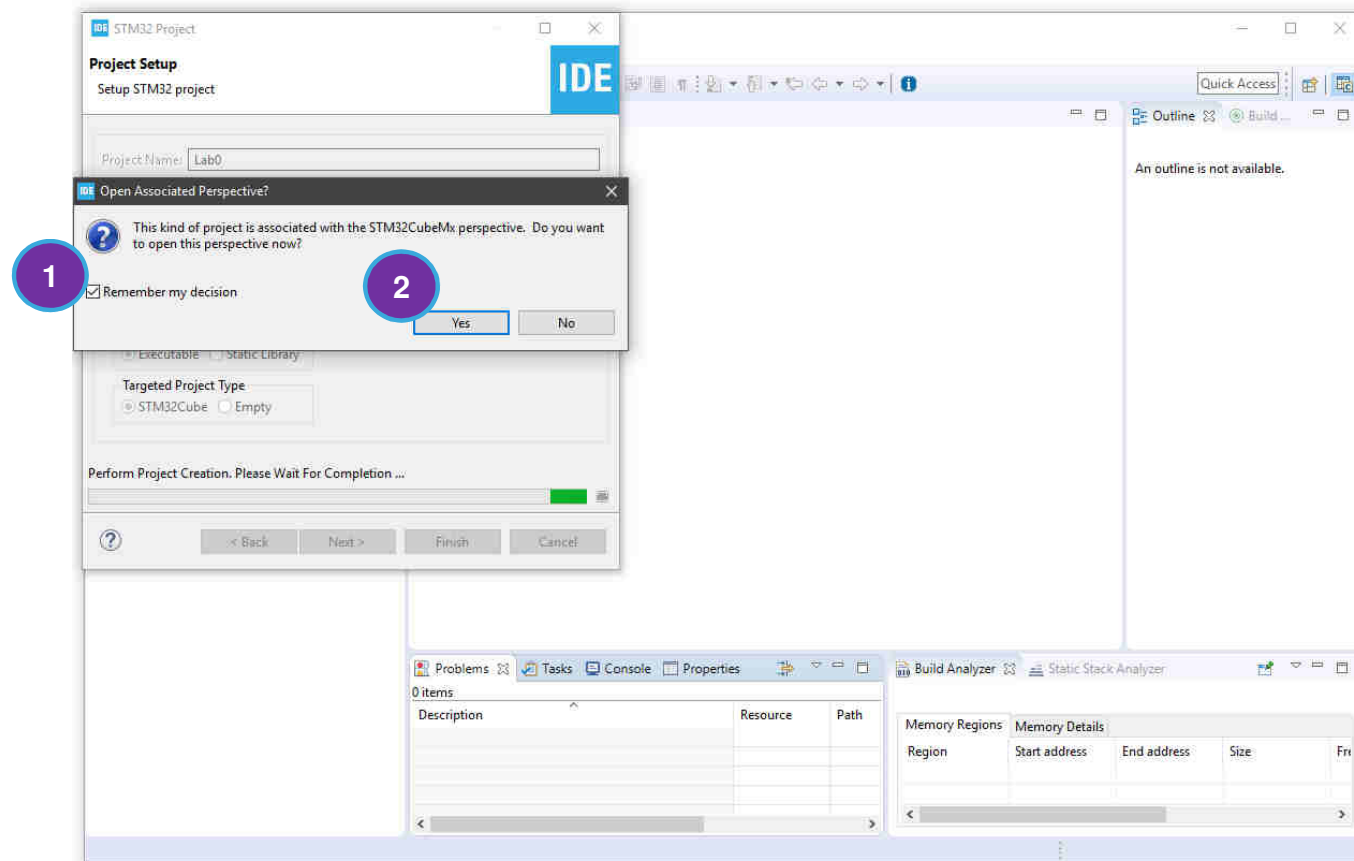


1. Click **Yes** to init peripherals in default mode



1. Check **Remember my decision**

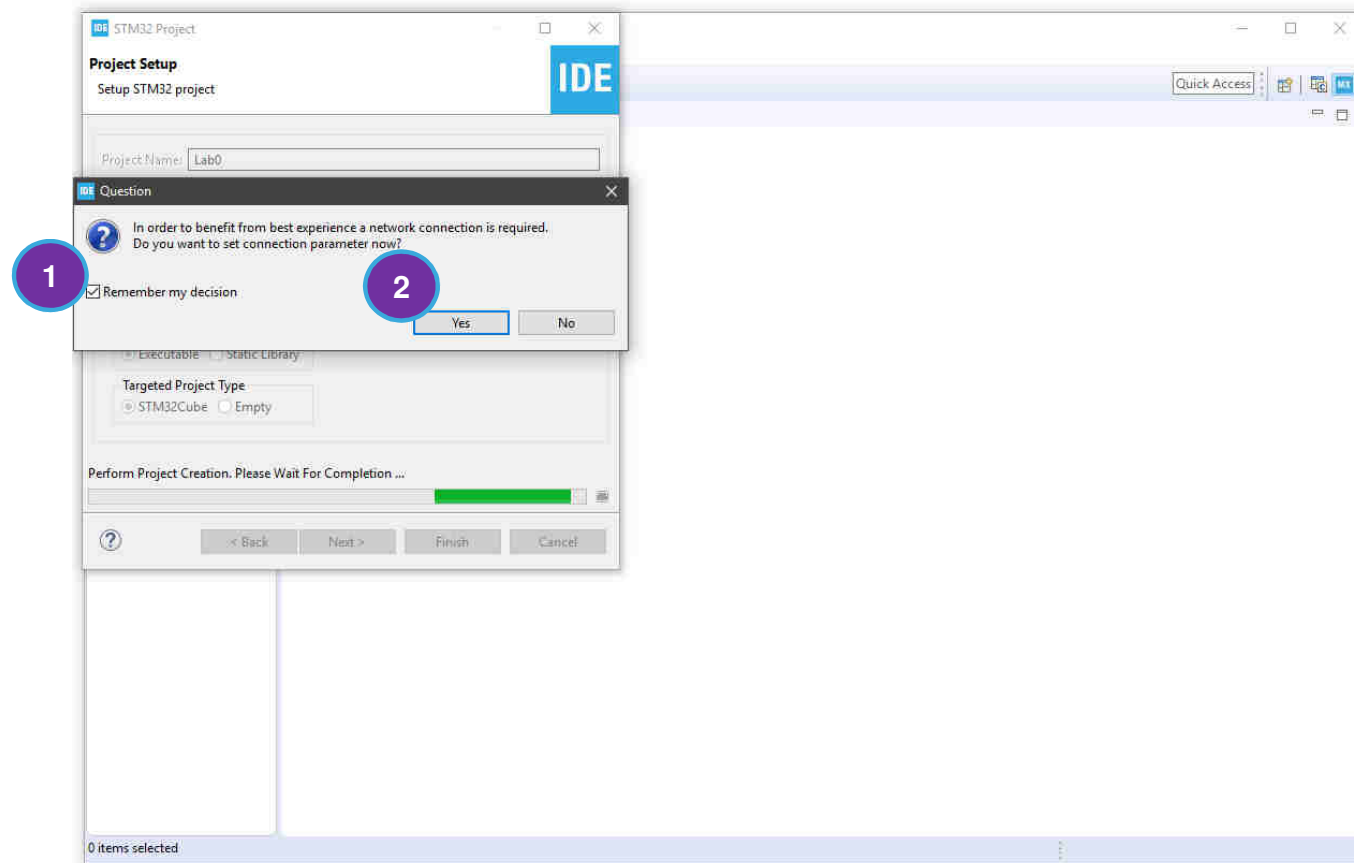
2. Click **Yes**



1. Check **Remember my decision**

2. Click **No** *

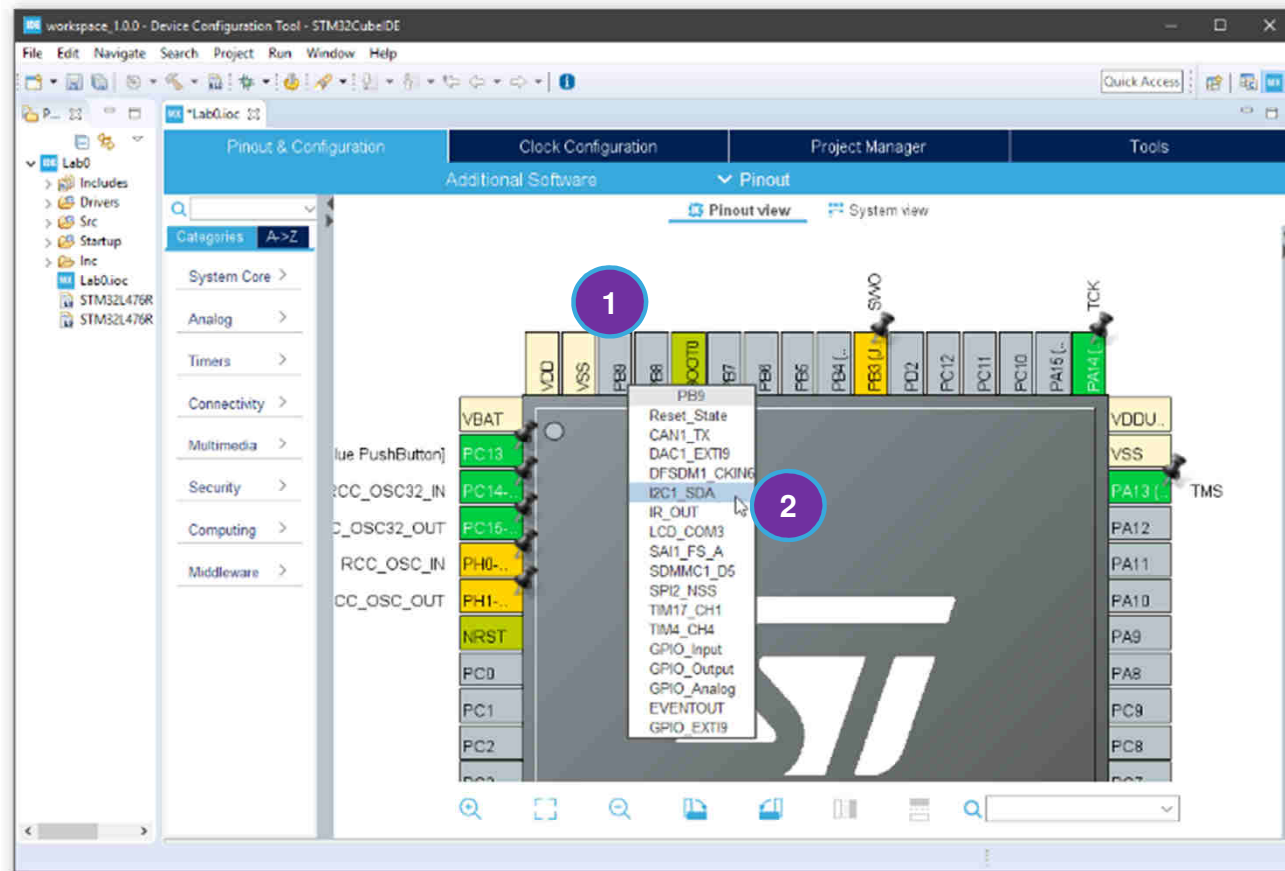
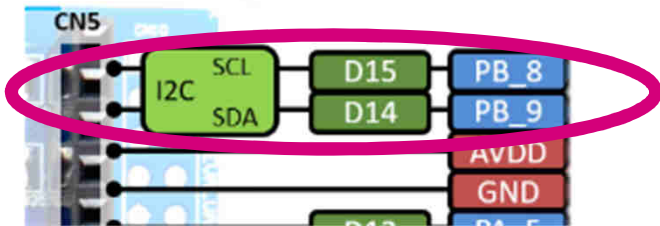
* We are using all the tools in offline mode, so that internet connection is not strictly needed



Lab0 – Configure the I2C Bus

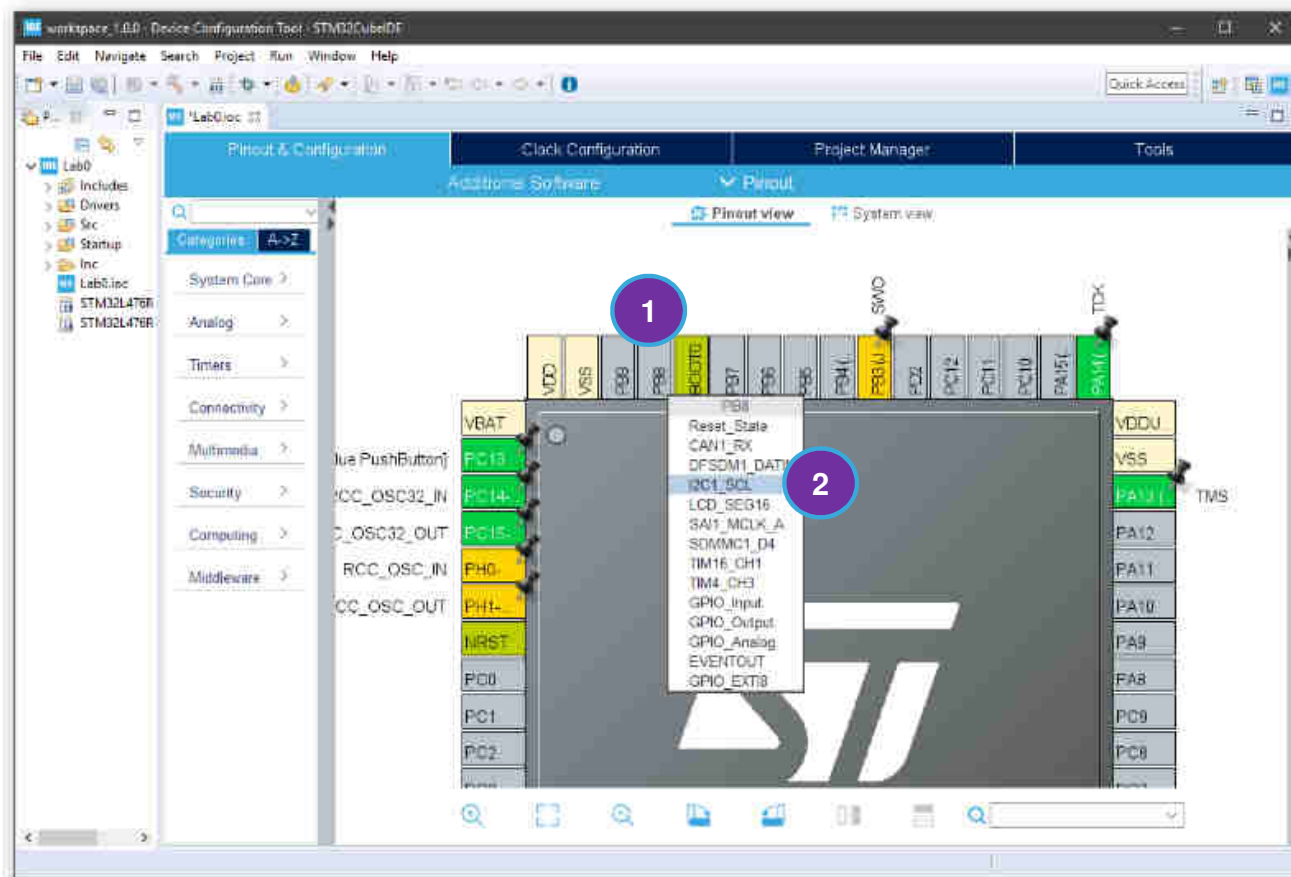
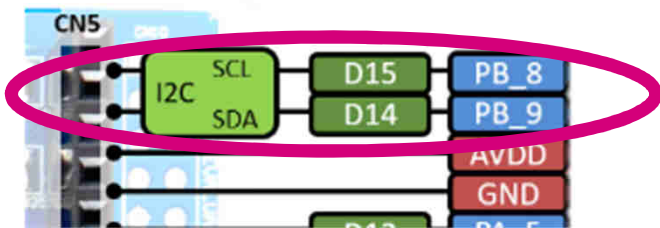
69

1. Left Click on **PB9** pin
2. Select **I2C1_SDA**



70

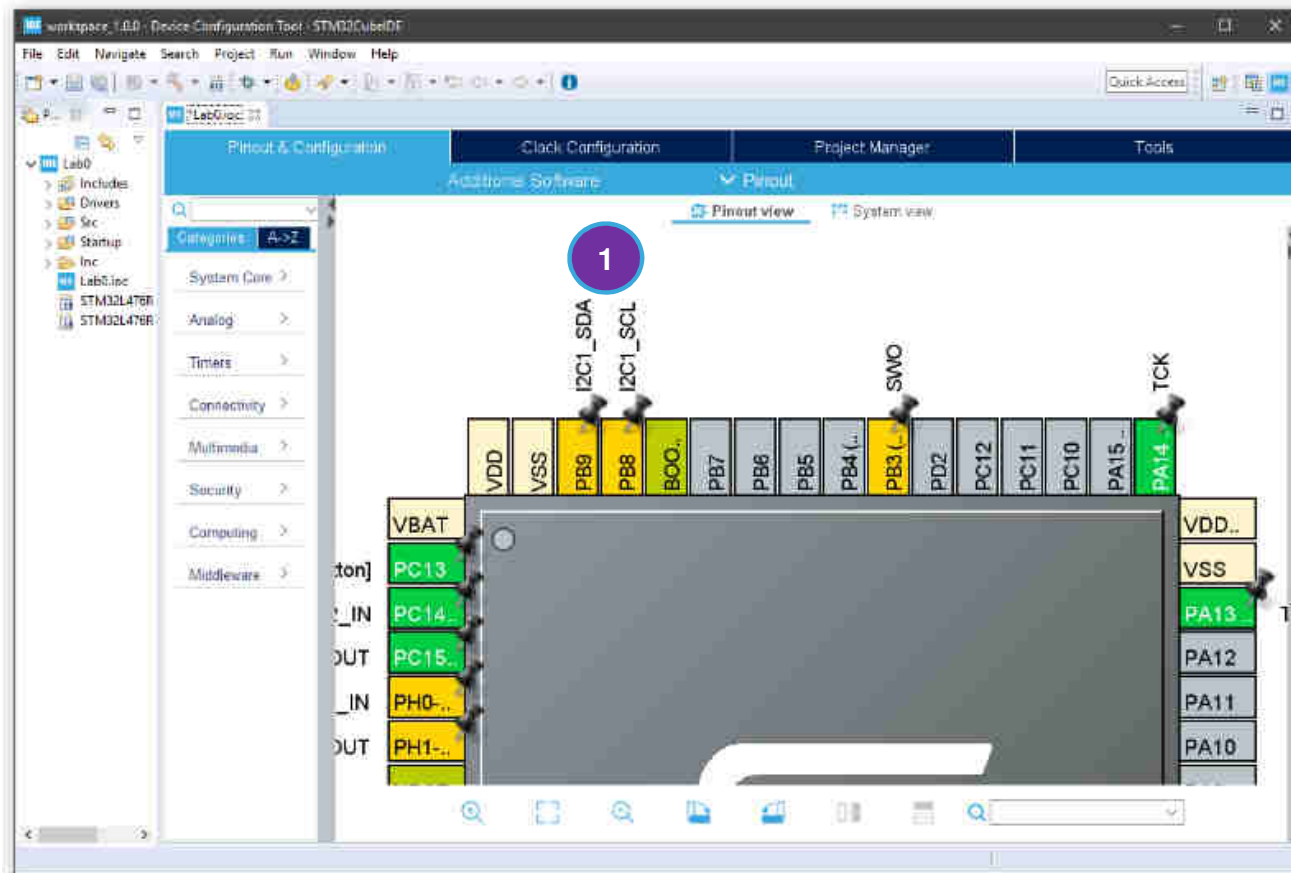
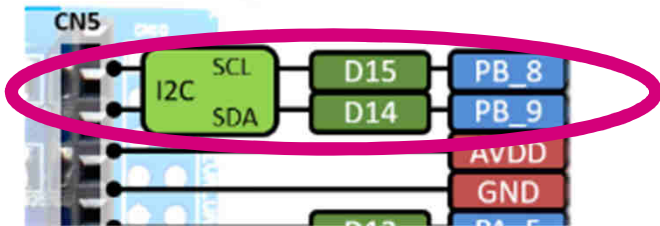
- ## 2. Select I2C1_SCL



Lab0 – Configure the I2C Bus

71

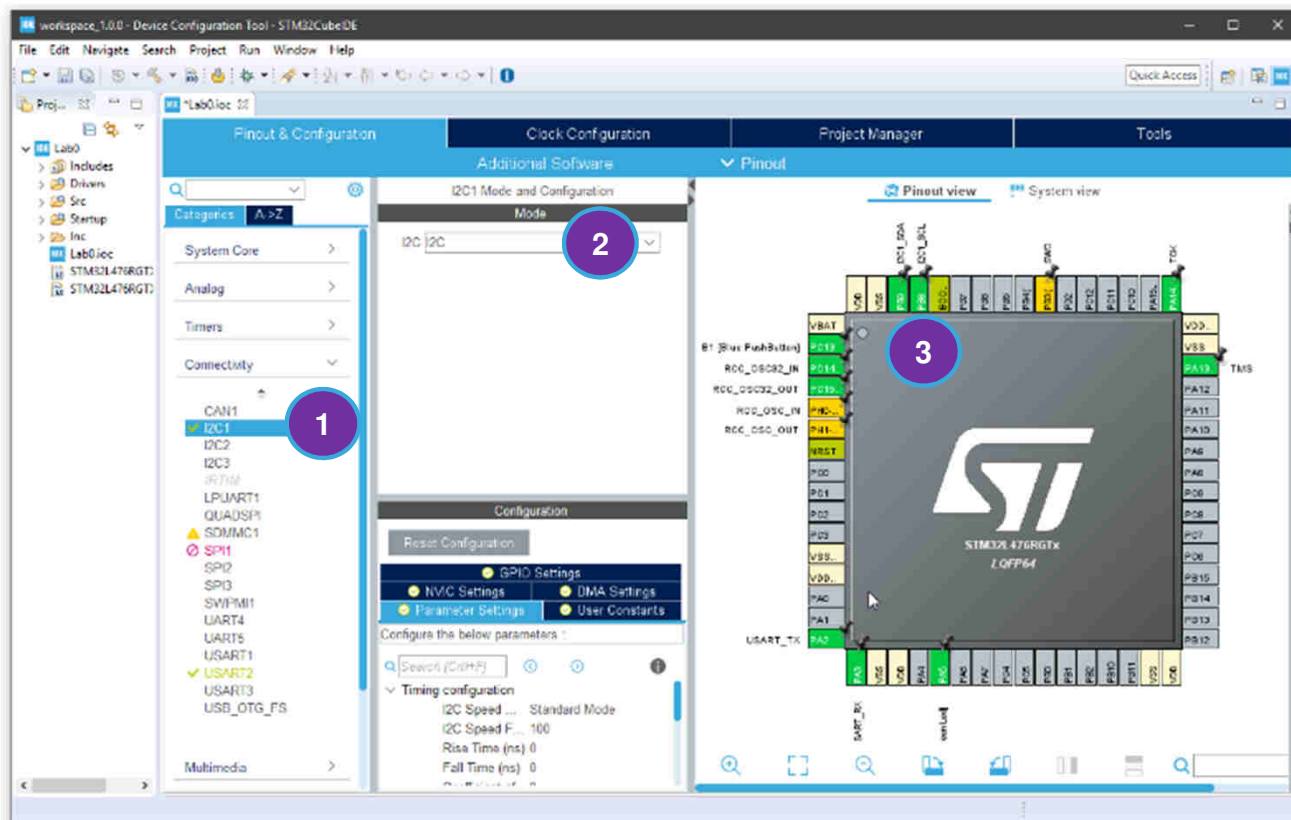
1. At this point I2C1 pins PB9 and PB8 should appear in yellow (selected but not configured)



Lab0 – Configure the I2C Bus

72

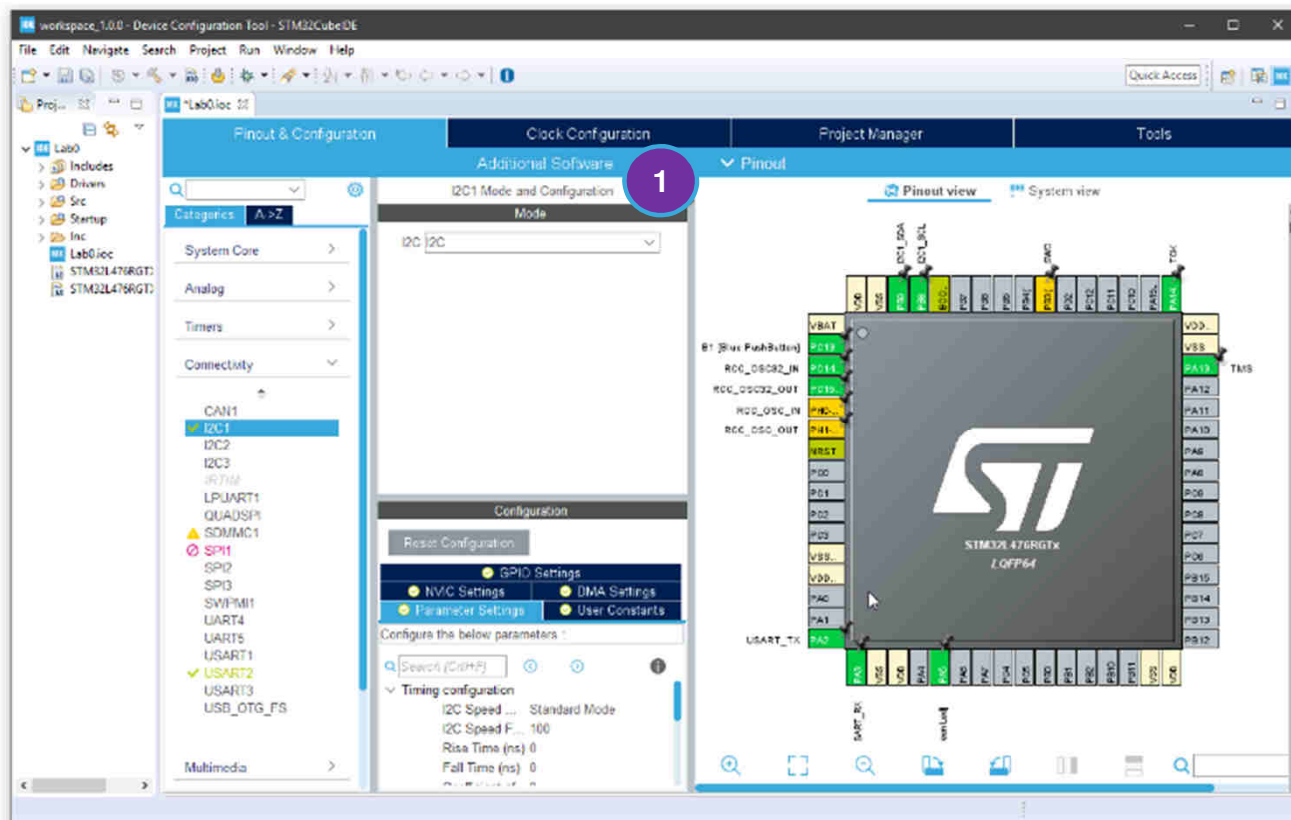
1. Expand *Connectivity* tab and check **I2C1**
2. Select **I2C** in *I2C1 Mode and Configuration*
3. PB8 and PB9 should now become green



Lab0 – Select the MEMS Library

73

1. Click on **Additional Software**



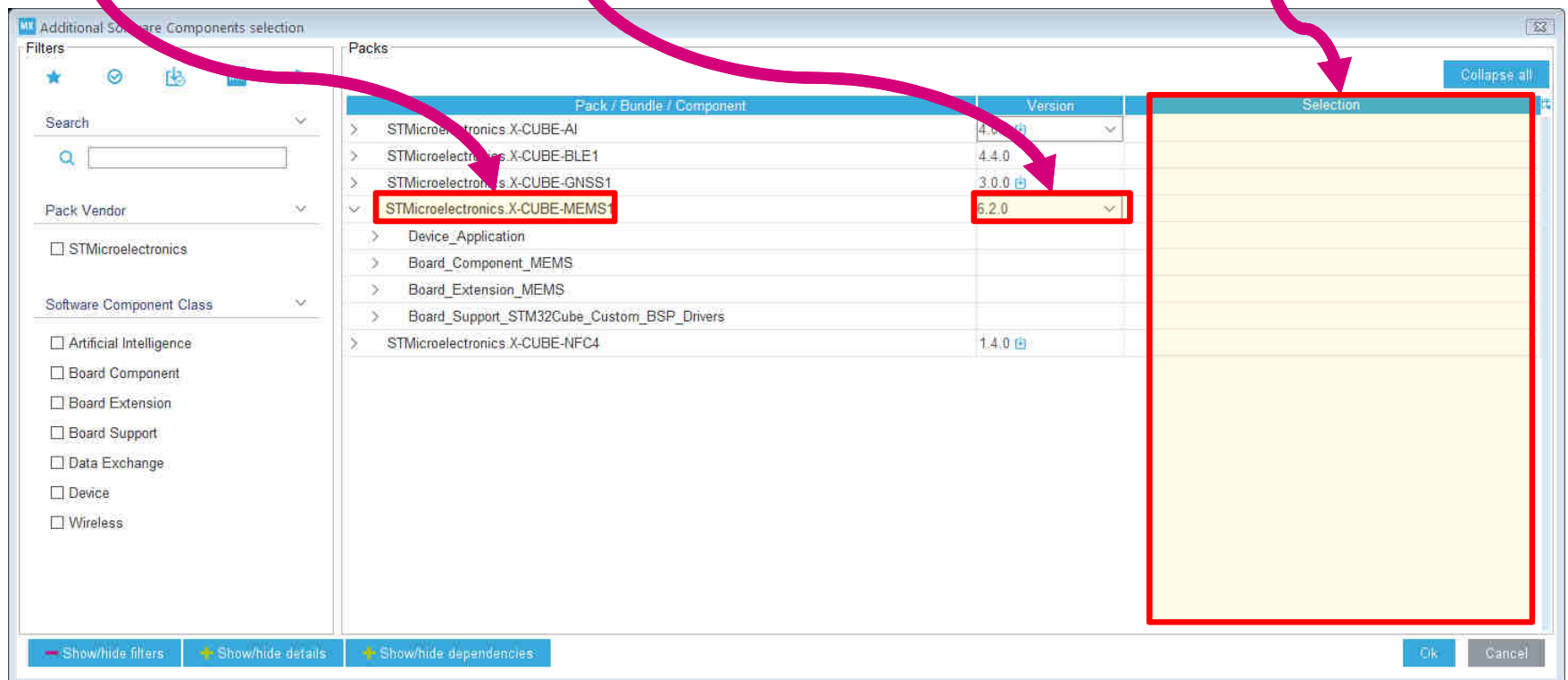
Additional Software Intro

74

X-CUBE-MEMS1/... will be the Pack/Bundle we are going to use in this hands-on

If multiple X-Cube packs, use latest version: here version **6.2.0**

If needed, enlarge the column **Selection** to see the options available

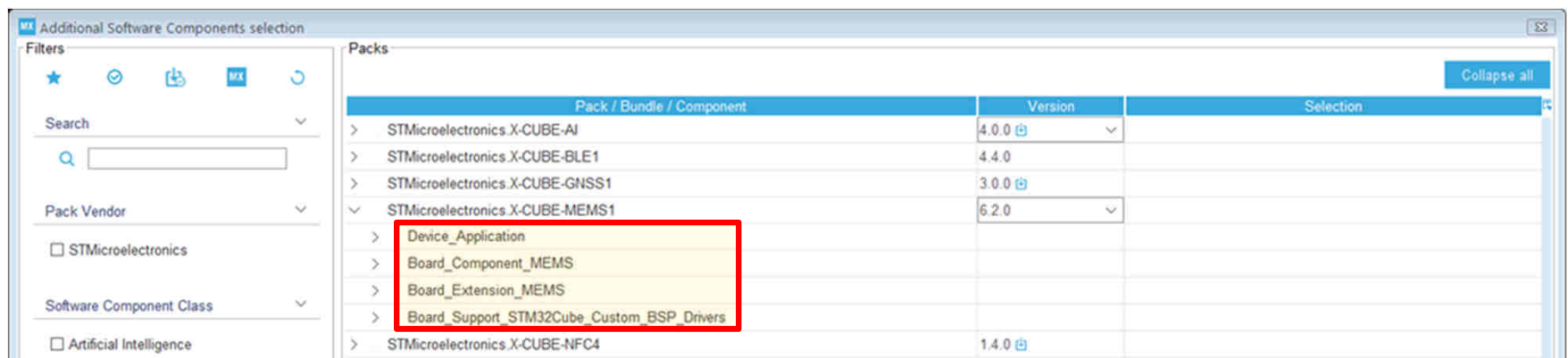


Additional Software Intro

75

There are two ways to use the X-CUBE-MEMS1 Pack/Bundle:

- If you are using the X-NUCLEO from STMicroelectronics
 1. Select the high level **Device** application. Example: **IKS01A3_DataLogTerminal**
 2. Select the **Board Extension** that you are using. Example: **IKS01A3**
- If you are using a custom expansion board
 1. Select the high level **Device** application. Example: **DataLogTerminal**
 2. Select the middle level **Board Support Pack (BSP)**. Example: **Custom/MOTION_SENSOR**
 3. Select the low level **Board Components**. Example: **AccGyr/LSM6DSO on I2C**



Additional Software Intro

76

There are two ways to use the X-CUBE-MEMS1 Pack/Bundle:

Lab0 - Lab 5

- If you are using the X-NUCLEO from STMicroelectronics
 1. Select the high level **Device** application. Example: **IKS01A3_DataLogTerminal**
 2. Select the **Board Extension** that you are using. Example: **IKS01A3**

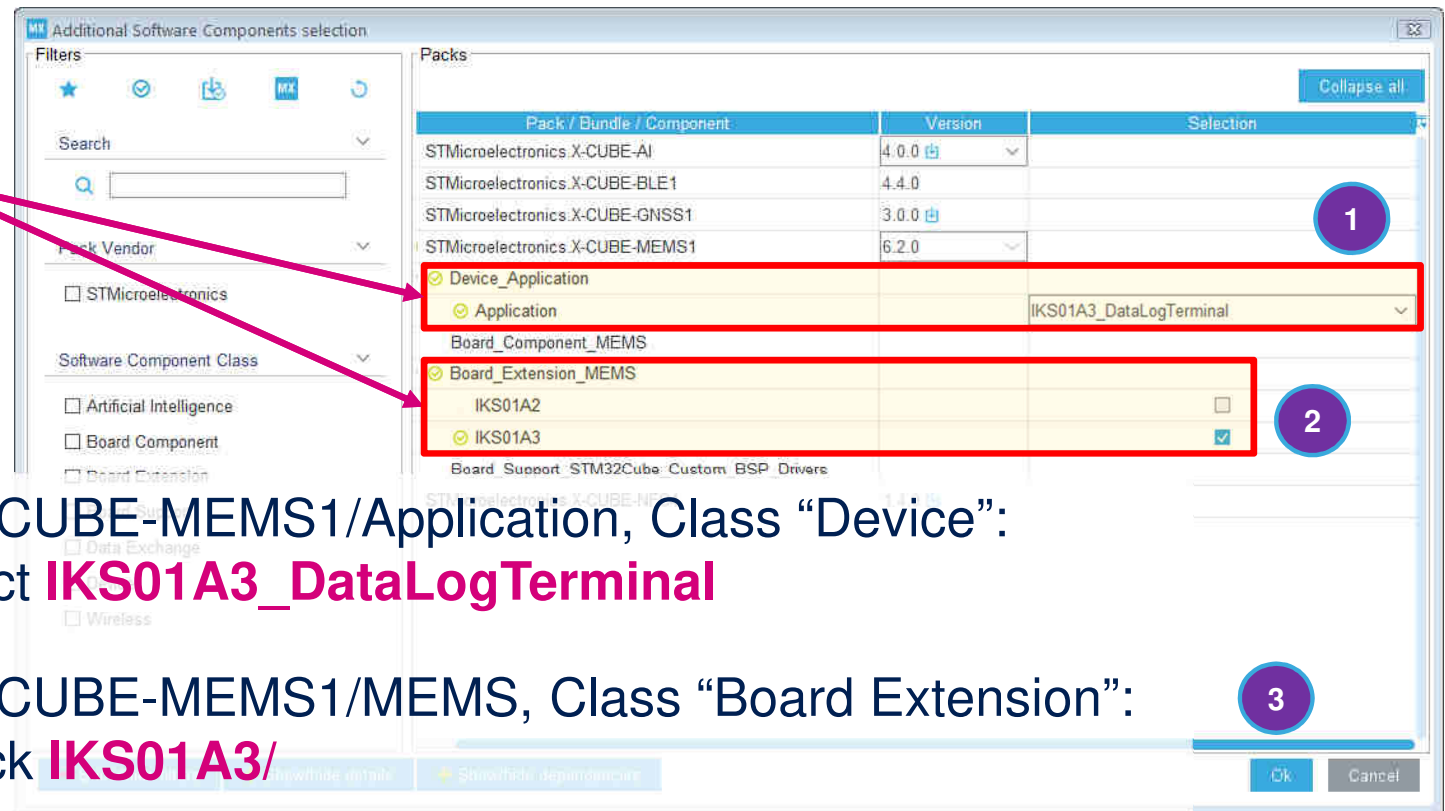
Lab6

- If you are using a custom expansion board
 1. Select the high level **Device** application. Example: **DataLogTerminal**
 2. Select the middle level **Board Support Pack (BSP)**. Example: **Custom/MOTION_SENSOR**
 3. Select the low level **Board Components**. Example: **AccGyr/LSM6DSO on I2C**

Lab0 – Select the MEMS Library

77

Click to
expand tree

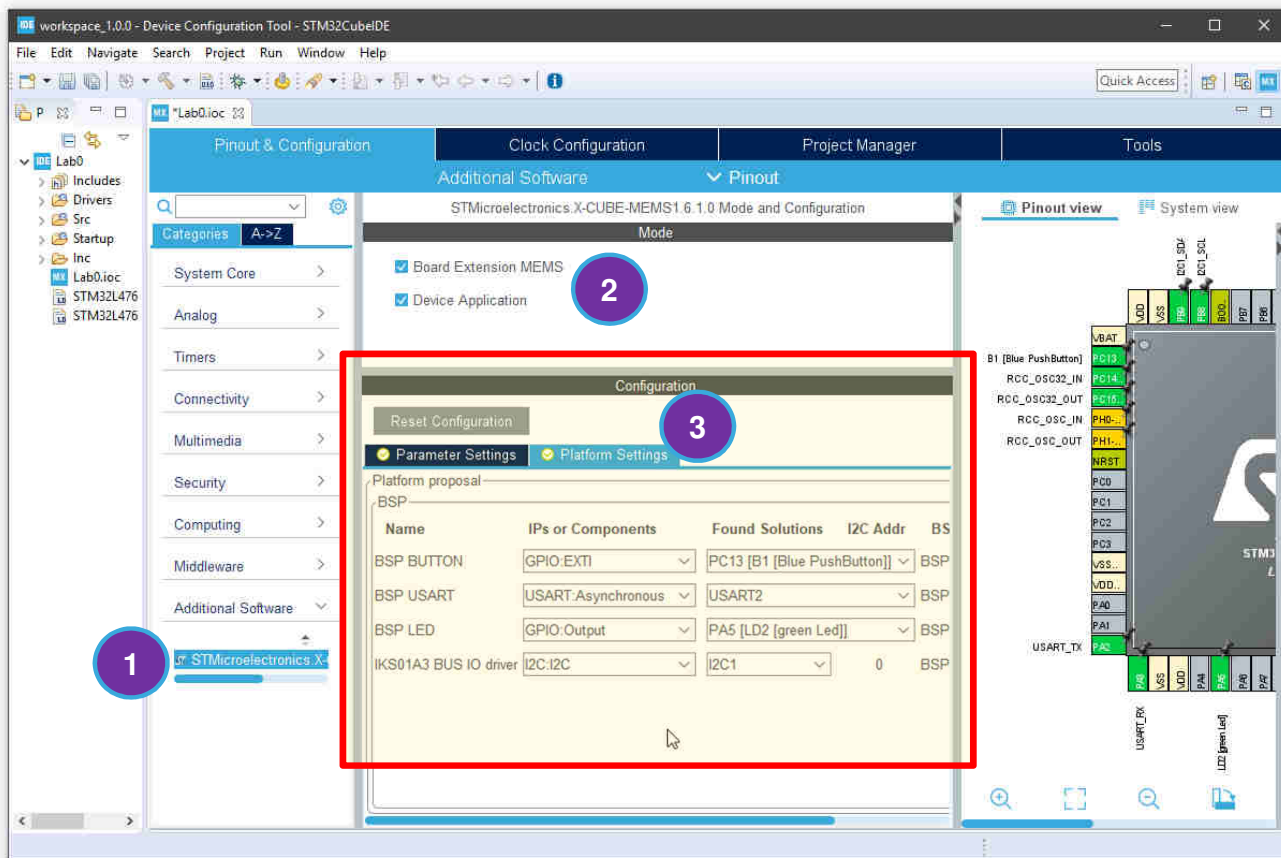


1. In X-CUBE-MEMS1/Application, Class “Device”:
Select **IKS01A3_DataLogTerminal**
2. In X-CUBE-MEMS1/MEMS, Class “Board Extension”:
Check **IKS01A3/**
3. Click **OK**

Lab0 – Configure the MEMS Library

78

1. Expand Additional Software and select the X-CUBE-MEMS1
2. Check both:
Board Extension MEMS
Device Application
3. Configure Platform Settings as in picture (details in next page)



Lab0 – Configure the MEMS Library

79

Configuration

Reset Configuration

Parameter Settings Platform Settings

Platform proposal

BSP

Name	IPs or Components	Found Solutions	I2C Addr	BS
BSP BUTTON	GPIO:EXTI	PC13 [B1 [Blue PushButton]]		BSP
BSP USART	USART:Asynchronous	USART2		BSP
BSP LED	GPIO:Output	PA5 [LD2 [green Led]]		BSP
IKS01A3 BUS IO driver	I2C:I2C	I2C1	0	BSP

Configuration

Pinout

Mode

Configuration

Pinout view

System view

Components

Found Solutions

I2C Addr

BS

EXTI

PC13 [B1 [Blue PushButton]]

BSP

Asynchronous

USART2

BSP

Output

PA5 [LD2 [green Led]]

BSP

IKS01A3 BUS IO driver

I2C:I2C

I2C1

0

BSP

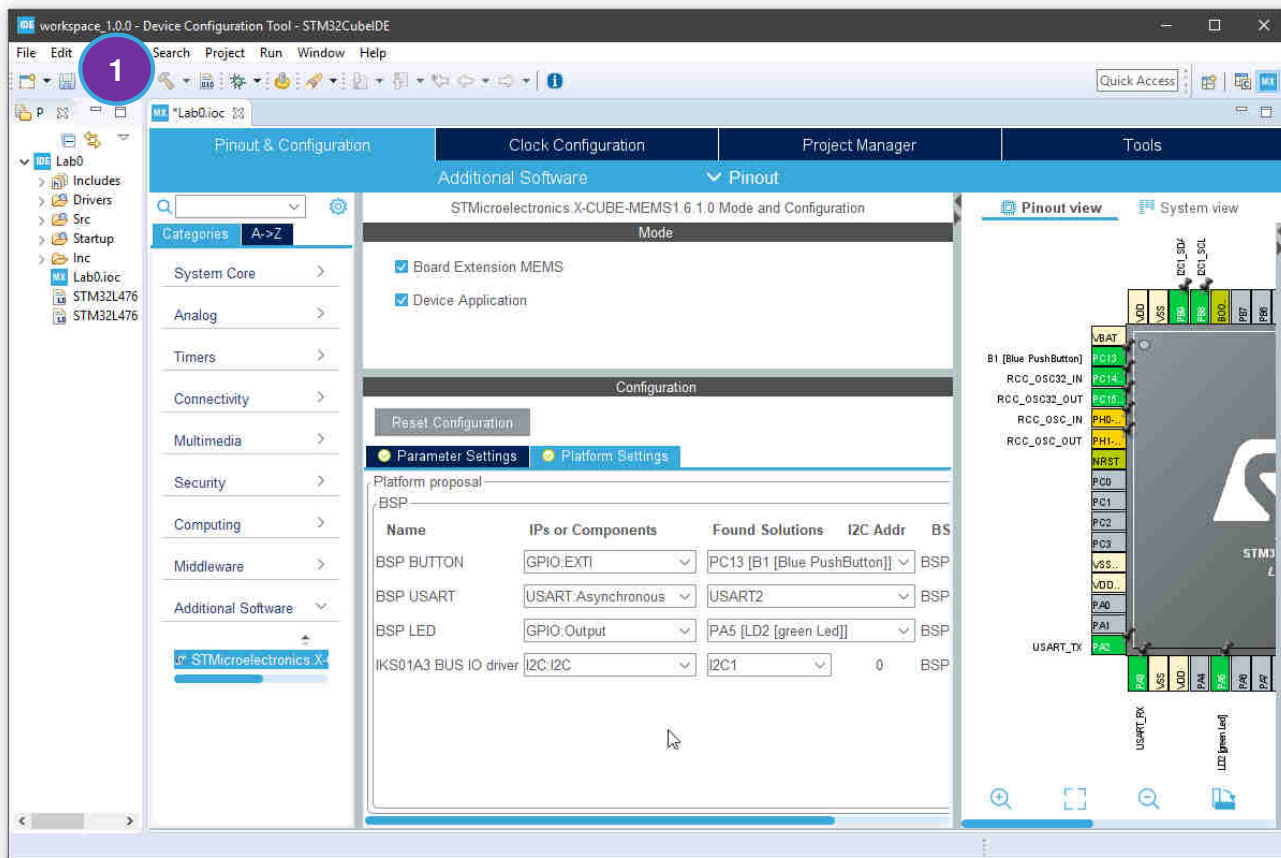
STMicroelectronics X-NUCLEO-IKS01A3

life.augmented

Lab0 – Save the Project

80

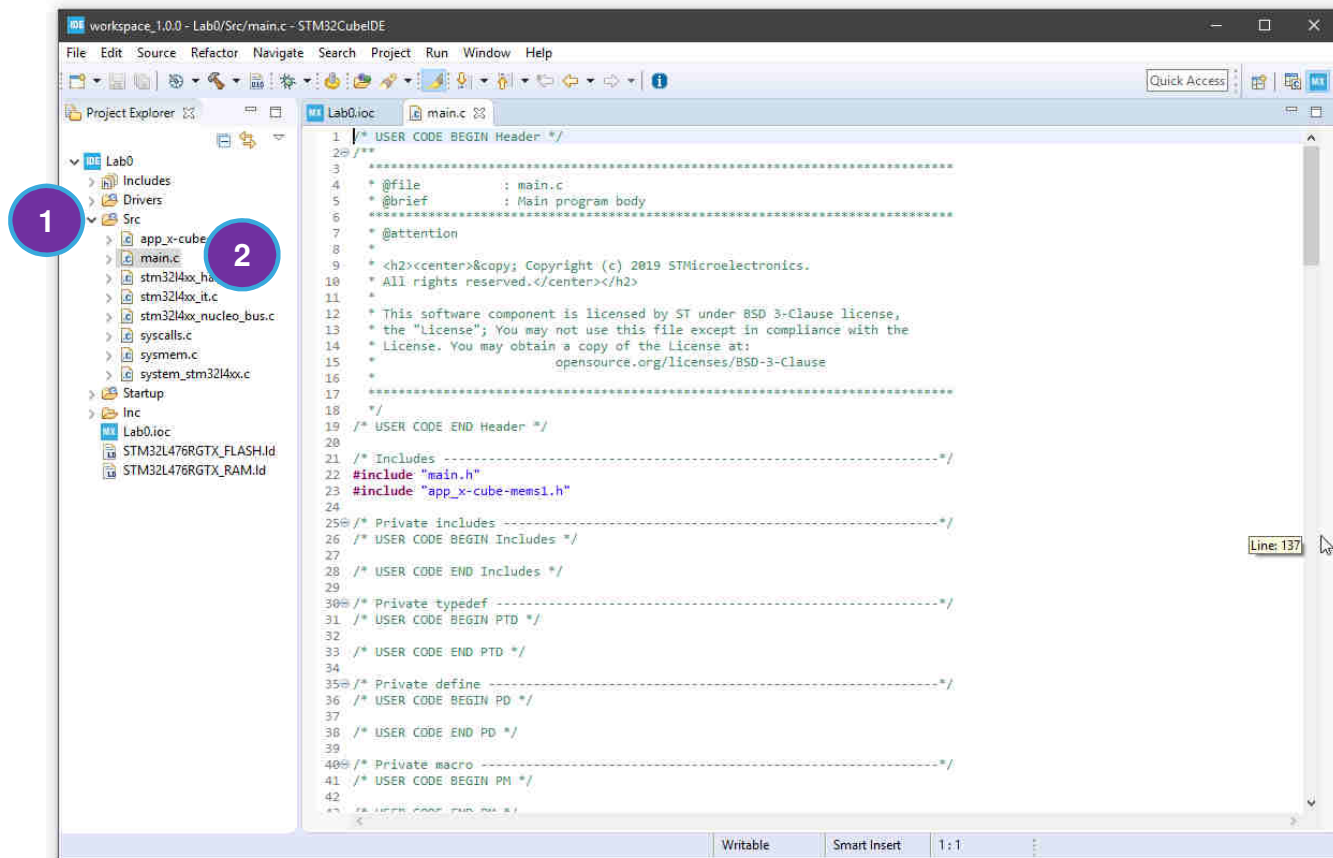
1. Click the save button



Lab0 – Code Editing

82

1. Expand **Src**
2. Double click on **main.c**

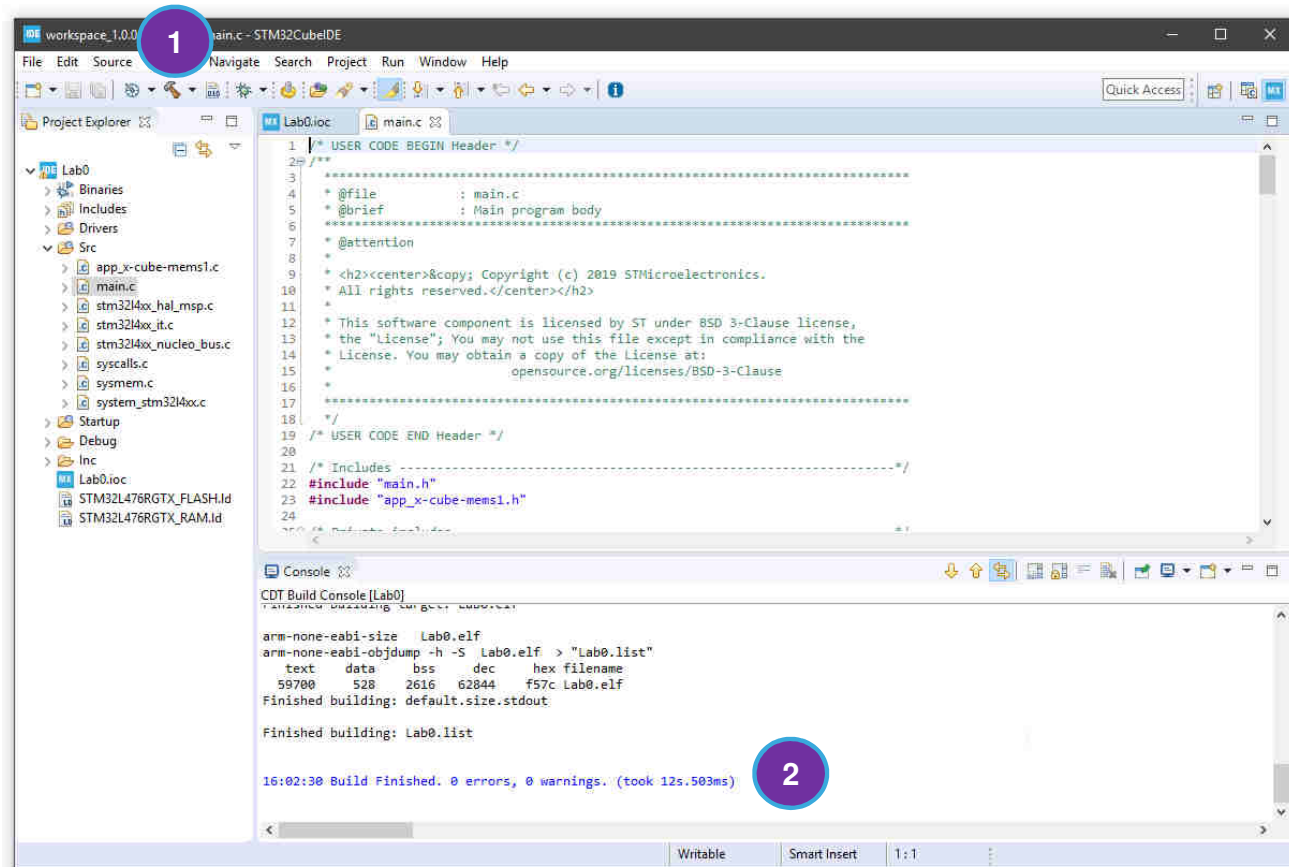


Lab0 - Compiling

83

1. Click on the hammer  to begin compilation, or press **CTRL+B**

2. Compilation should terminate with 0 errors and 0 warning



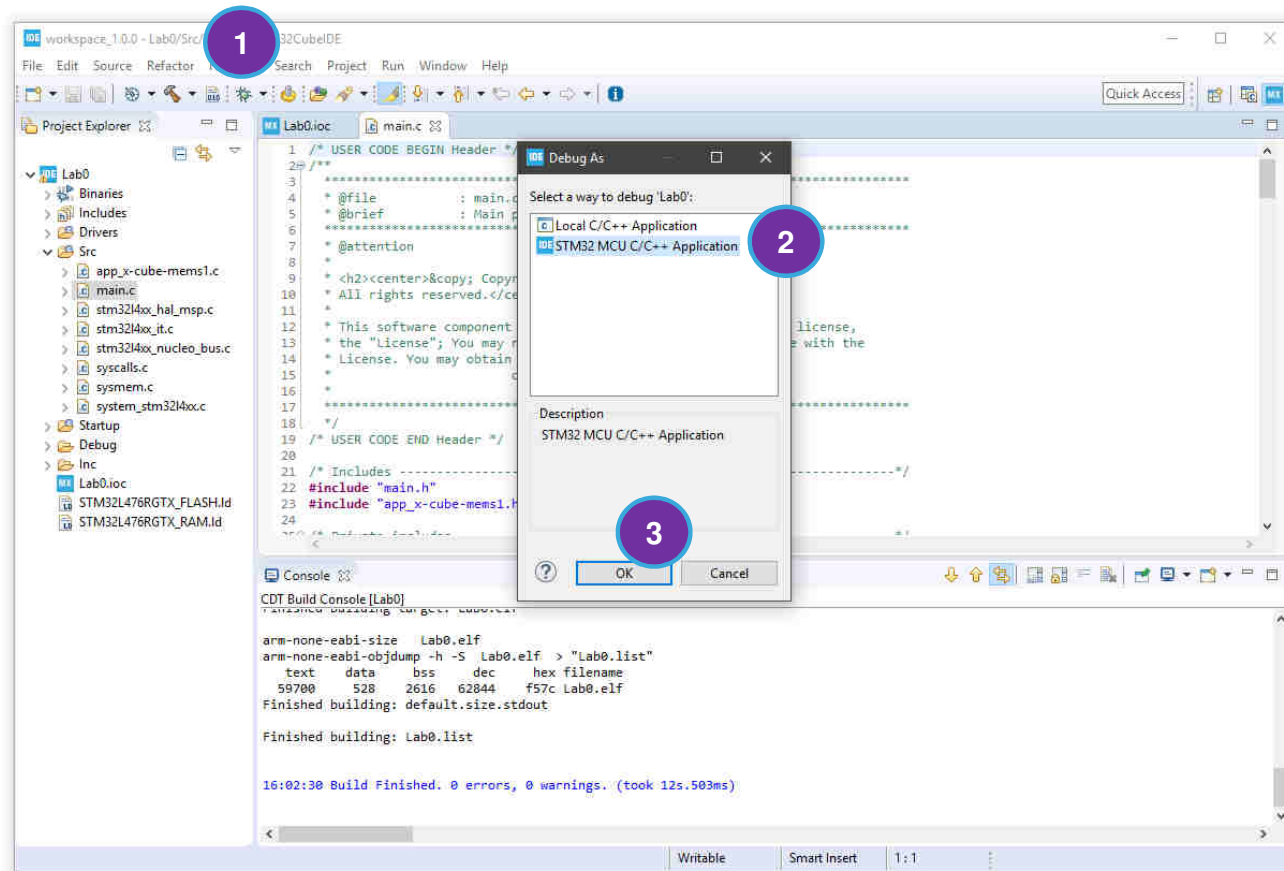
Lab0 - Debugging

84

1. Click on the bug  to begin debugging

2. Select **STM32 MCU C/C++ App**

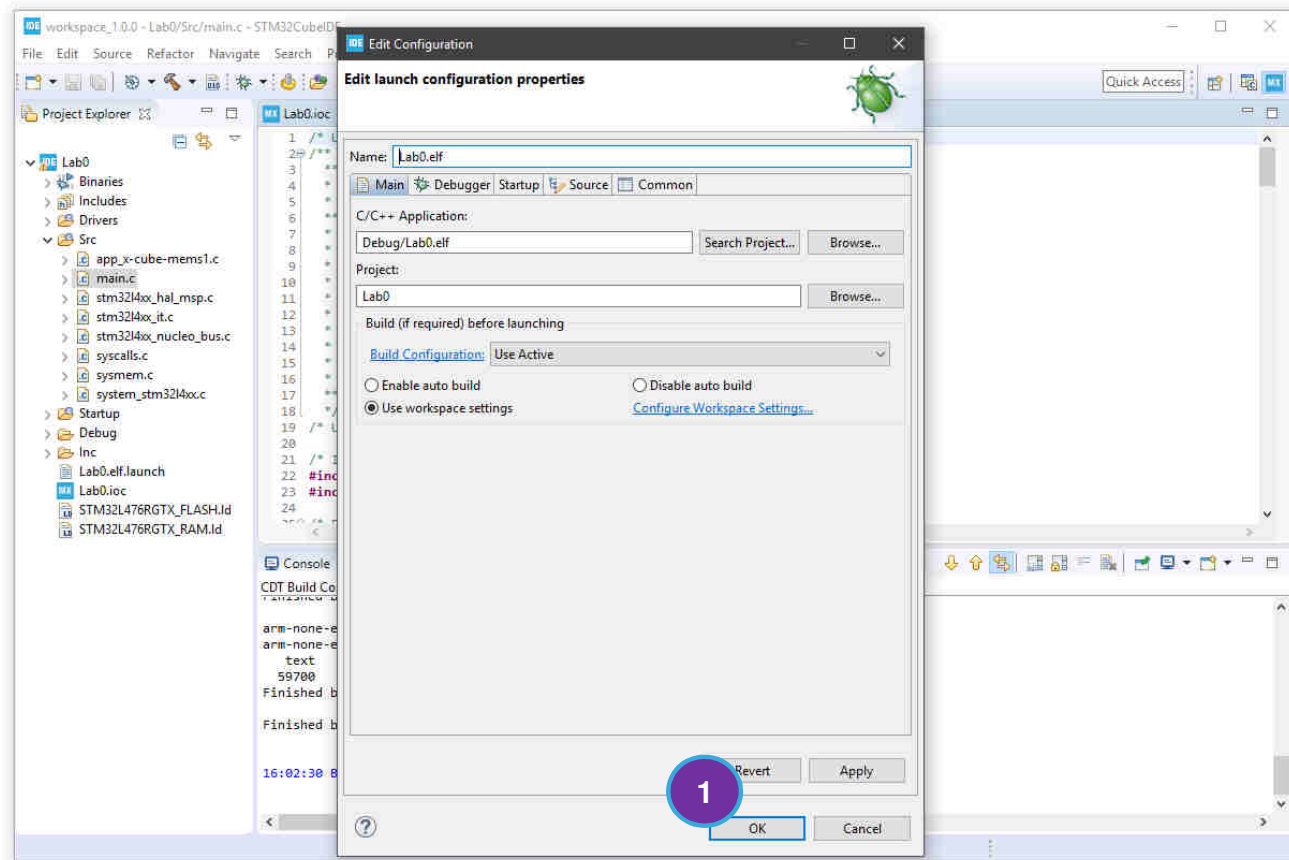
3. Click **OK**



Lab0 - Debugging

85

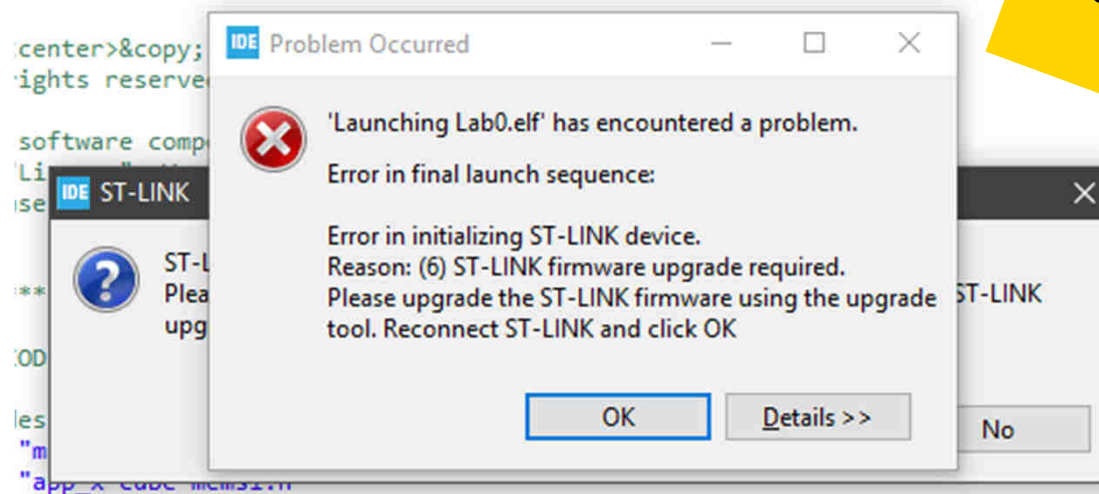
1. Click **OK**



Lab0 - Debugging

86

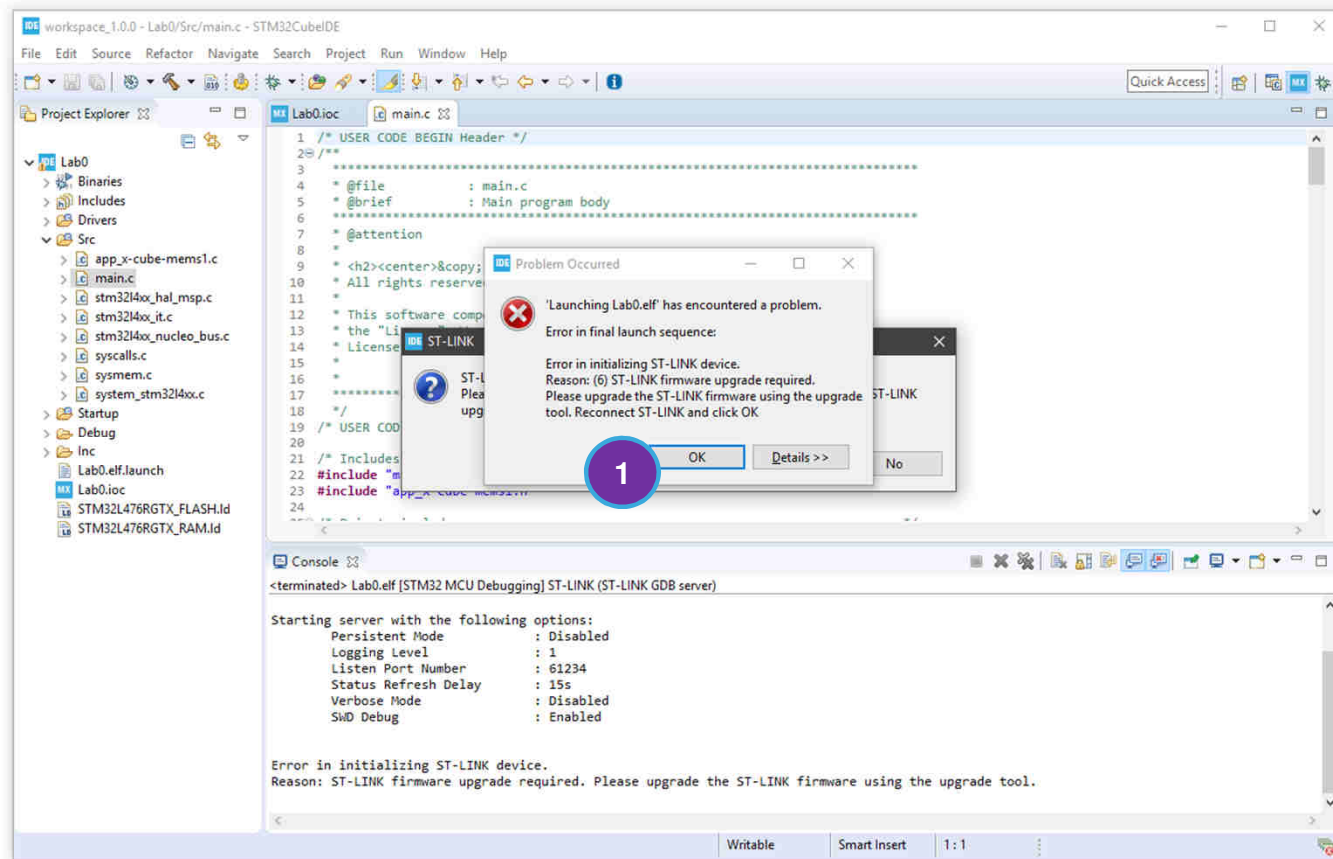
- The first time you debug the board by pressing , a **Problem Occurred** because ST-LINK needs to be upgraded



New NUCLEO boards
always need to be
upgraded

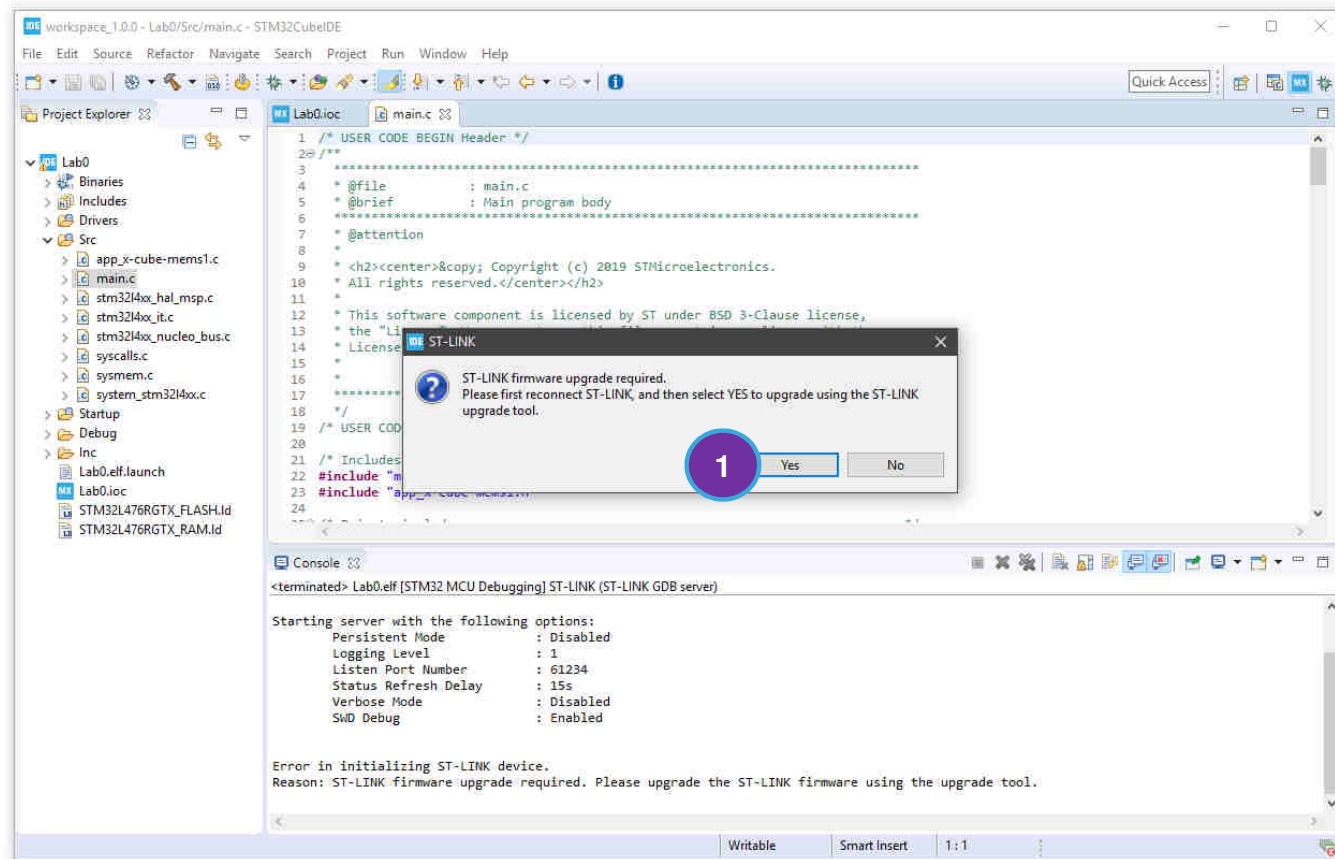
Lab0 – Updating ST-LINK 87

1. Click **OK** to run upgrade to latest firmware



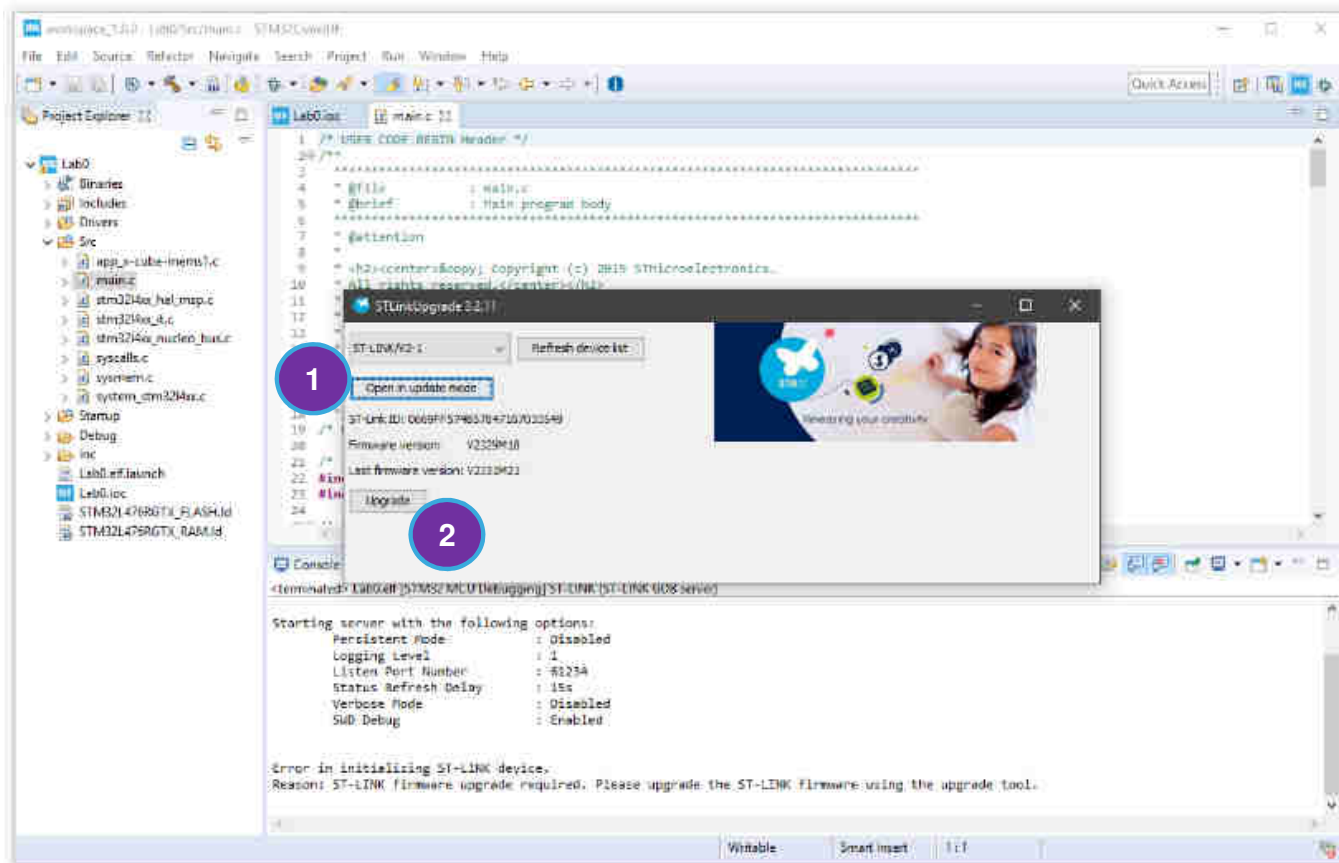
Lab0 – Upgrading ST-LINK 88

1. Click **Yes** when is asked to upgrade the ST-LINK



Lab0 – Upgrading ST-LINK 89

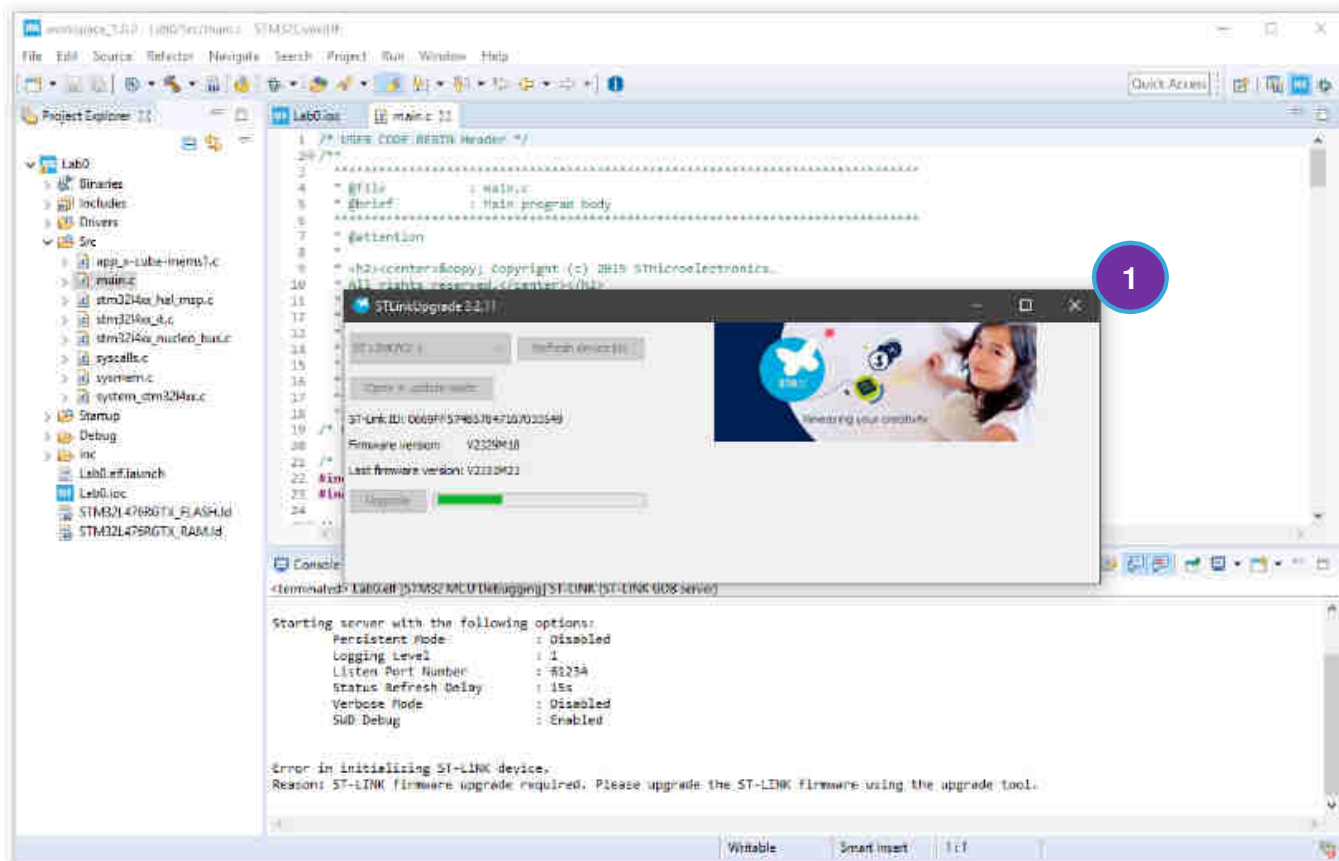
1. Click **Open in update mode** to force ST-LINK
2. Click on **Upgrade**



Lab0 – Upgrading ST-LINK 90

Wait until update is finished and then close the window.

1. Click on **X** when finished



91

- 

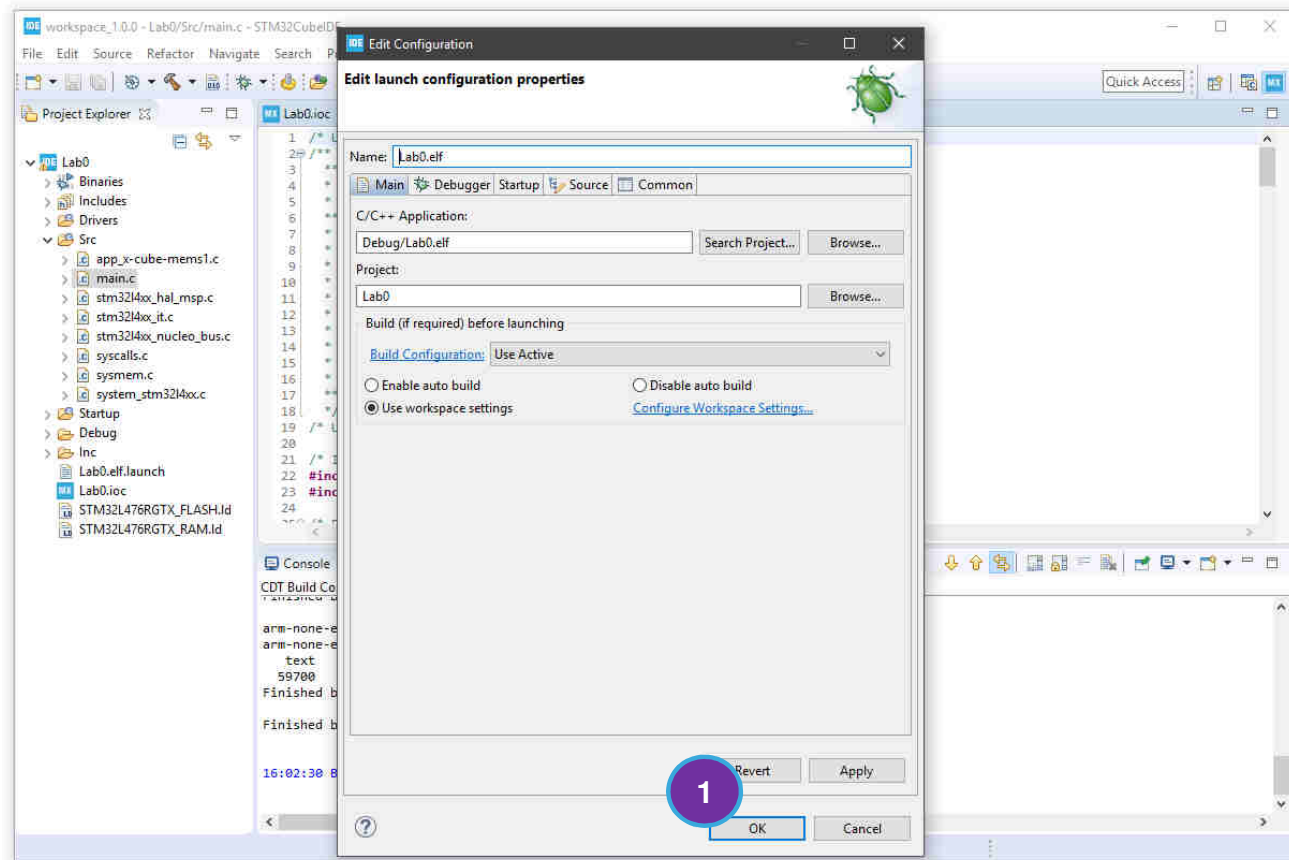
- ### 3. Click **OK**



Lab0 - Debugging

92


1. Click **OK**

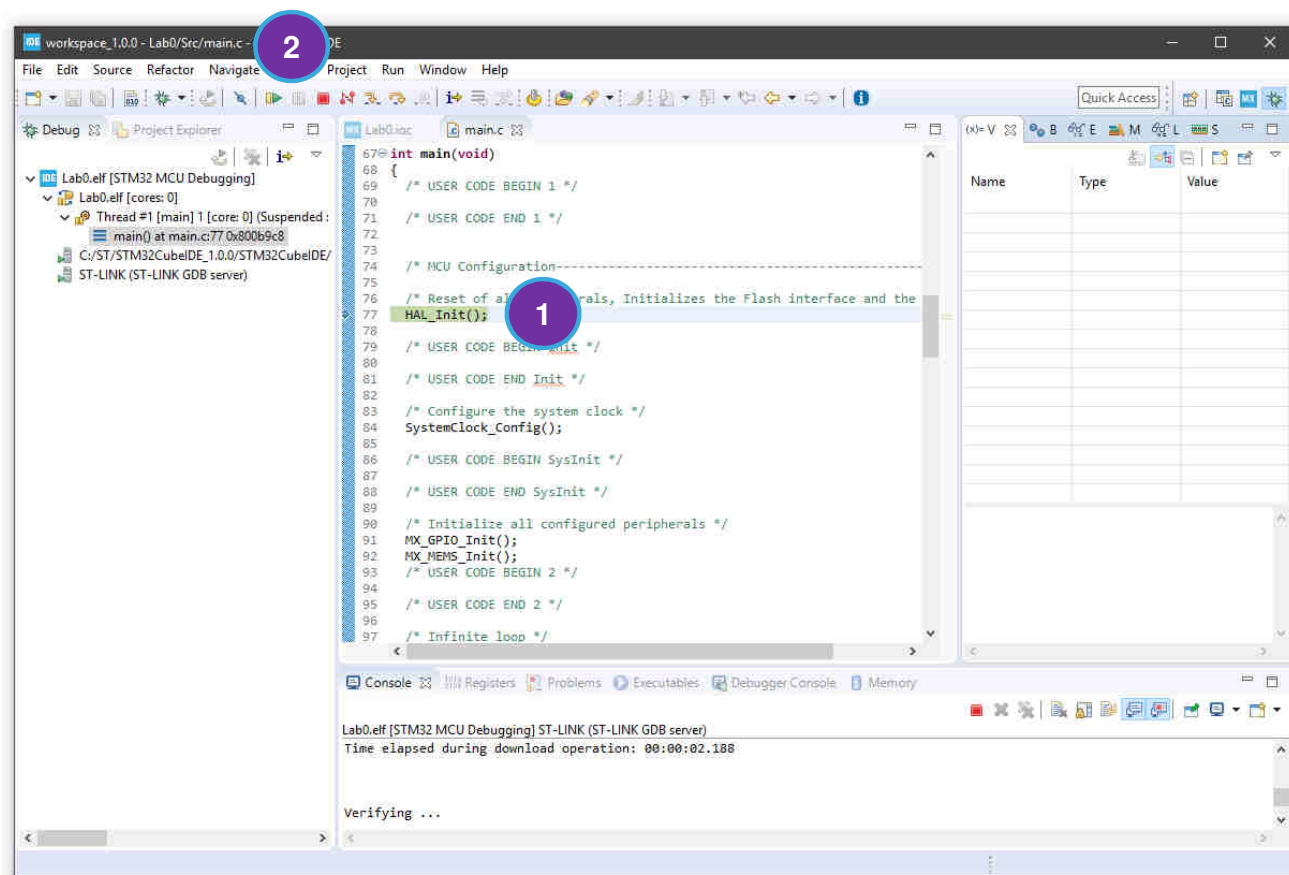


Lab0 - Debugging

93

1. Code start at the first line of the main function

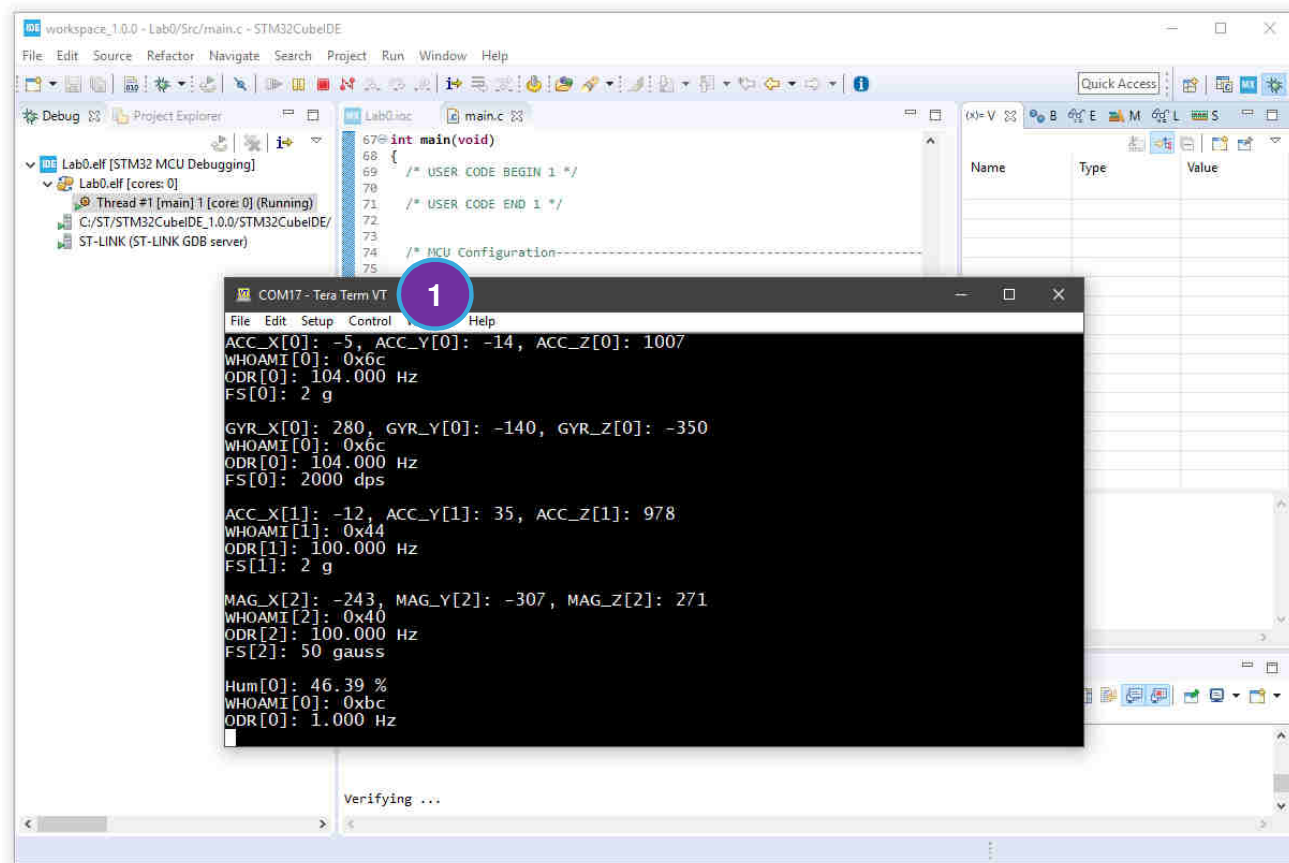
2. Click play  button to run the code



Lab0 - Debugging

94

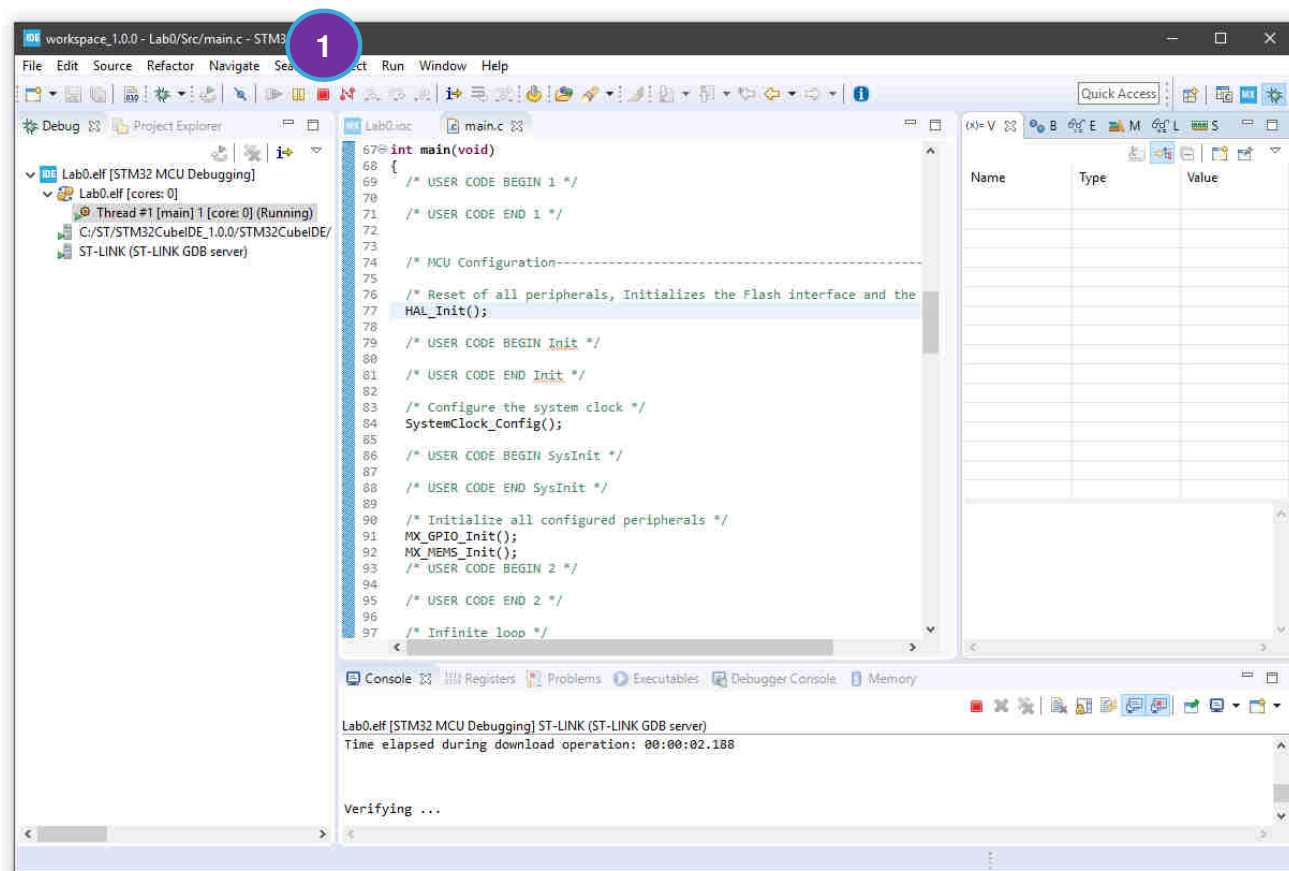
1. Open Tera Term to view the output



Lab0 - Debugging

95

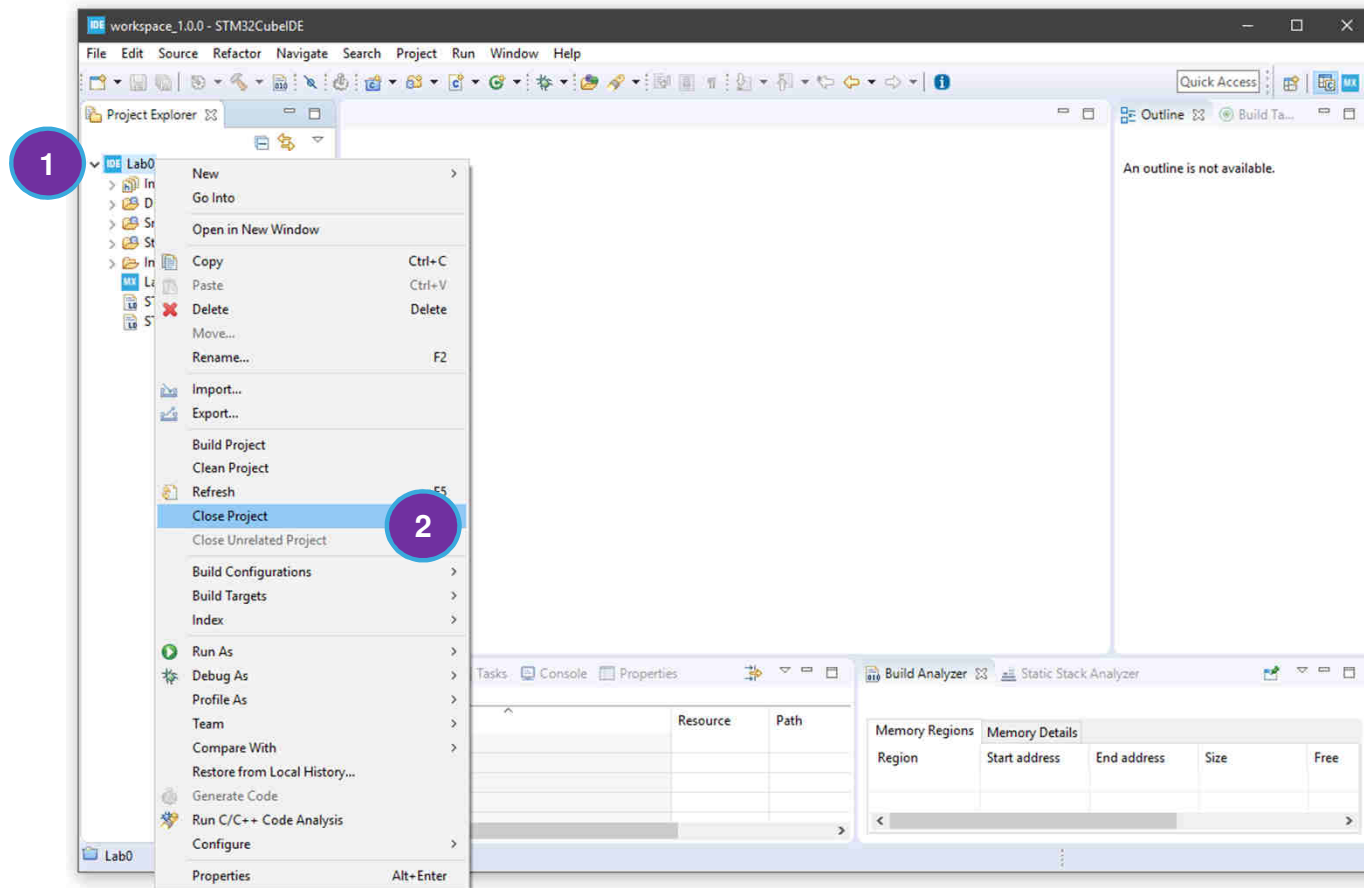
1. Click stop  button to interrupt the debugging



Lab0 – Closing the Project

96

1. Right-Click on **Lab0** project
2. Click on **Close Project**



LAB1



Goals:

- Configure a new project using X-CUBE-MEMS1
- **Configure LIS2DW12 accelerometer in order to generate an interrupt at every orientation change**
- Enable interrupts in STM32CubeIDE
- Visualizing the new orientation on Tera Term

Power saving and flexible Accelerometer

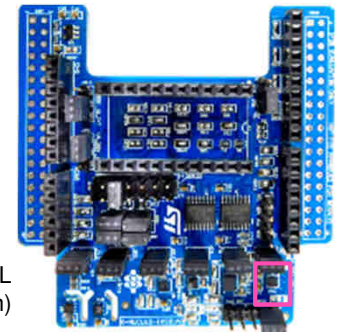
- Down to 0.38 μA power consumption (1.6Hz ODR)
- High Perf. mode: up to 1600Hz with noise density 90 $\mu\text{g}/\sqrt{\text{Hz}}$
- 5 Power Modes + 2 Noise Modes
- 32-level FIFO buffer
- Digital Features
 - Free fall
 - Wake-up
 - 6D / 4D
 - Stationary/Motion detection
 - Double Tap

Enabling battery saving

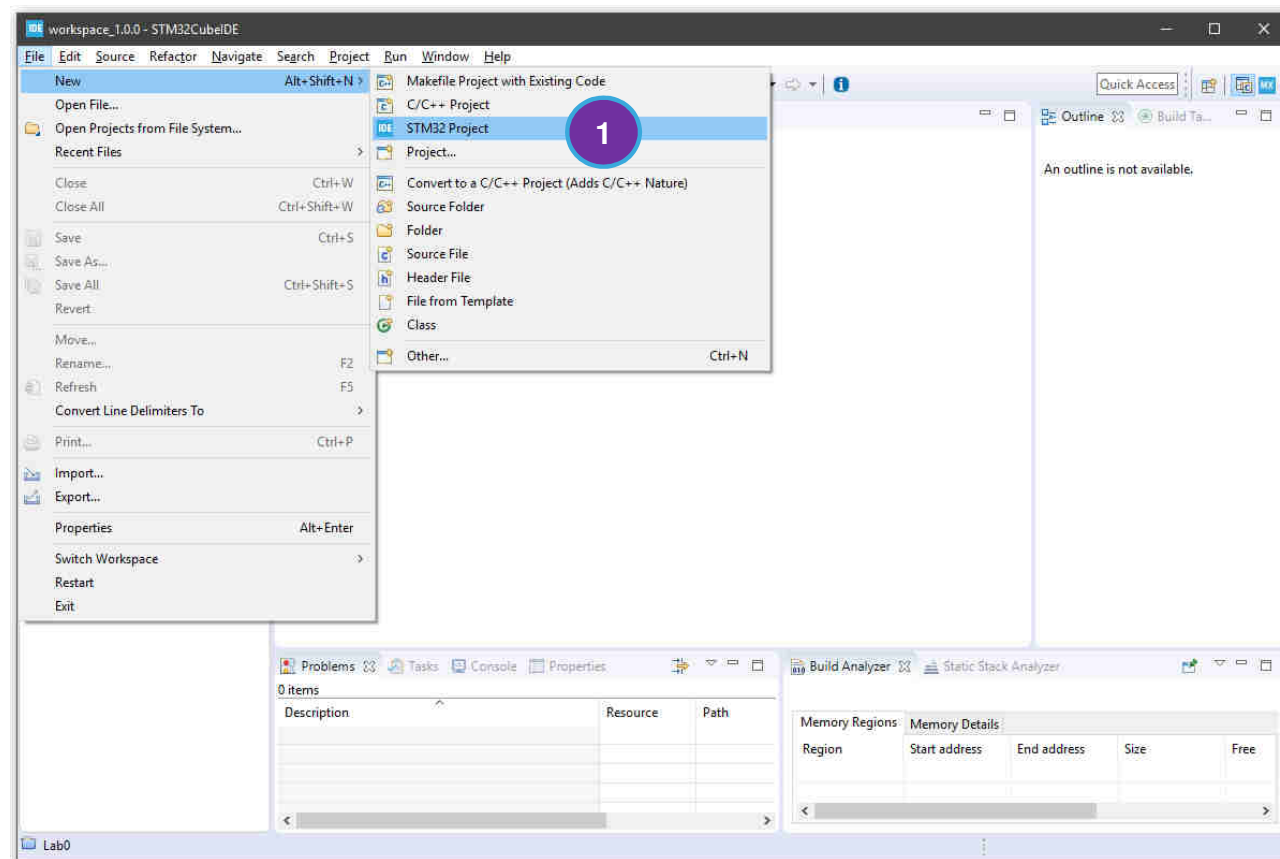
Accuracy

High Flexibility

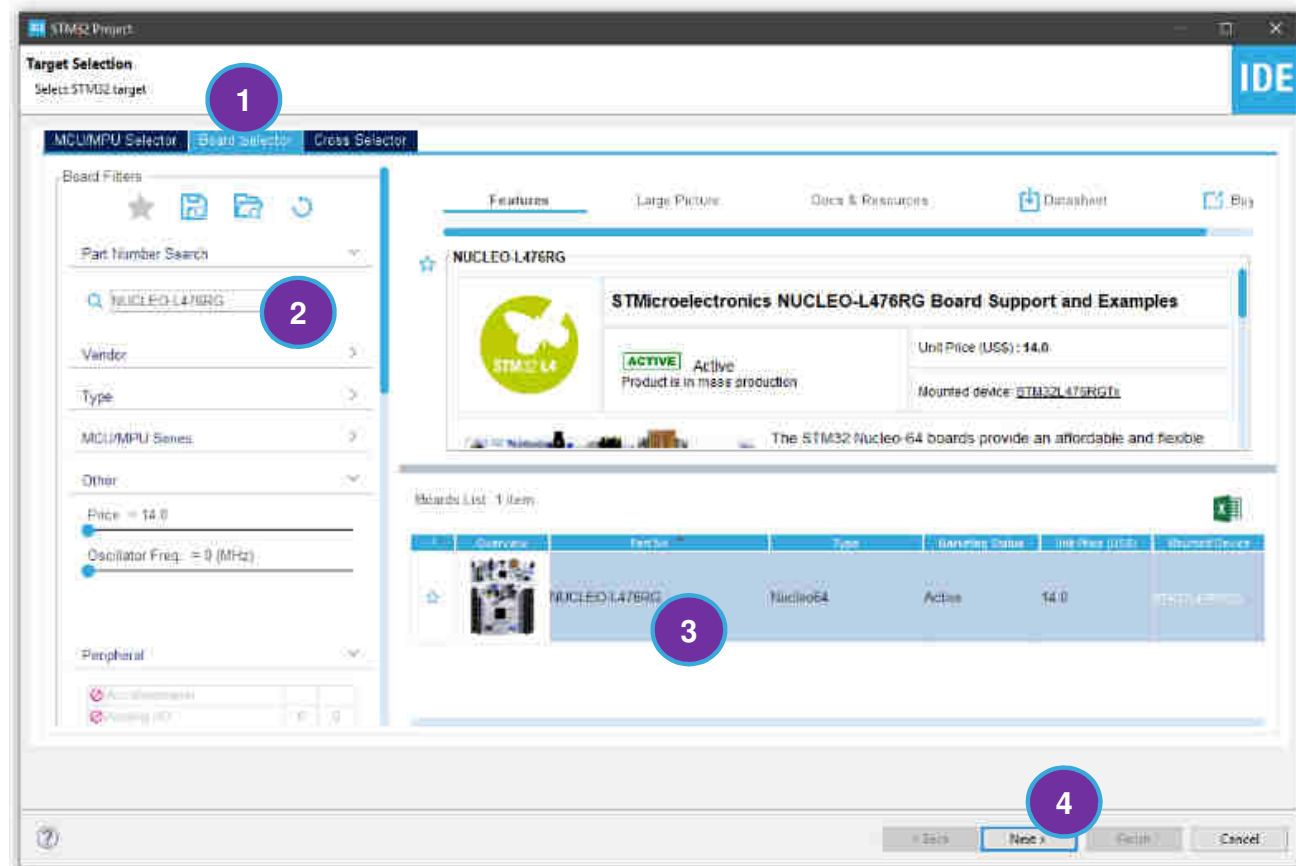
System Power Saving & Smart Functions



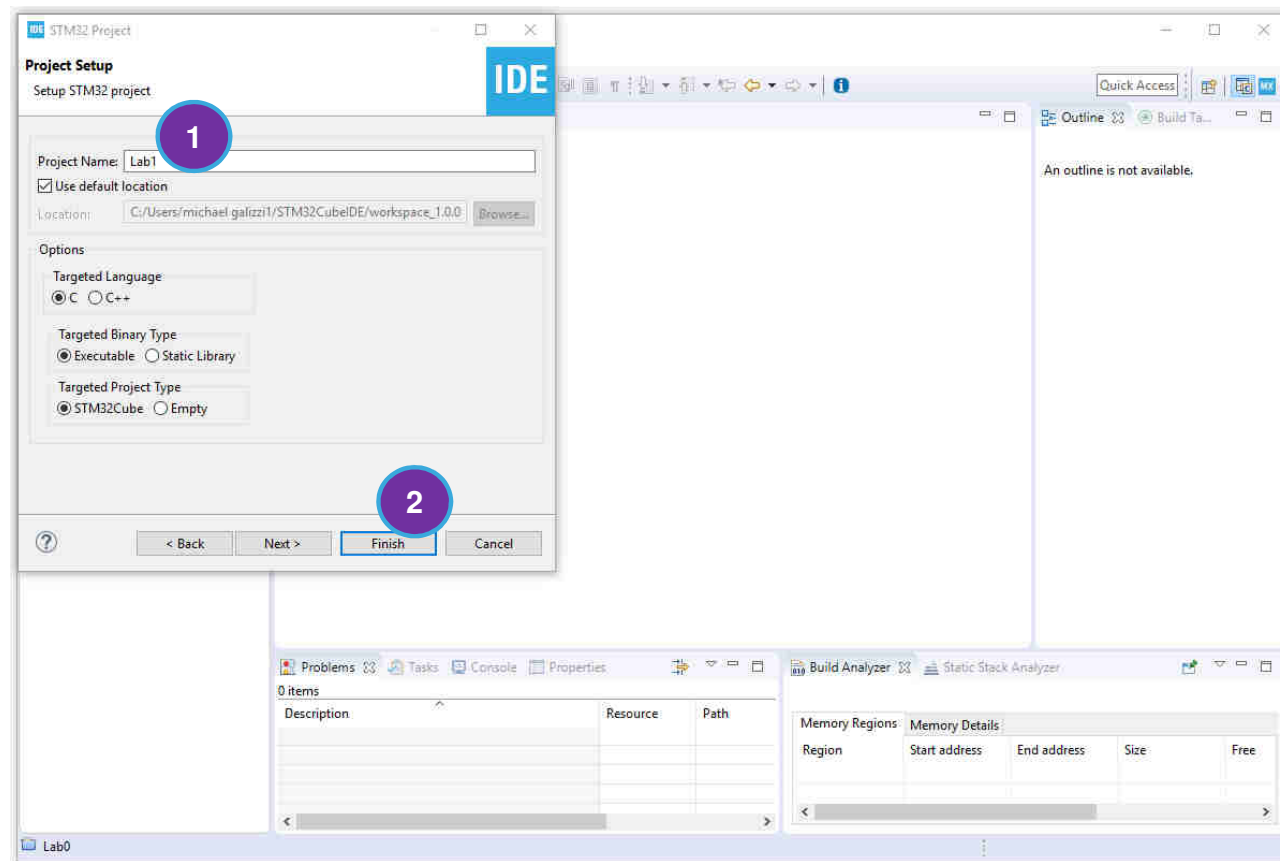
1. Click on **File > New > STM32 Project**



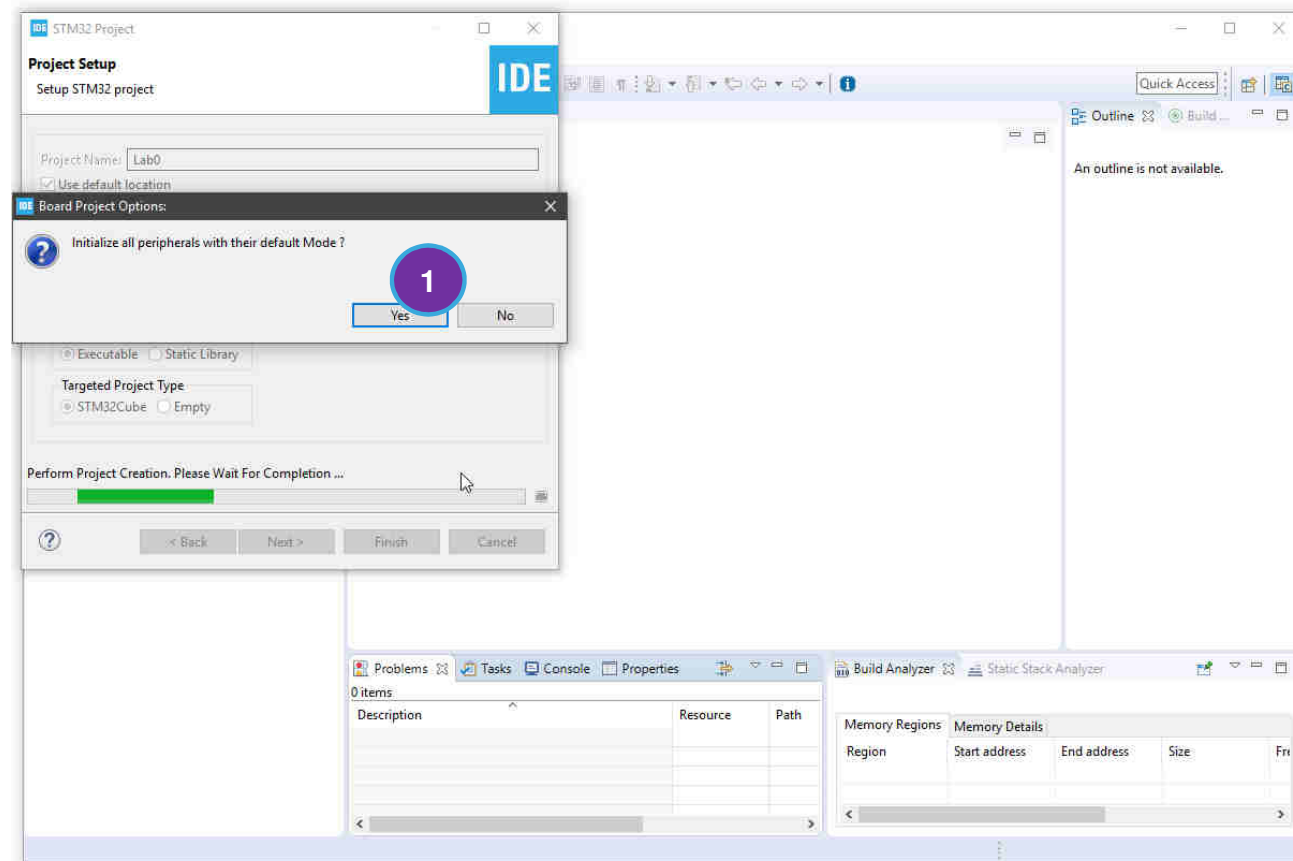
1. Click on **Board Selector**
2. Type **NUCLEO-L476RG**
3. Click on the board
4. Click **Next >**



1. Project Name **Lab1**
2. Click **Finish**

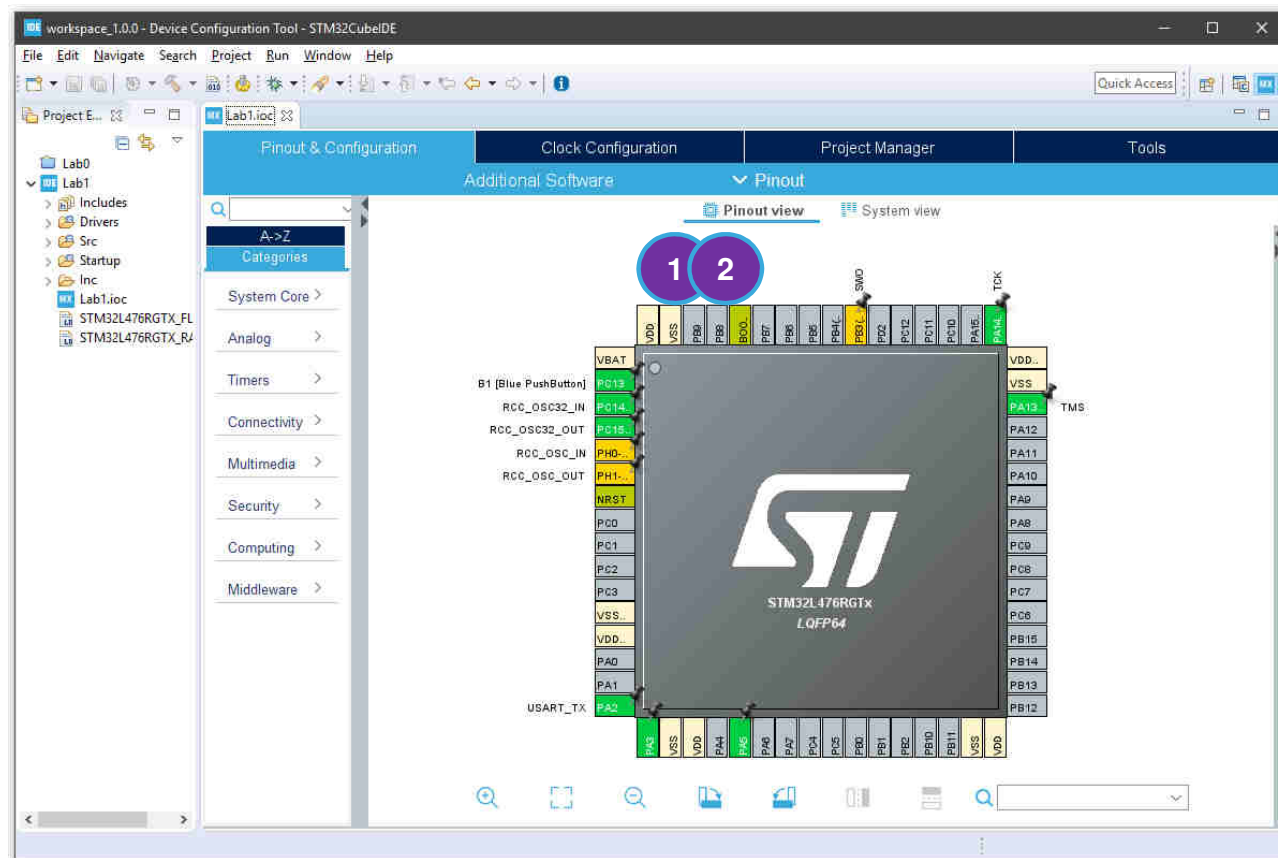
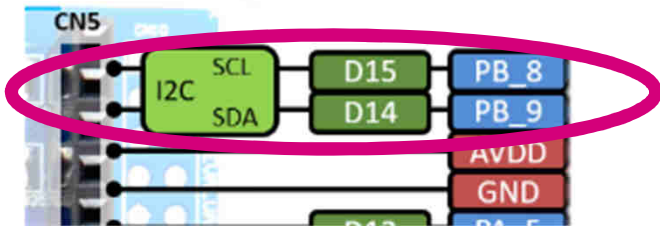


1. Click **Yes** to init peripherals in default mode



Lab1 – Configure the I2C Bus 103

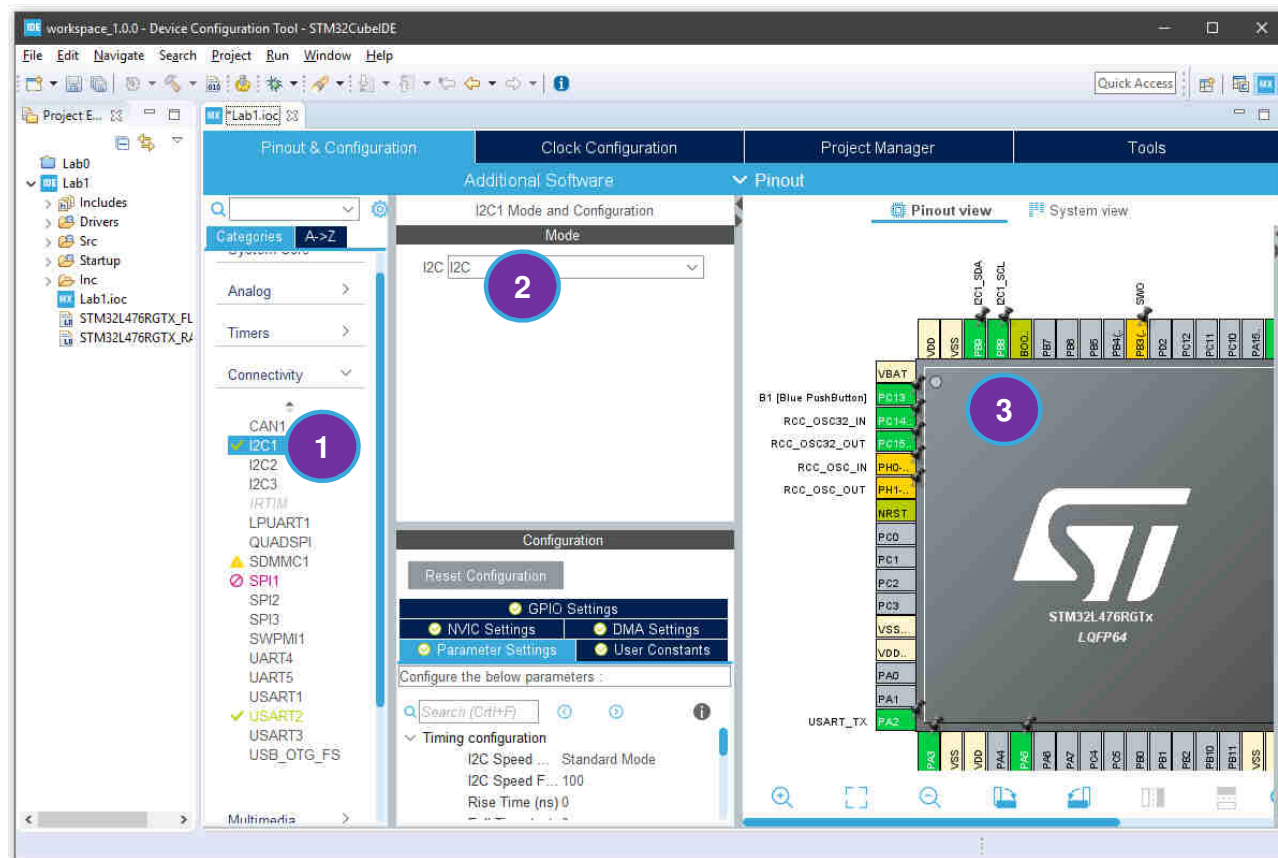
1. Left Click on **PB9** and select I2C1_SDA
2. Left Click on **PB8** and select I2C1_SCL



Lab1 – Configure the I2C Bus

104

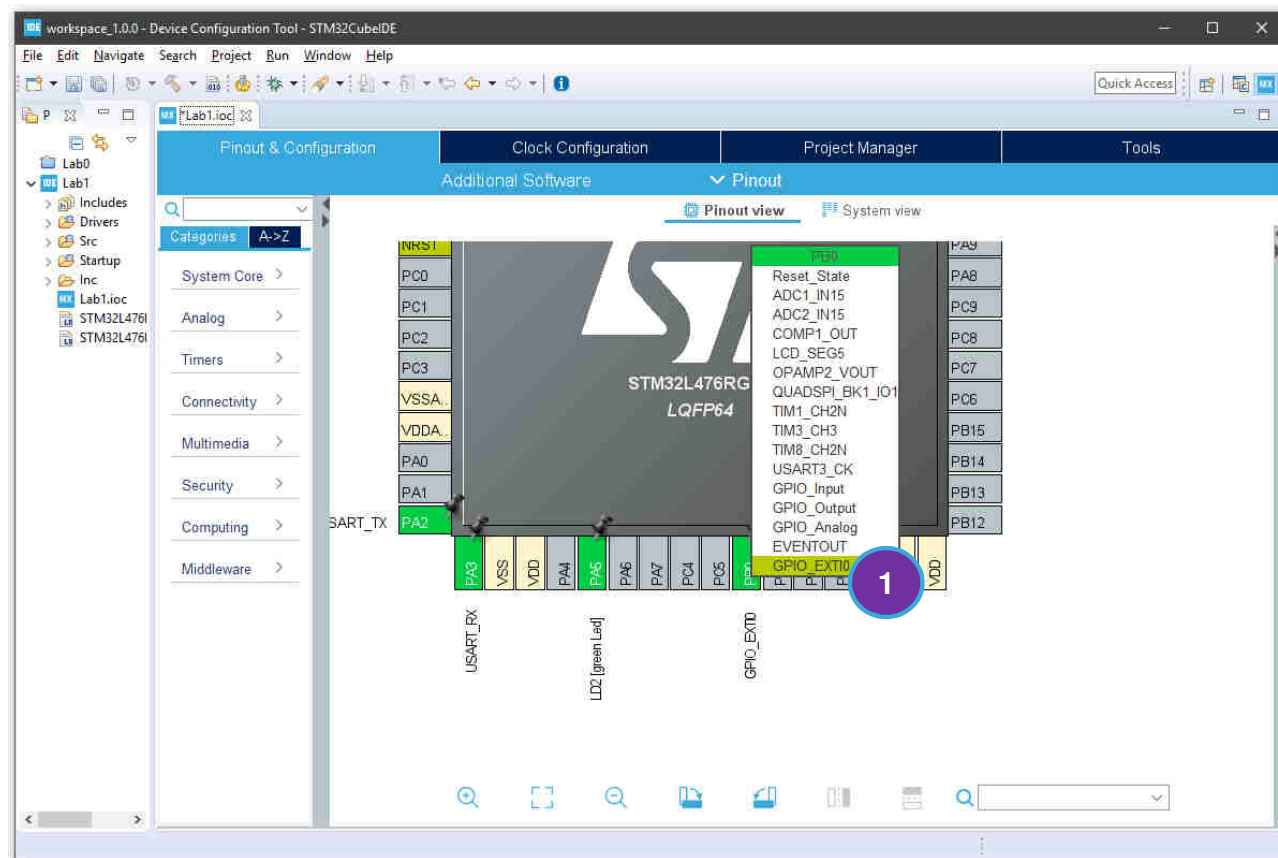
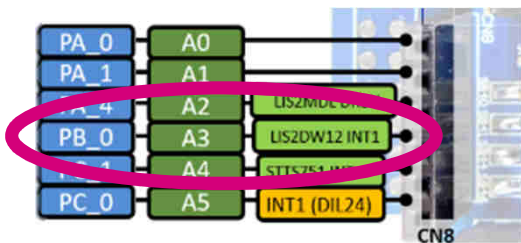
1. Expand *Connectivity* tab and check **I2C1**
2. Select **I2C** in *I2C1 Mode and Configuration*
3. PB8 and PB9 should now become green



Lab1 – Configure LIS2DW12 Interrupt

105

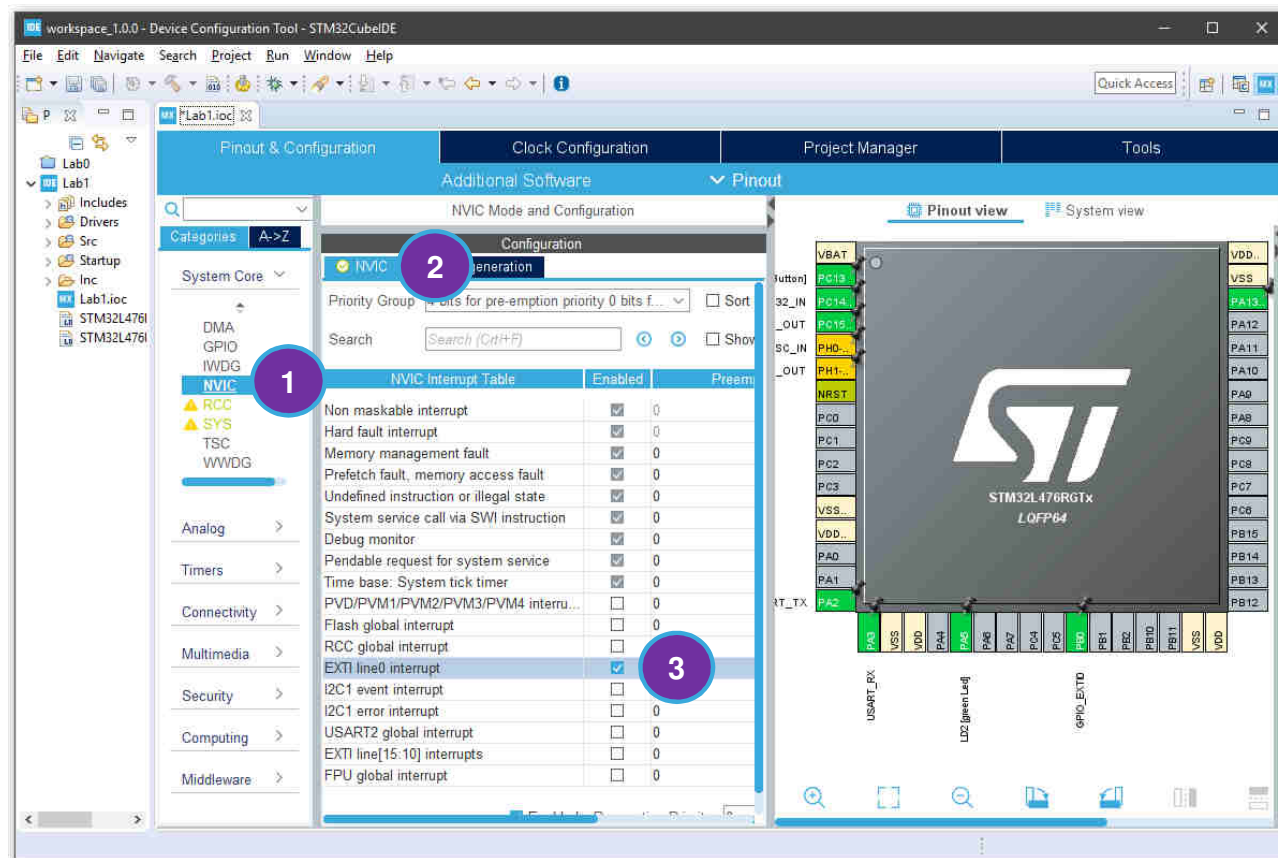
1. Left Click on **PB0** and select **GPIO_EXTI0**



Lab1 – Configure LIS2DW12 Interrupt

106

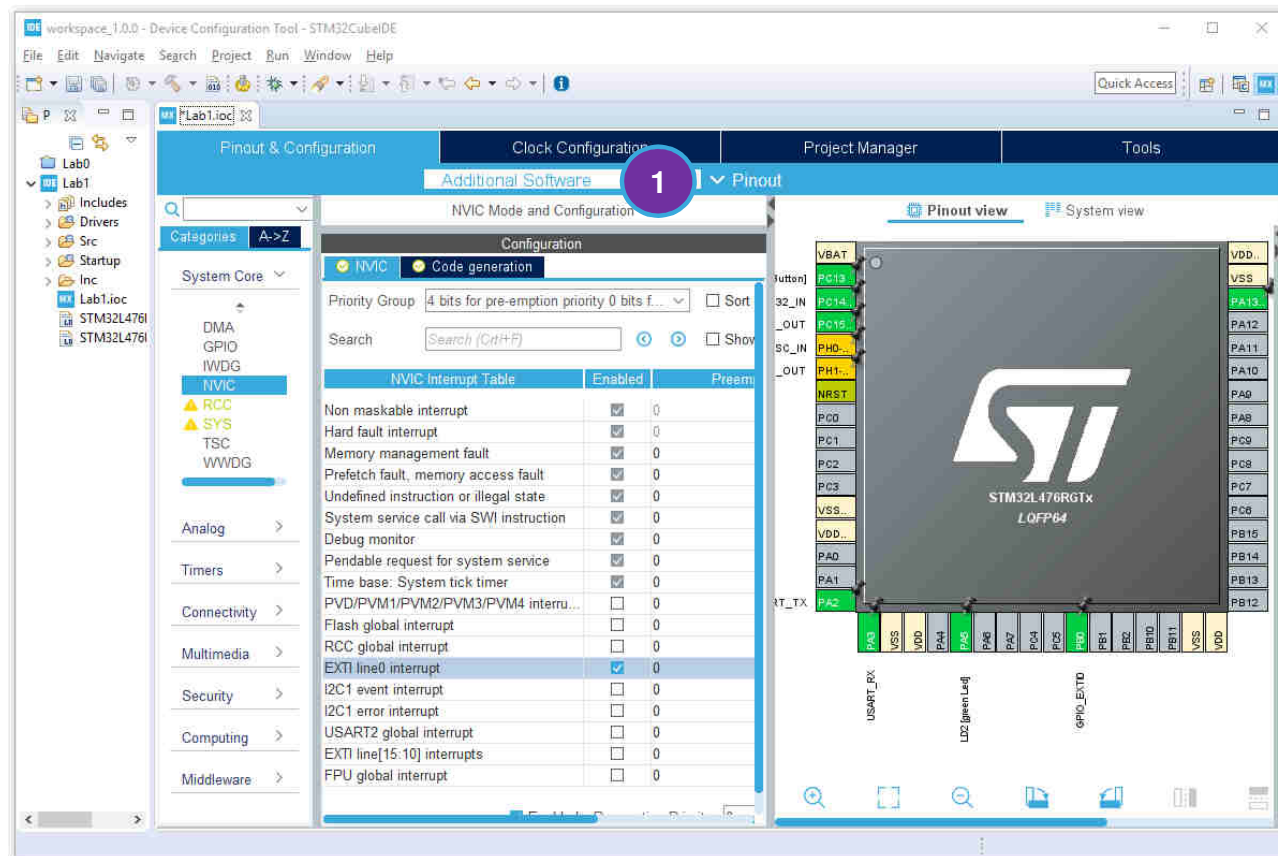
1. Check **NVIC** in tab System Core
2. Select **NVIC** in NVIC Mode and Configuration
3. Enable **EXTI line0 interrupt**



Lab1 – Select the MEMS Library

107

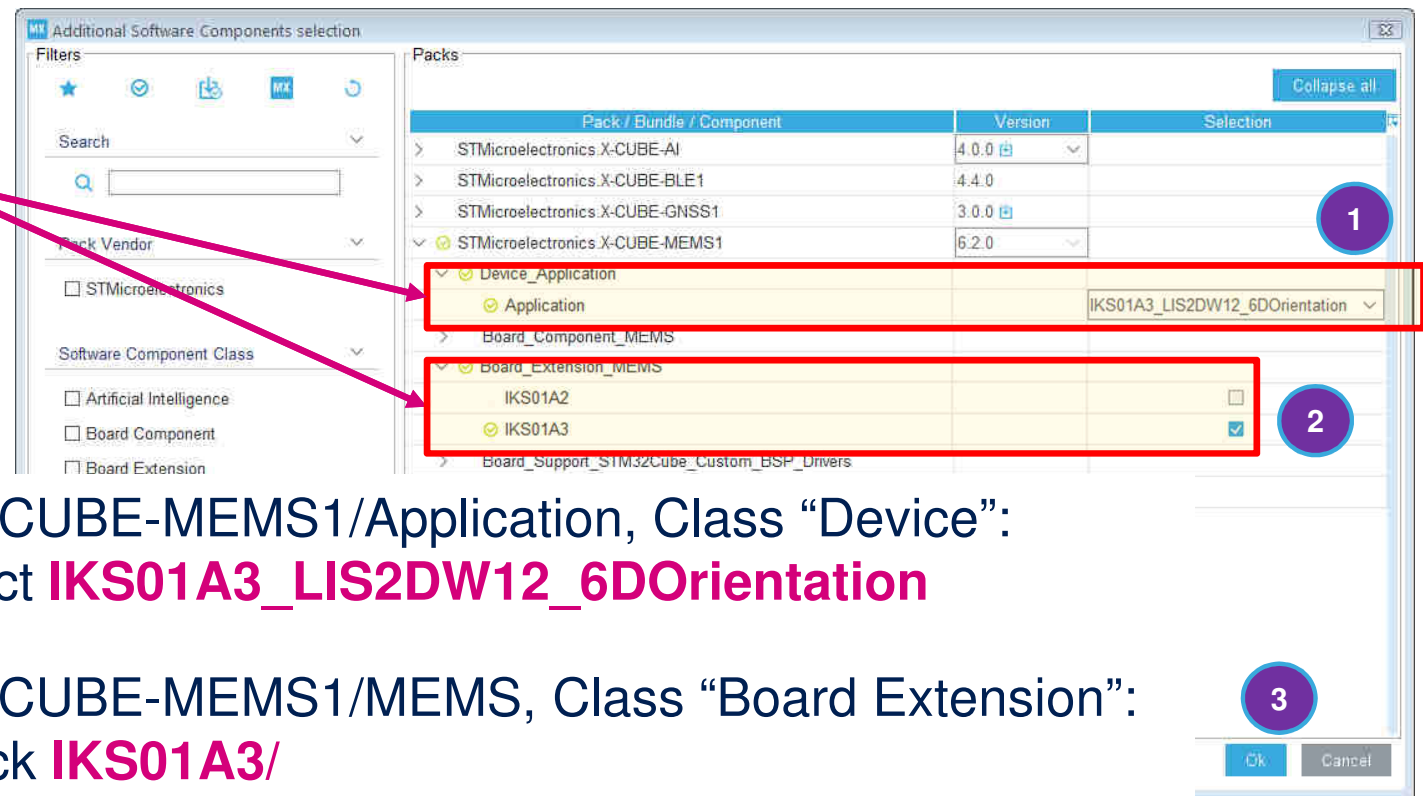
1. Click on **Additional Software**



Lab1 – Select the MEMS Library

108

Click to
expand tree



1. In X-CUBE-MEMS1/Application, Class “Device”:
Select **IKS01A3_LIS2DW12_6DOrientation**
2. In X-CUBE-MEMS1/MEMS, Class “Board Extension”:
Check **IKS01A3/**
3. Click **OK**

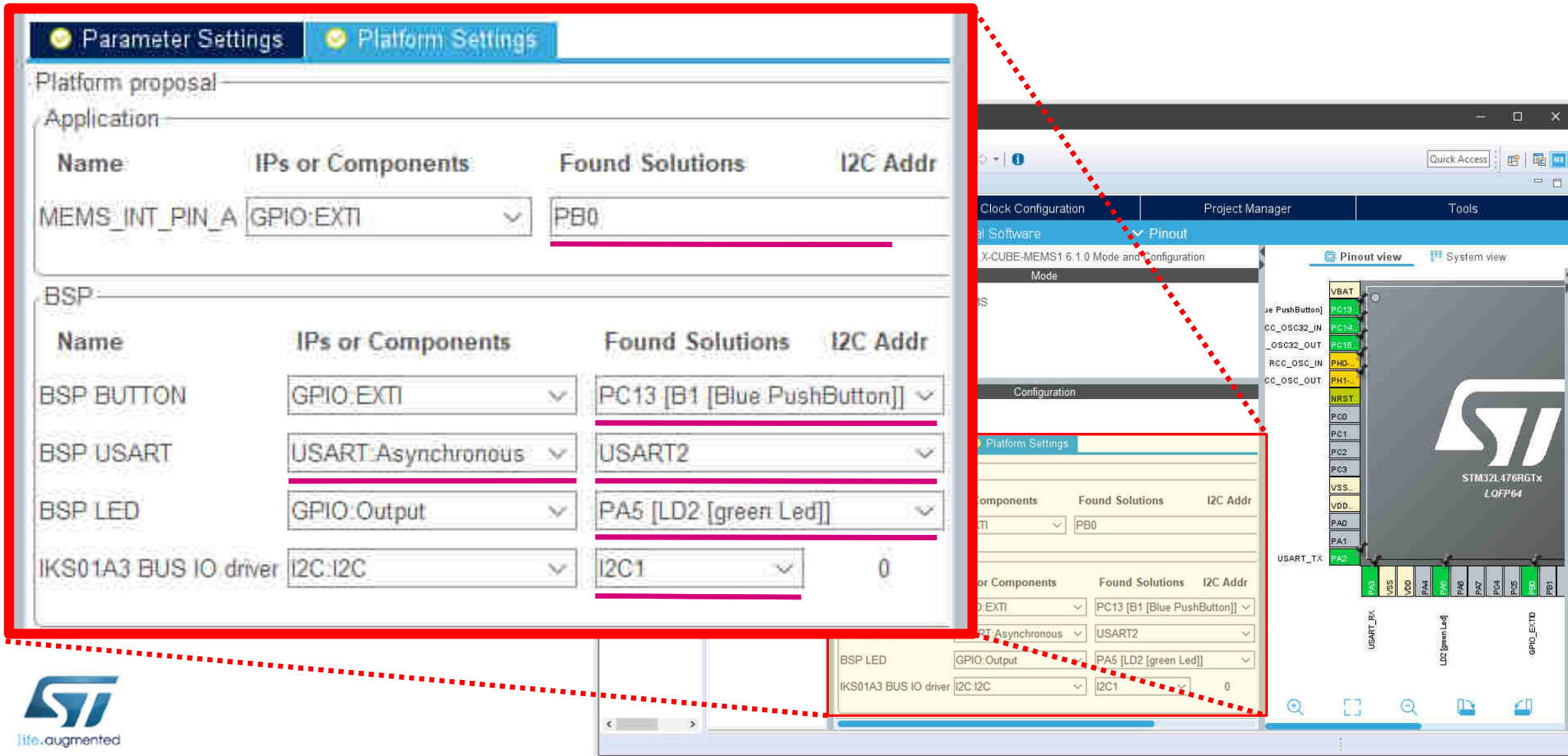
109

- ## Board Extension MEMS Device Application



Lab1 – Configure the MEMS Library

110



The screenshot displays the STM32CubeMX IDE interface. The 'Platform Settings' window is open, showing the configuration for the MEMS library. The 'Platform proposal' section is visible, and the 'Application' section shows the configuration for the MEMS library. The 'BSP' section lists the components and their found solutions.

Platform Settings

Platform proposal

Application

Name	IPs or Components	Found Solutions	I2C Addr
MEMS_INT_PIN_A	GPIO:EXTI	PB0	

BSP

Name	IPs or Components	Found Solutions	I2C Addr
BSP BUTTON	GPIO:EXTI	PC13 [B1 [Blue PushButton]]	
BSP USART	USART:Asynchronous	USART2	
BSP LED	GPIO:Output	PA5 [LD2 [green Led]]	
IKS01A3 BUS IO driver	I2C:I2C	I2C1	0

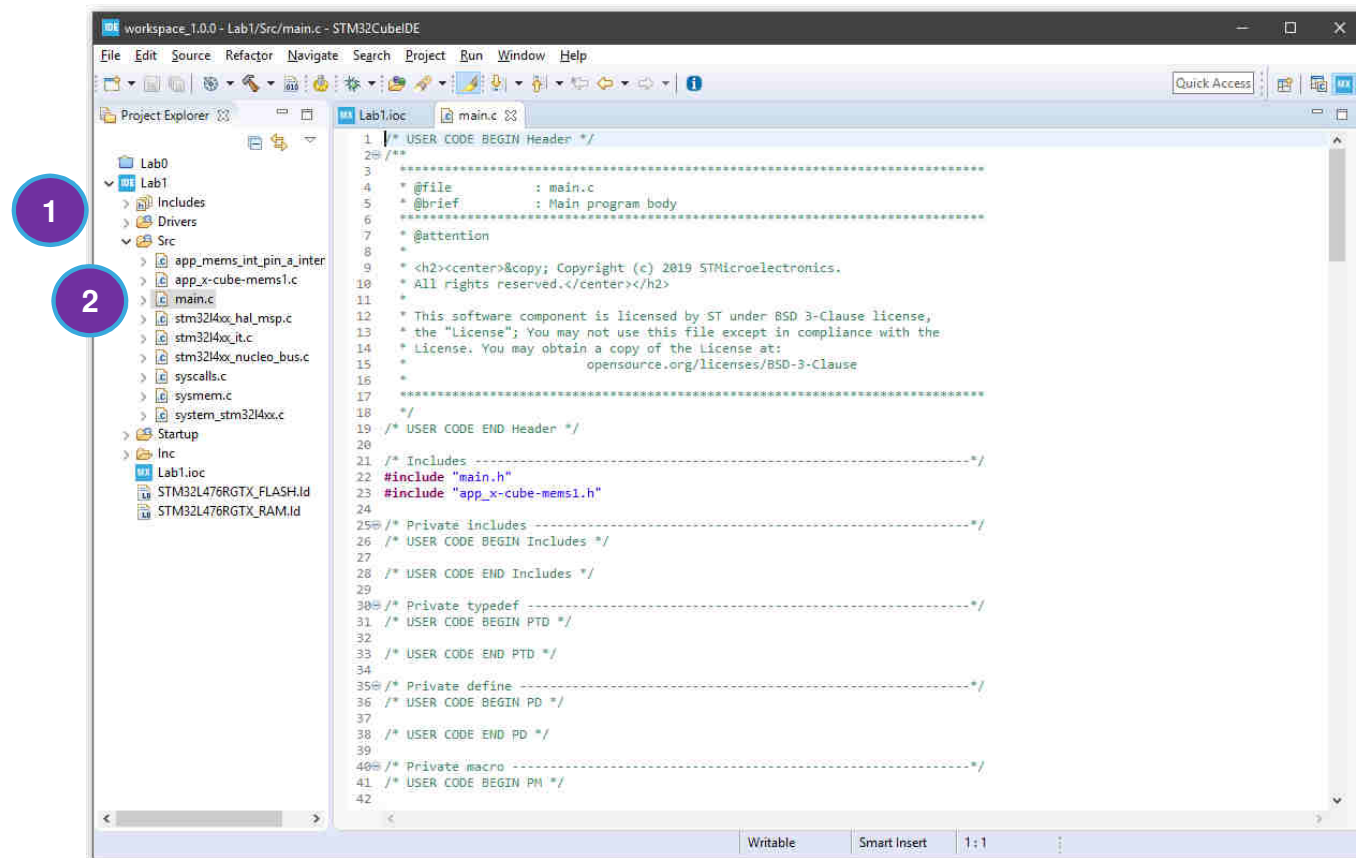
The Pinout view shows the STM32L476RGTx LQFP64 pinout. The pins are labeled as follows:

- VBAT
- PC13
- PC14
- PC15
- PHC
- PH1
- NRST
- PC0
- PC1
- PC2
- PC3
- VSS
- VDD
- PA0
- PA1
- PA2
- PA3
- PA4
- PA5
- PA6
- PA7
- PA8
- PA9
- PA10
- PA11
- PA12
- PA13
- PA14
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- PA161
- PA162
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- PA234
- PA235
- PA236
- PA237
- PA238
- PA239
- PA240
- PA241
- PA242
- PA243
- PA244
- PA245
- PA246
- PA247
- PA248
- PA249
- PA250
- PA251
- PA252
- PA253
- PA254
- PA255

Lab1 – Code Editing

112

1. Expand **Src** in folder **Lab1**
2. Double click on **main.c**

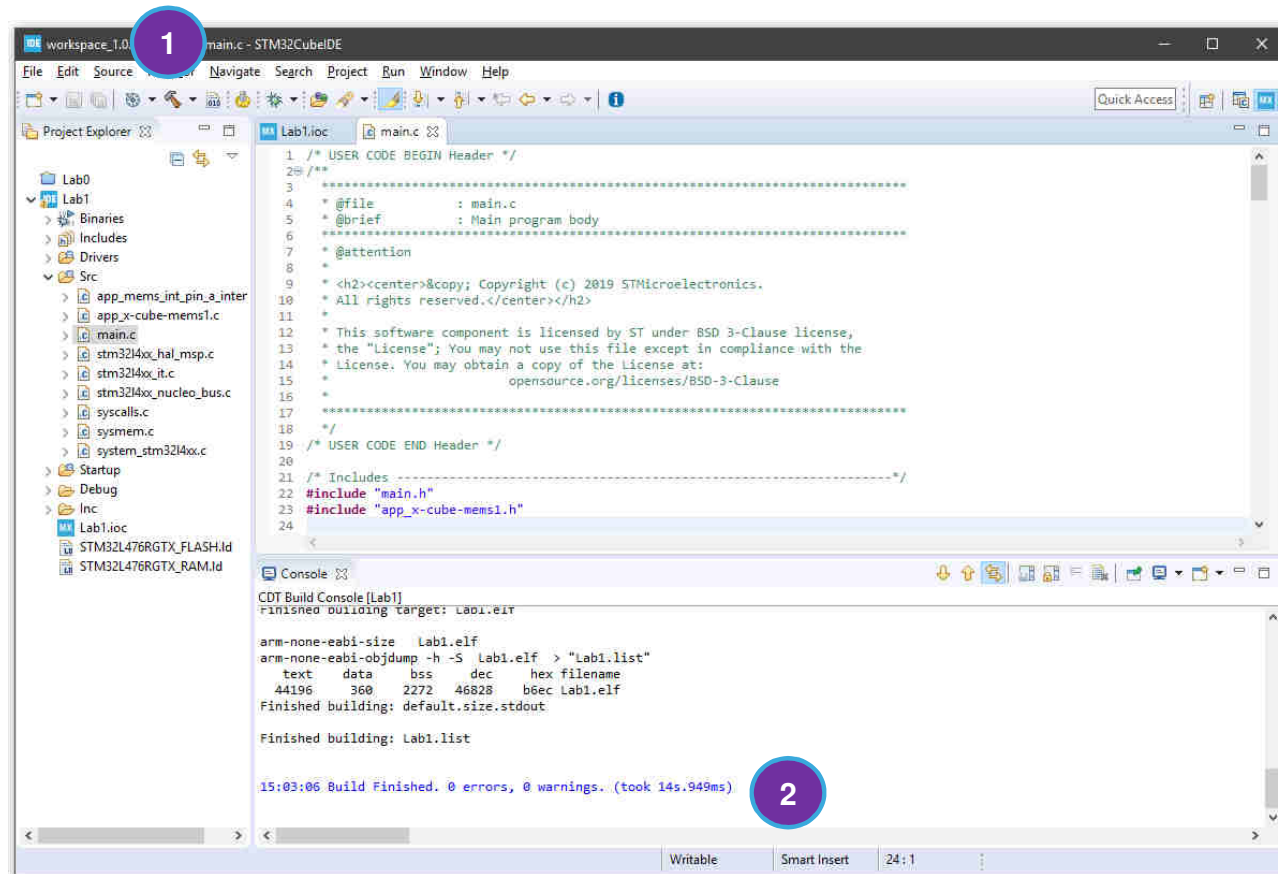


Lab1 - Compiling

113

1. Click on the hammer  to begin compilation, or press **CTRL+B**

2. Compilation should terminate with 0 errors and 0 warning



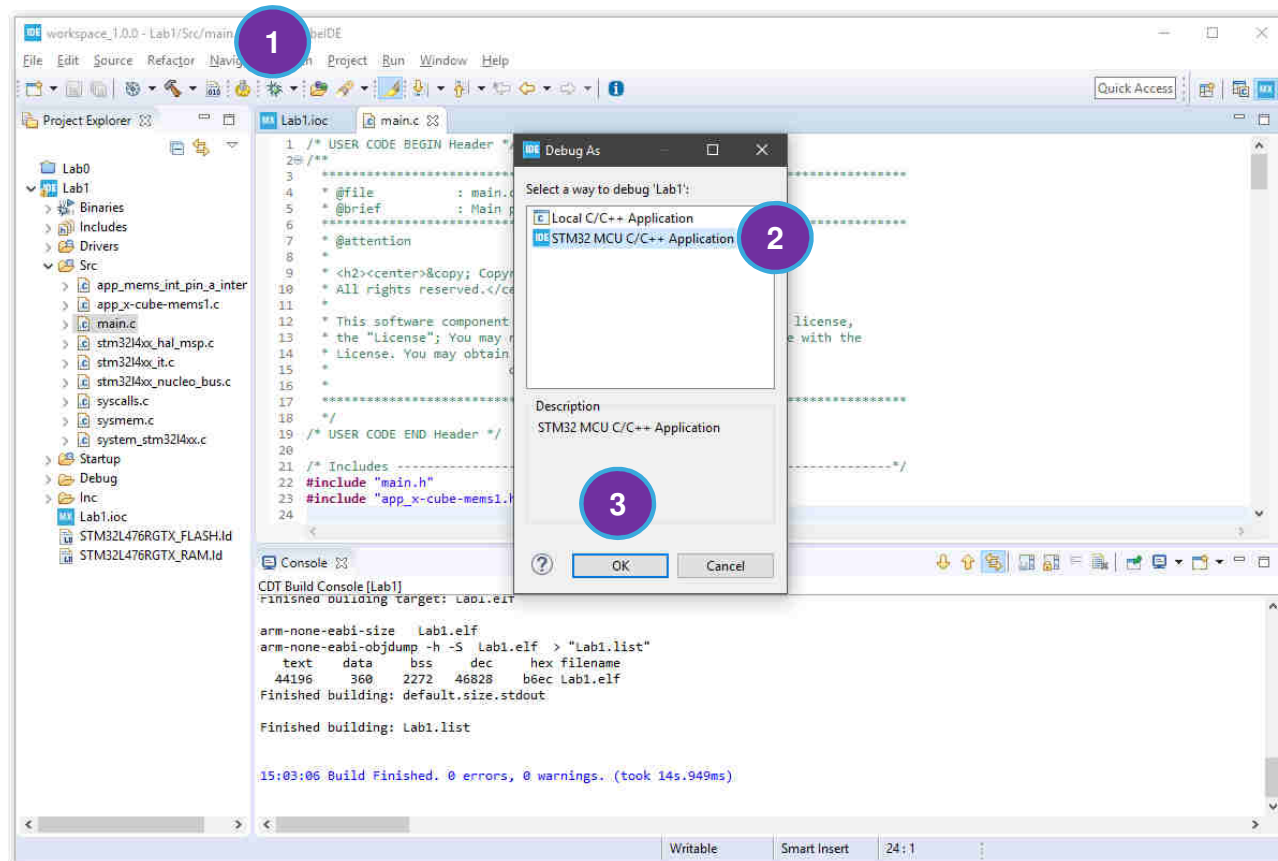
Lab1 - Debugging

114

1. Click on the bug  to begin debugging

2. Select **STM32 MCU C/C++ App**

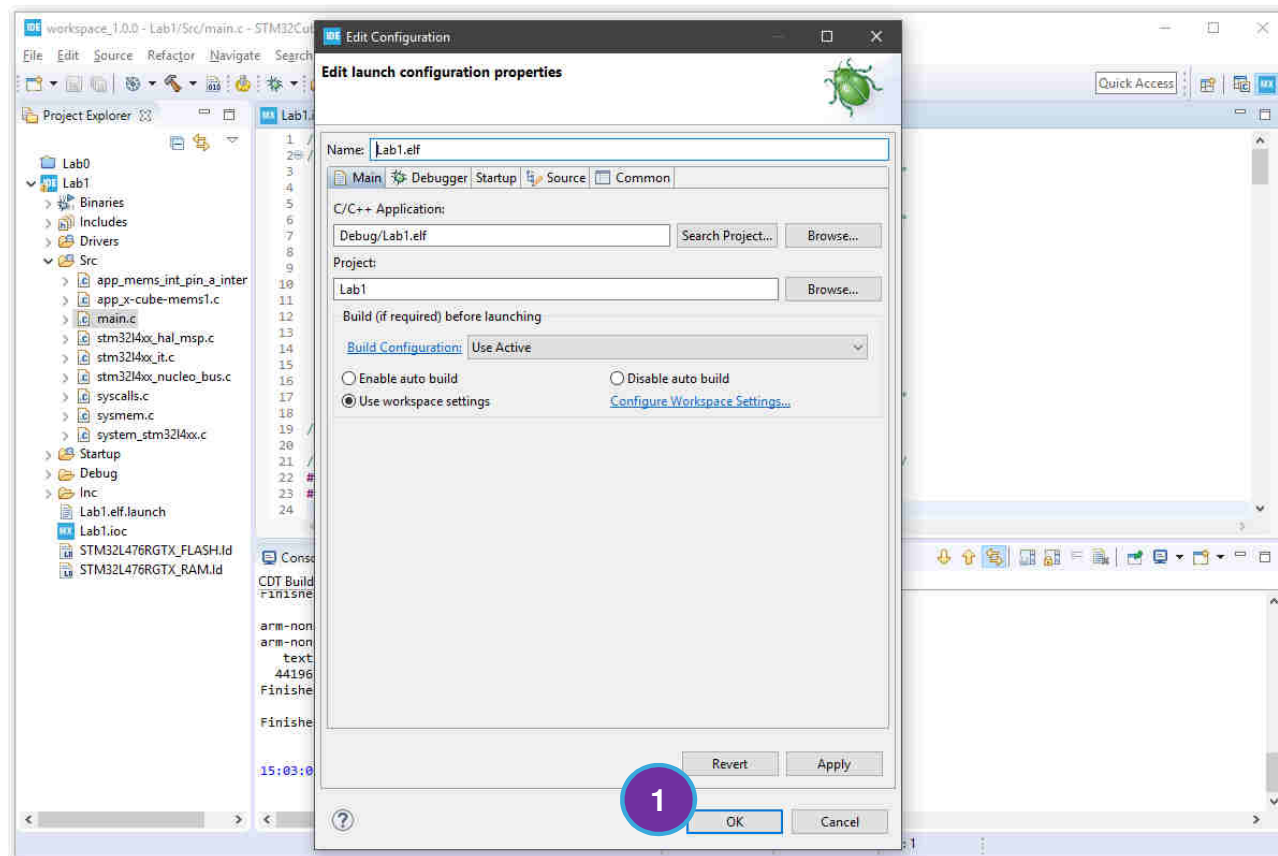
3. Click **OK**



Lab1 - Debugging

115


1. Click **OK**

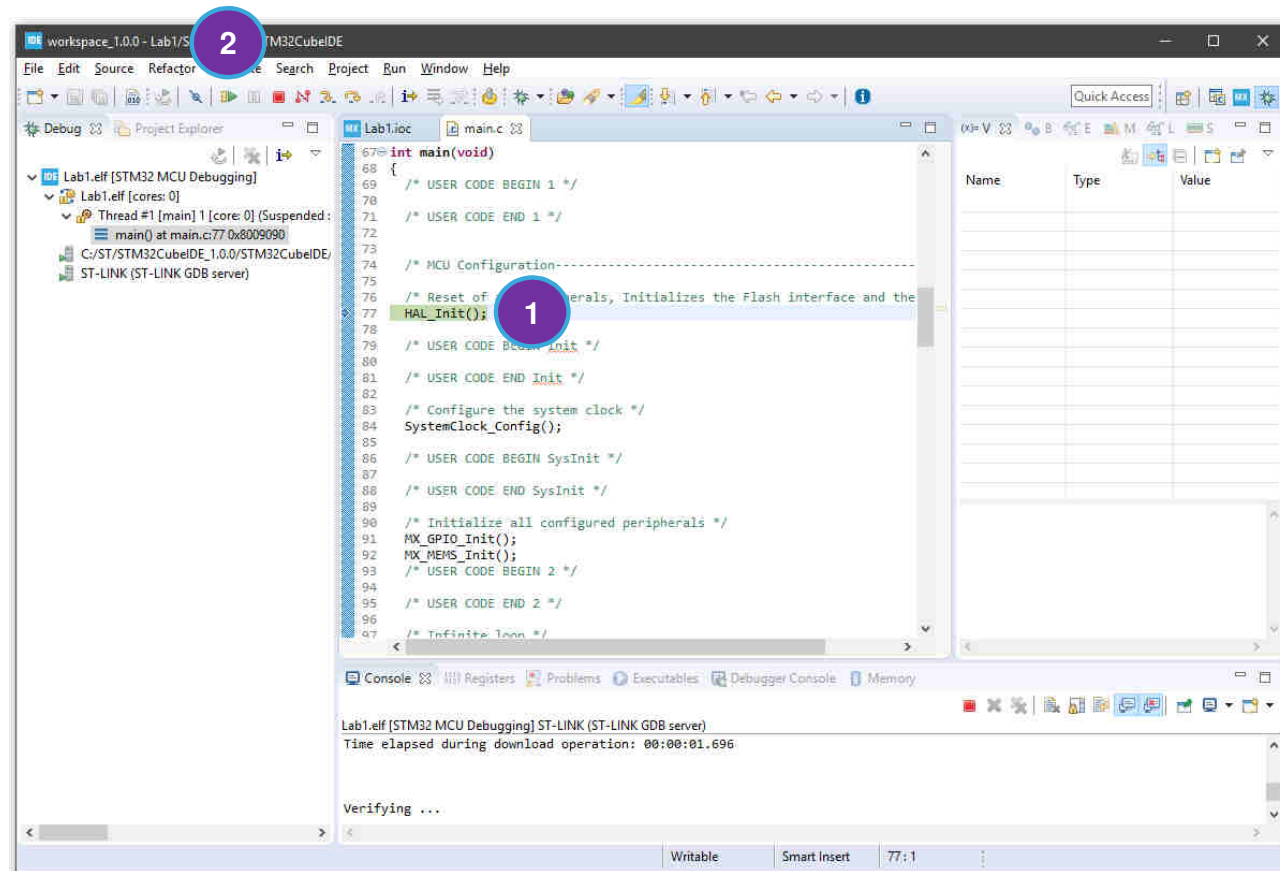


Lab1 - Debugging

116

1. Code start at the first line of the main function

2. Click play  button to run the code



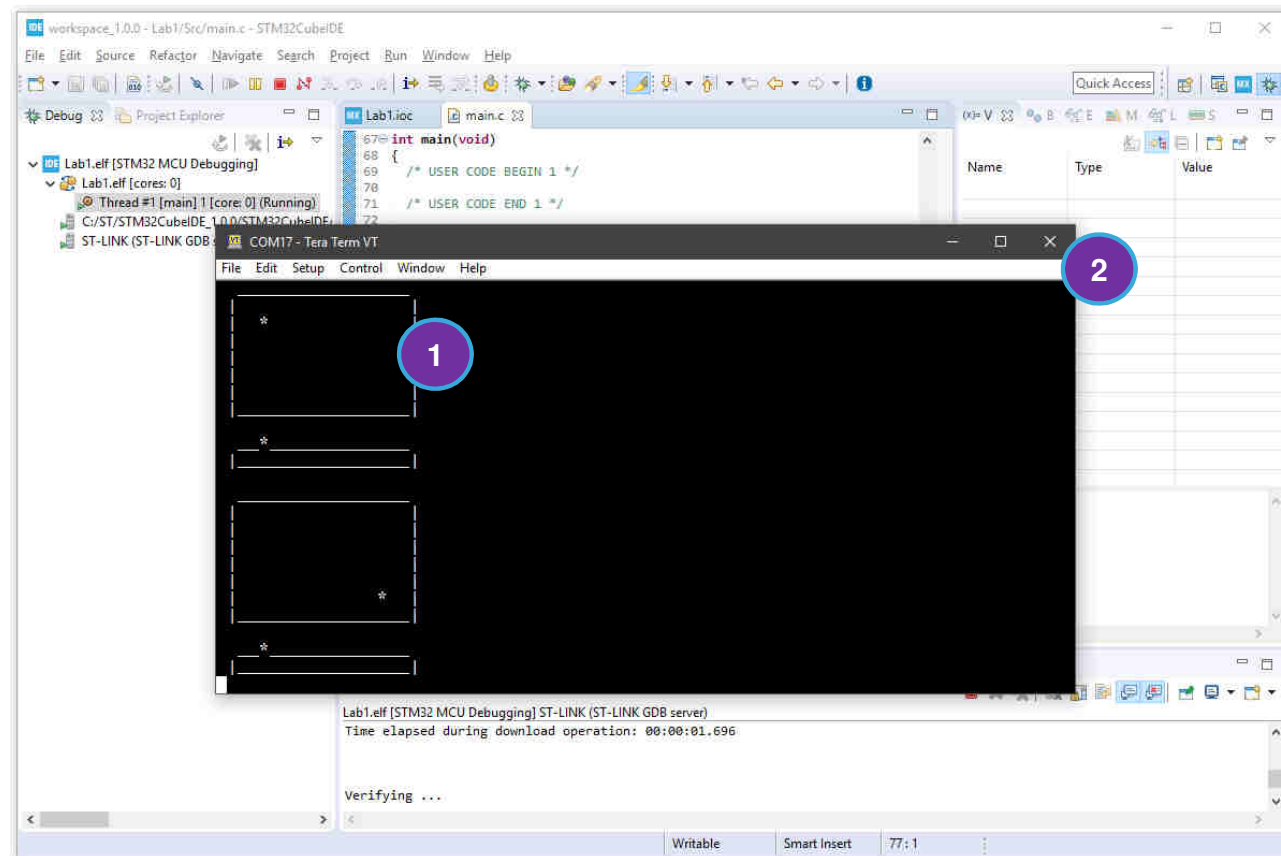
Lab1 - Testing

117

1. Open Tera Term to view the output

Rotate the board to see the output changing

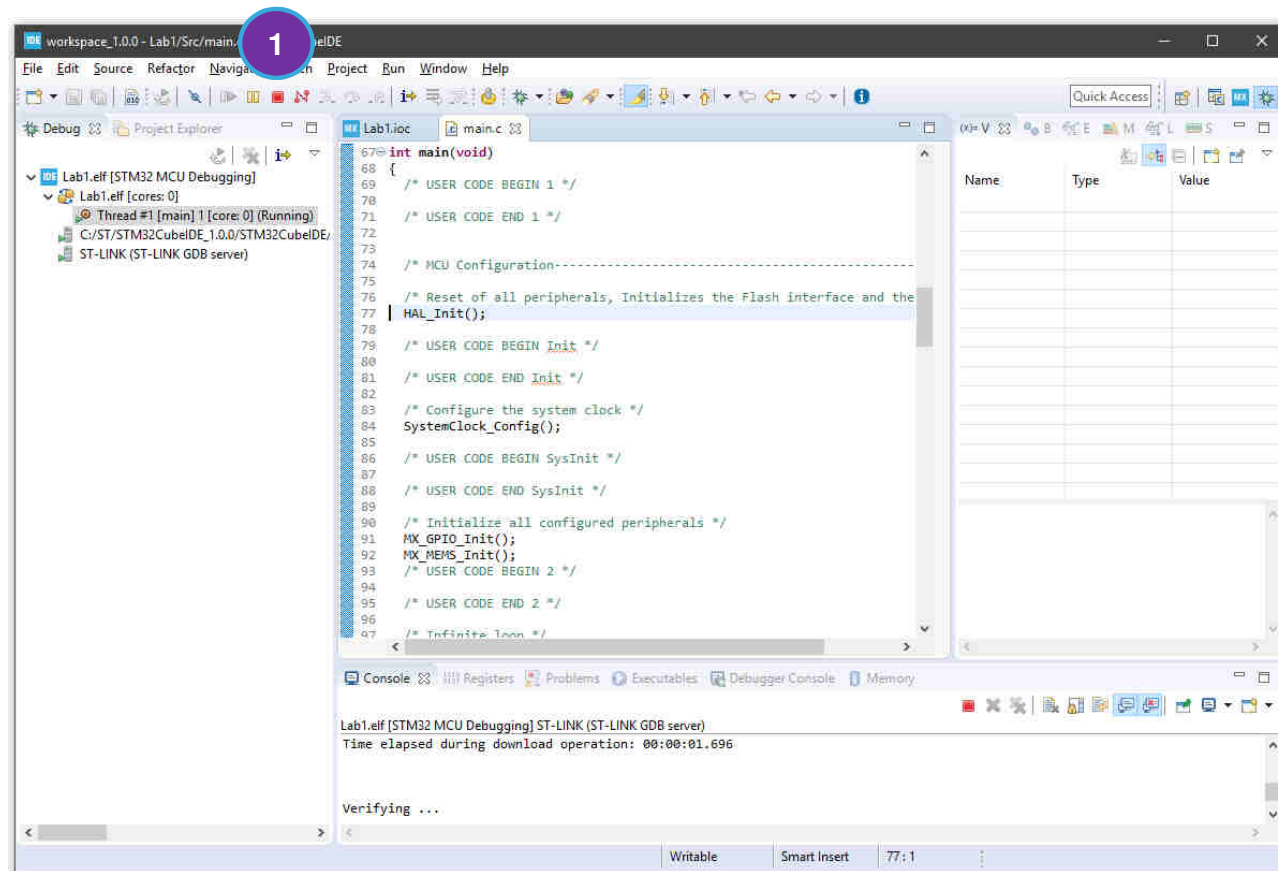
2. After testing close Tera Term by clicking **X**



Lab1 - Debugging

118

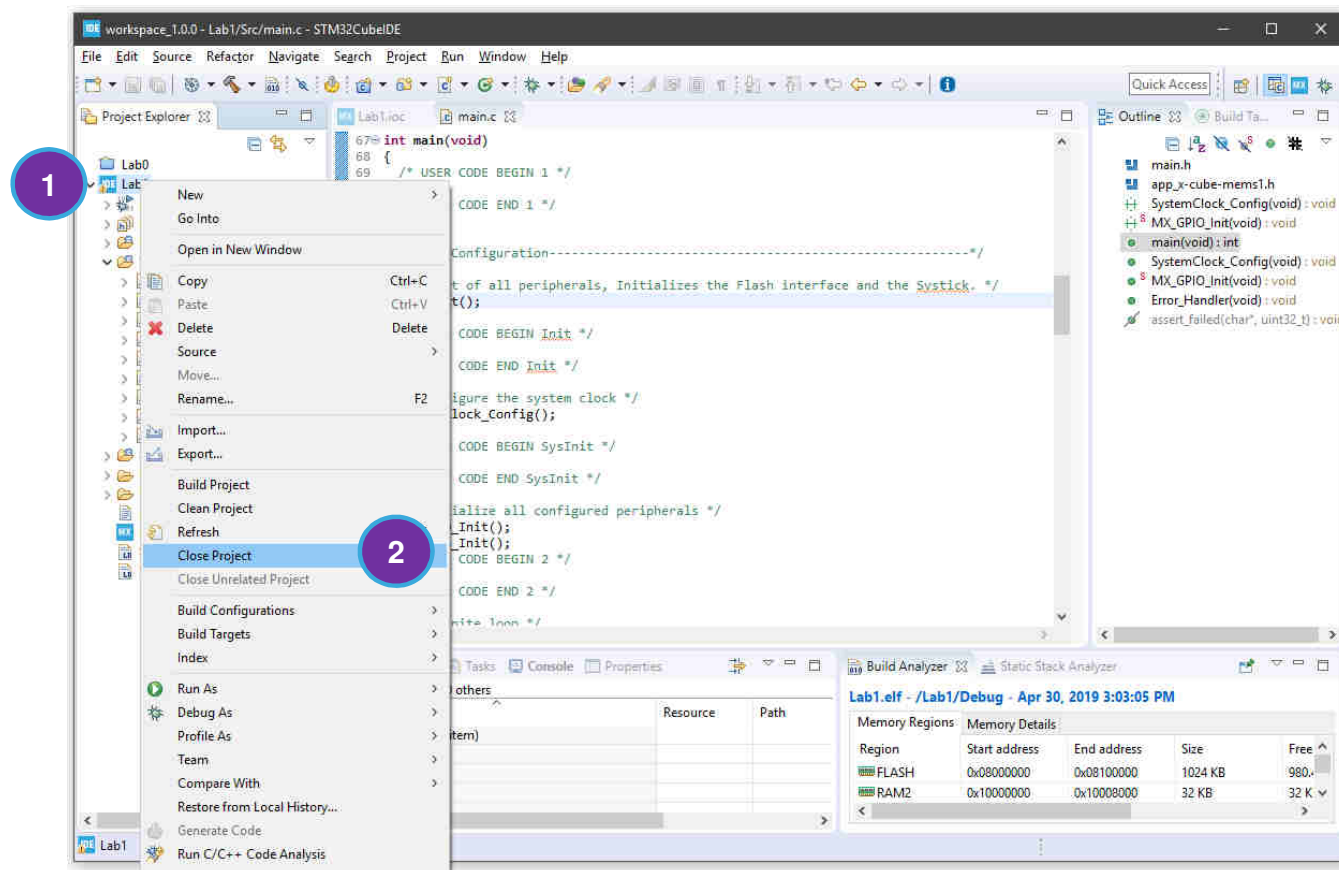
1. Click stop  button to interrupt the debugging



Lab1 – Closing the Project

119

1. Right-Click on **Lab1** project
2. Click on **Close Project**



LAB2

Goals:

- Configure a new project using X-CUBE-MEMS1
- Configure LPS22HH pressure and temperature sensor to acquire data using internal FIFO
- Enable interrupts in STM32CubeIDE

LPS22HH

121

High-performance, high-ODR Barometer / Altimeter

- Absolute Accuracy: 0.5hPa
- Relative Accuracy: $\pm 0.025\text{hPa}$
- RMS Noise: $\pm 0.65\text{Pa}$ (0.0065hPa)
- ODR up to 200Hz
- Embedded Temperature compensation
- Unique Full Molded Package

High Resolution - ~5cm

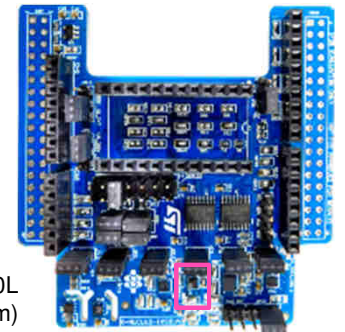
High Performance: excellent noise figure

Fast Response

System Power Saving

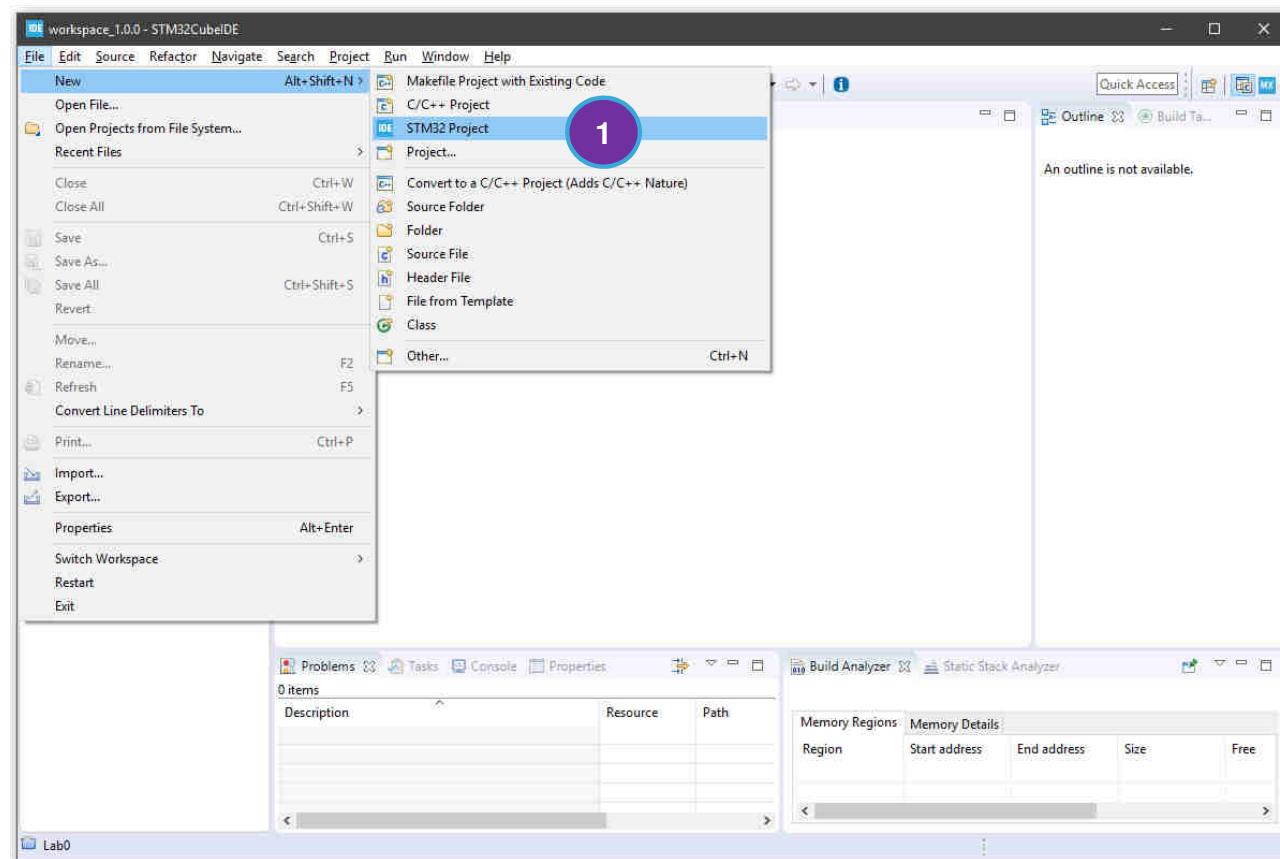
Robustness

Skip One Point Cal.
post Soldering
→ Cost Saving

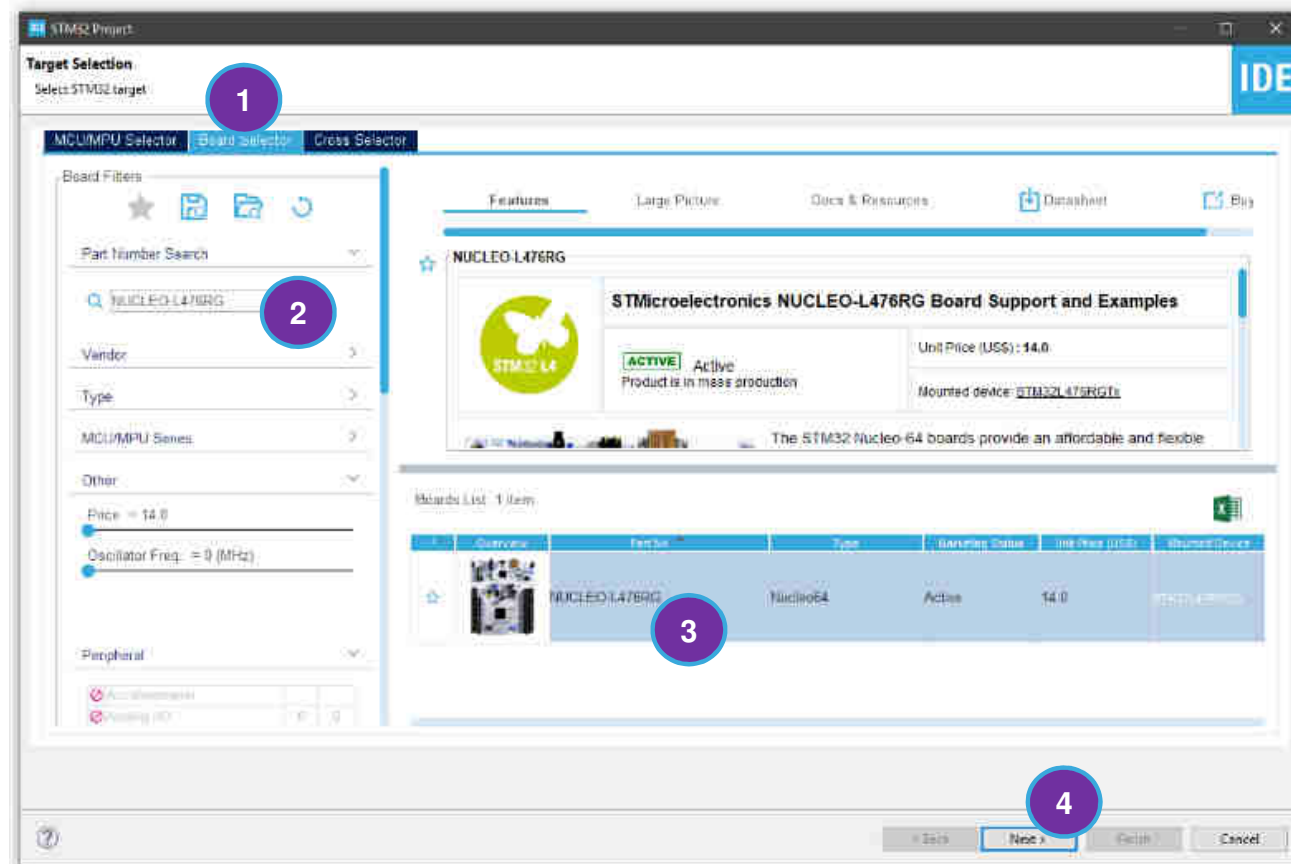


HLGA-10L
(2 x 2 x 0.73 mm)

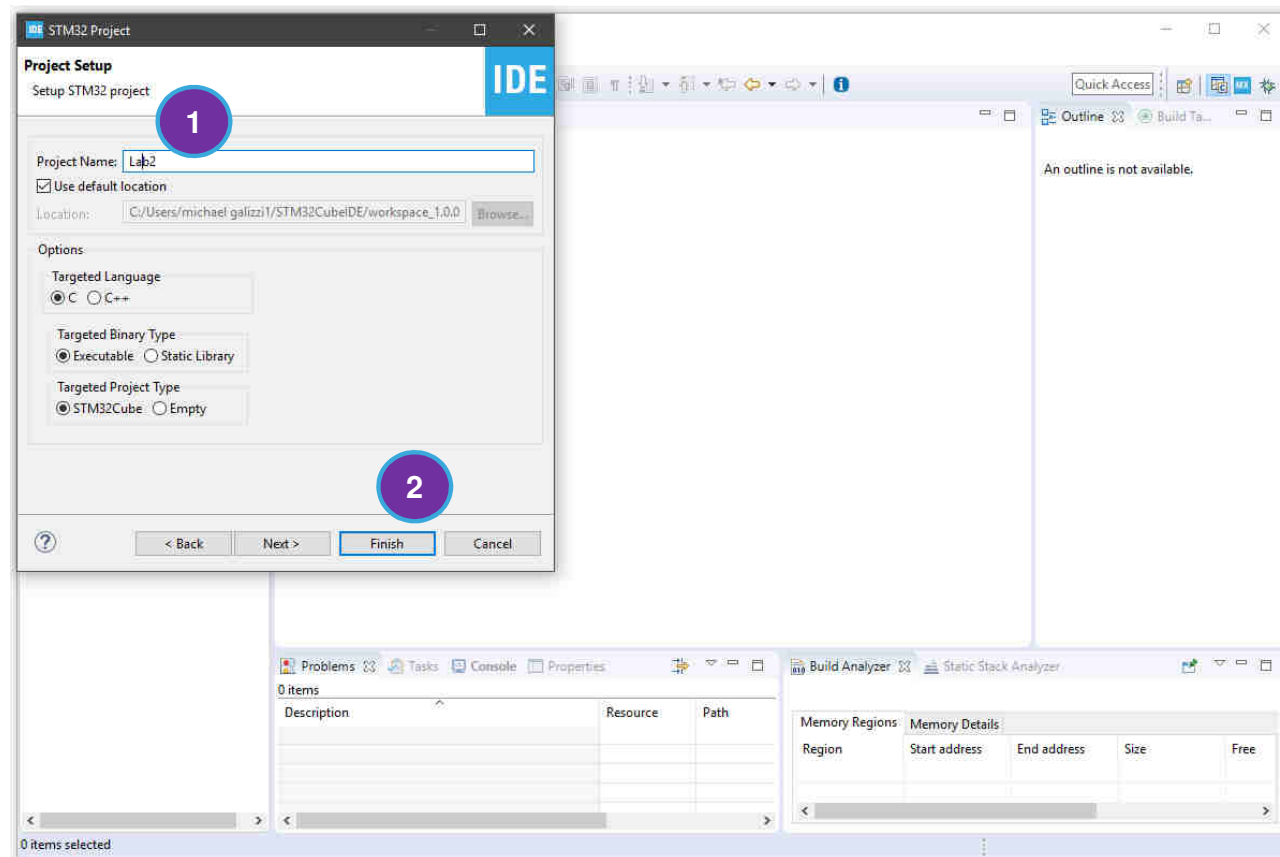
1. Click on **File > New > STM32 Project**



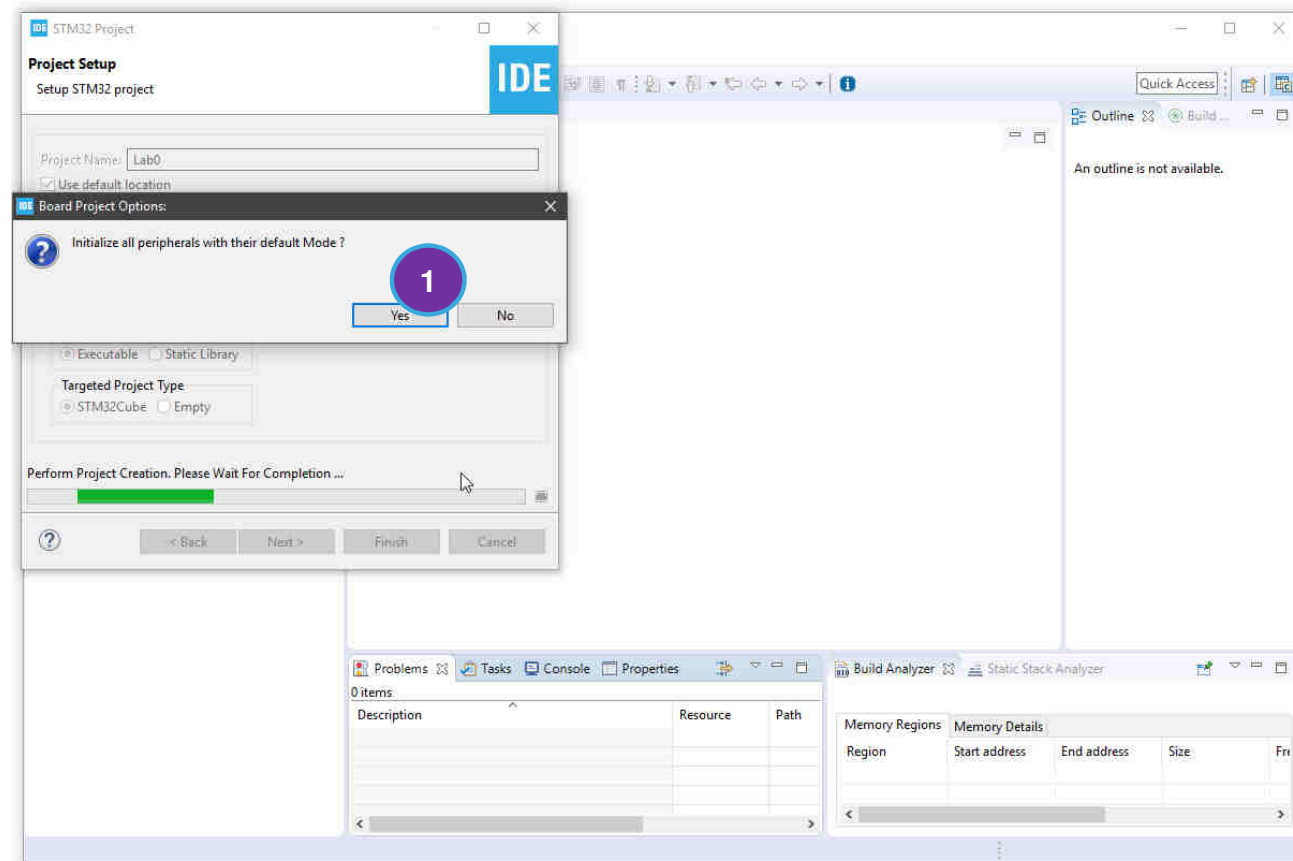
1. Click on **Board Selector**
2. Type **NUCLEO-L476RG**
3. Click on the board
4. Click **Next >**



1. Project Name **Lab2**
2. Click **Finish**



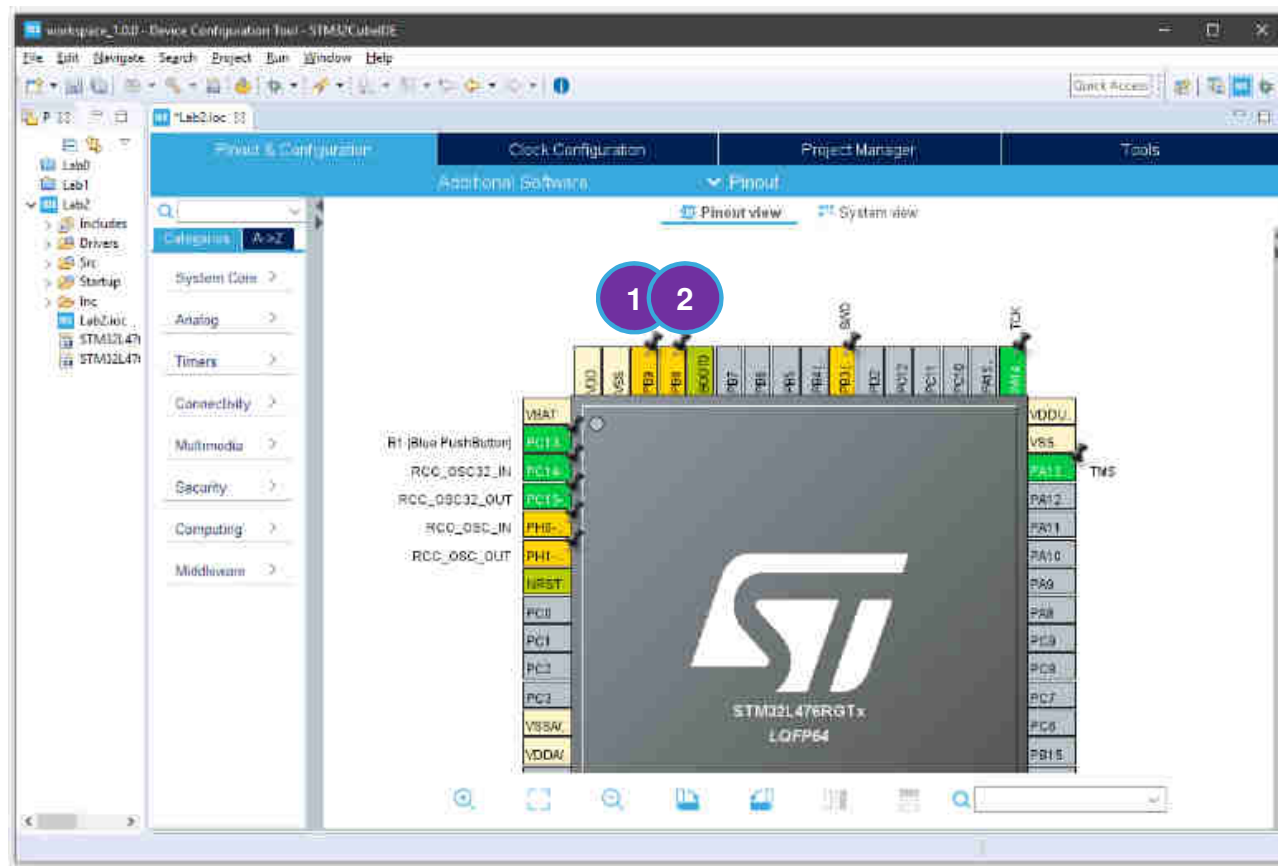
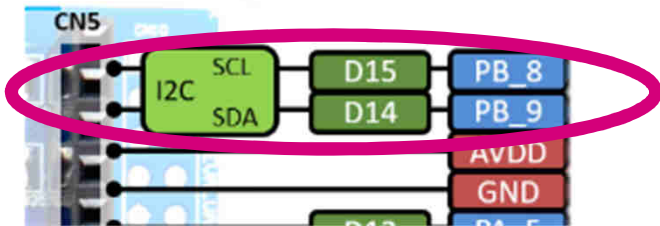
1. Click **Yes** to init peripherals in default mode



Lab2 – Configure the I2C Bus

126

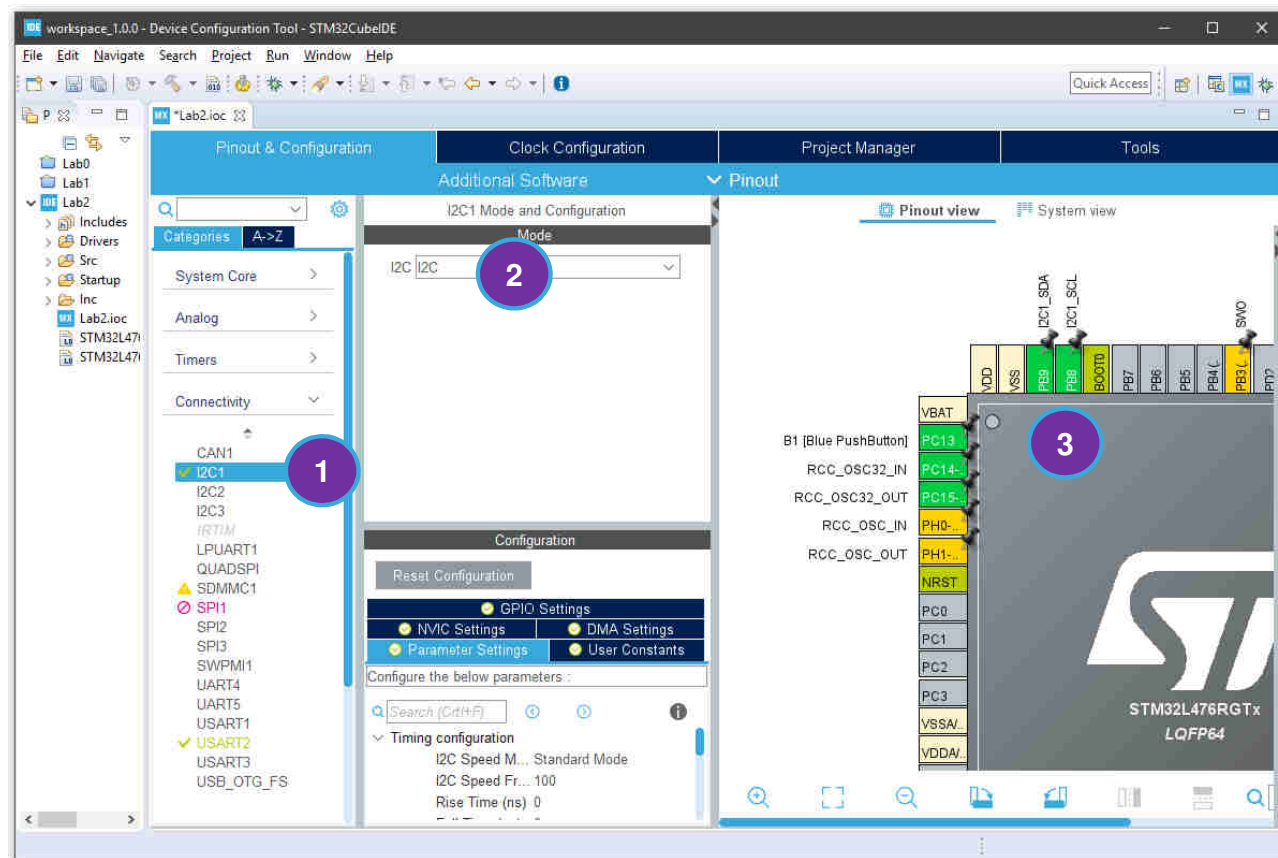
1. Left Click on **PB9** and select I2C1_SDA
2. Left Click on **PB8** and select I2C1_SCL



Lab2 – Configure the I2C Bus

127

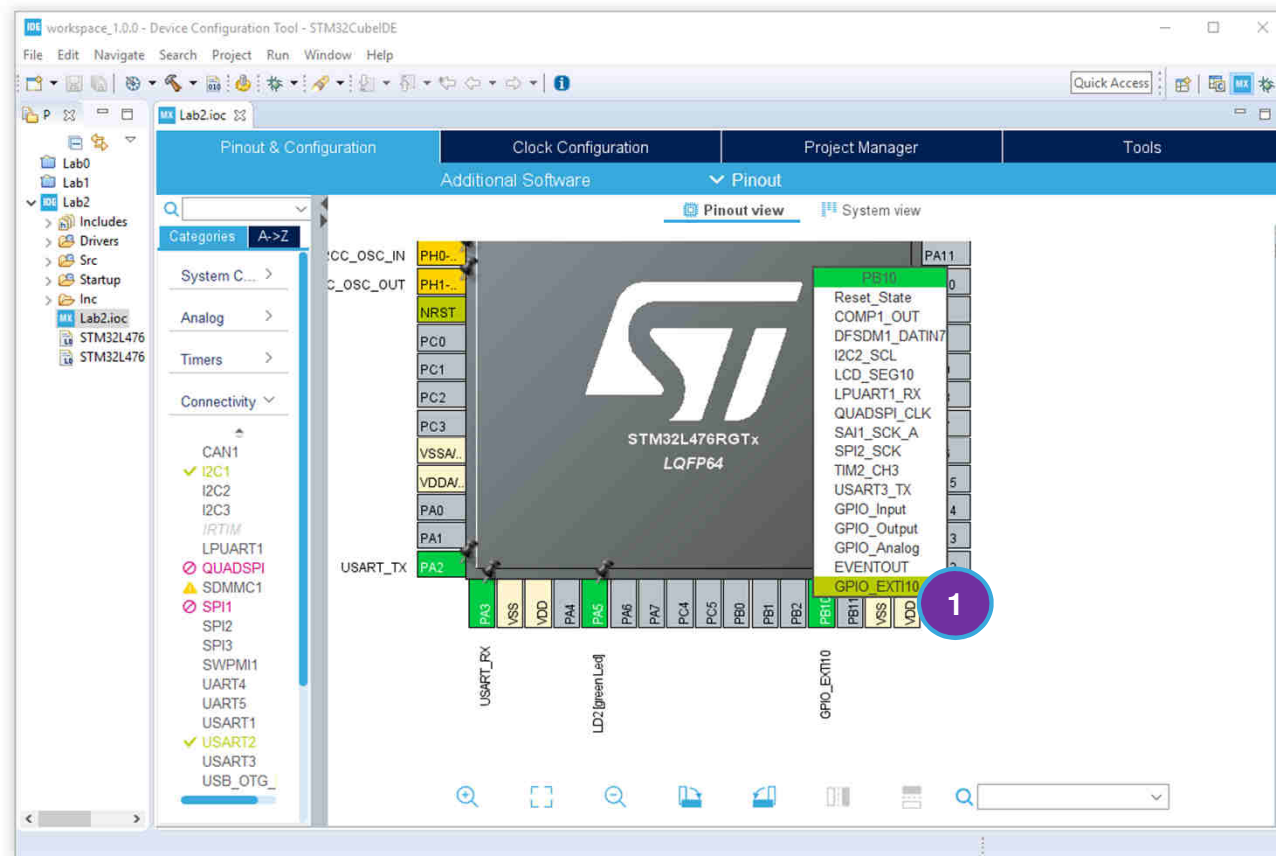
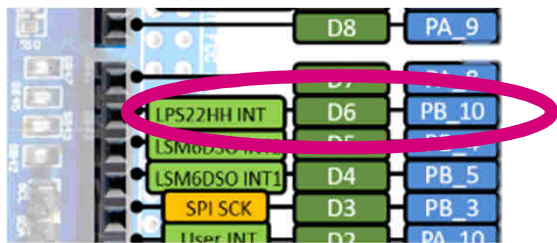
1. Expand *Connectivity* tab and check **I2C1**
2. Select **I2C** in *I2C1 Mode and Configuration*
3. PB8 and PB9 should now become green



Lab2 – Configure LPS22HH Interrupt

128

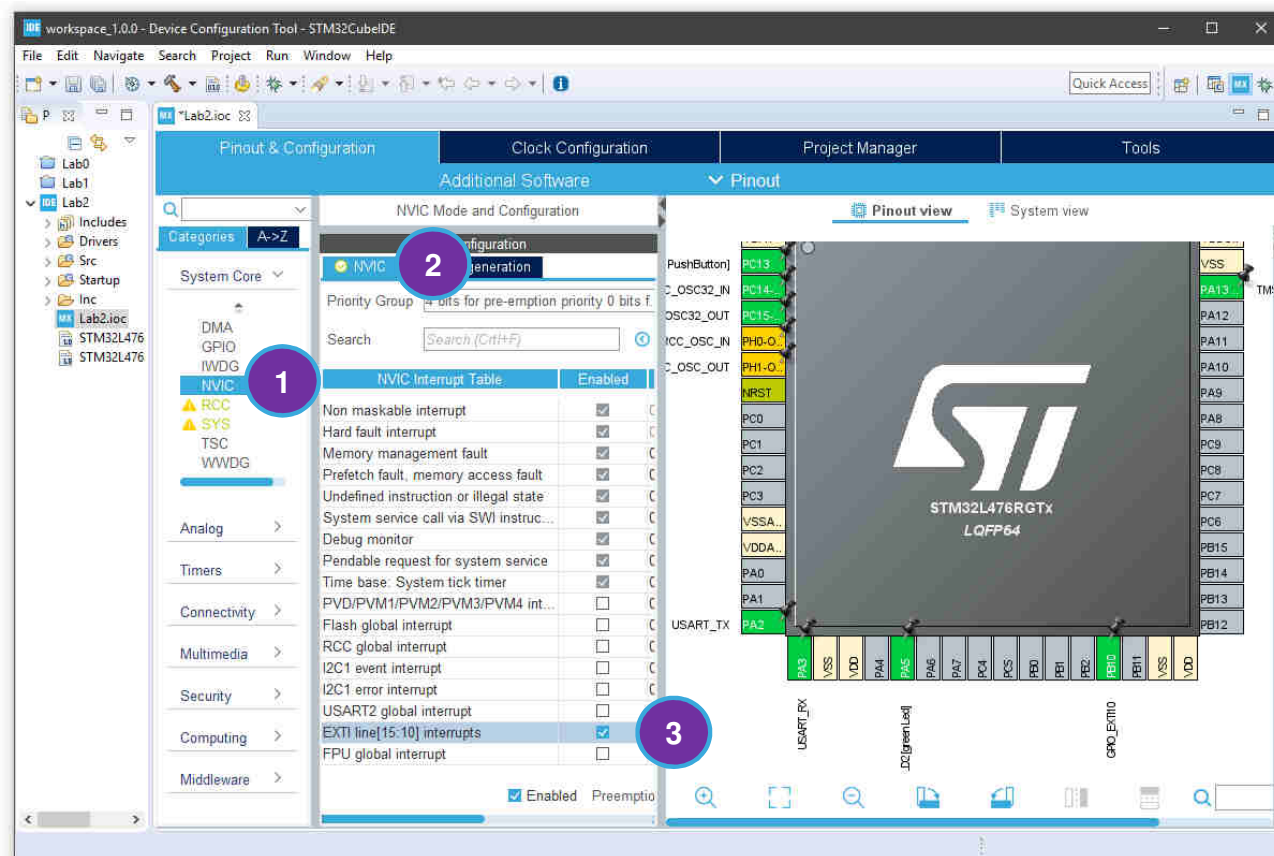
1. Left Click on **PB10** and select **GPIO_EXTI10**



Lab2 – Configure LPS22HH Interrupt

129

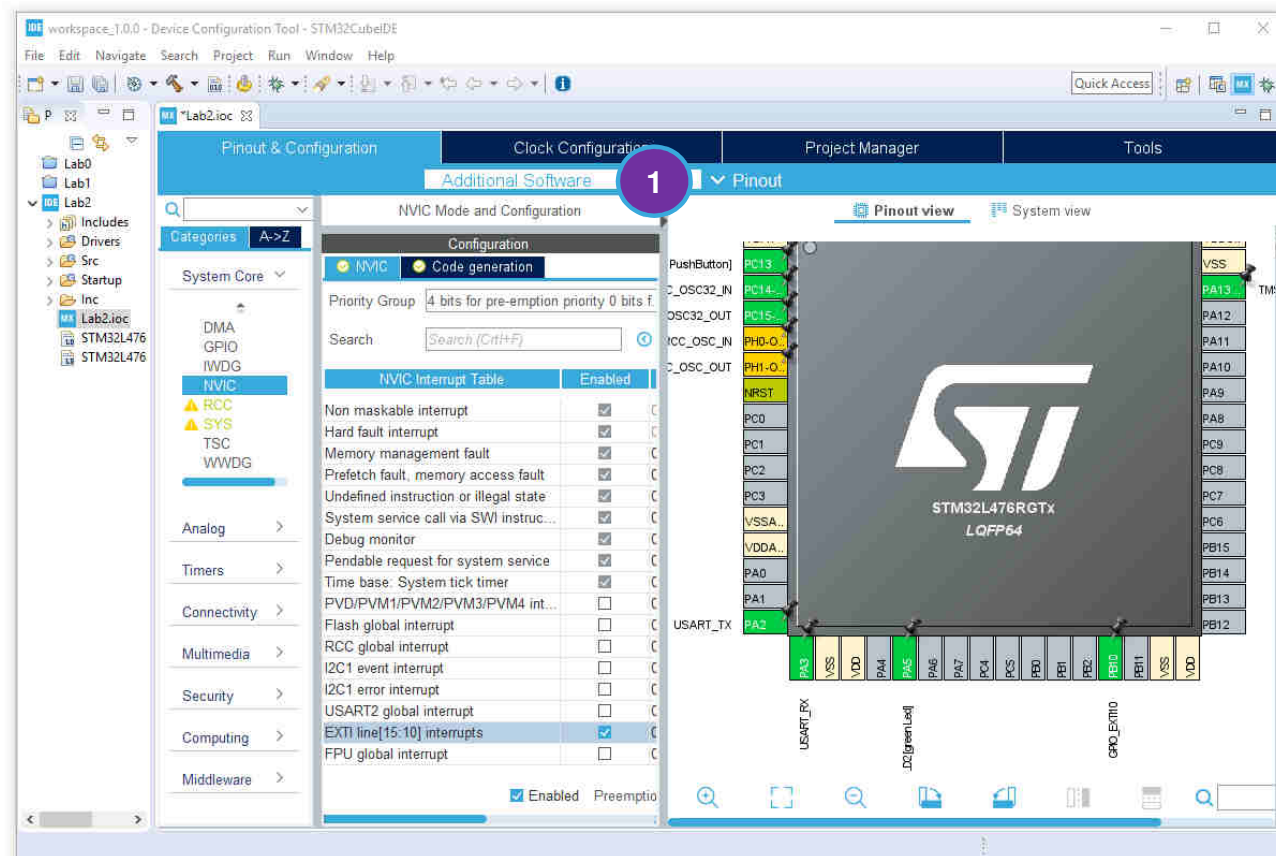
1. Check **NVIC** in tab System Core
2. Select **NVIC** in NVIC Mode and Configuration
3. Enable **EXTI line[15:10] interrupt**



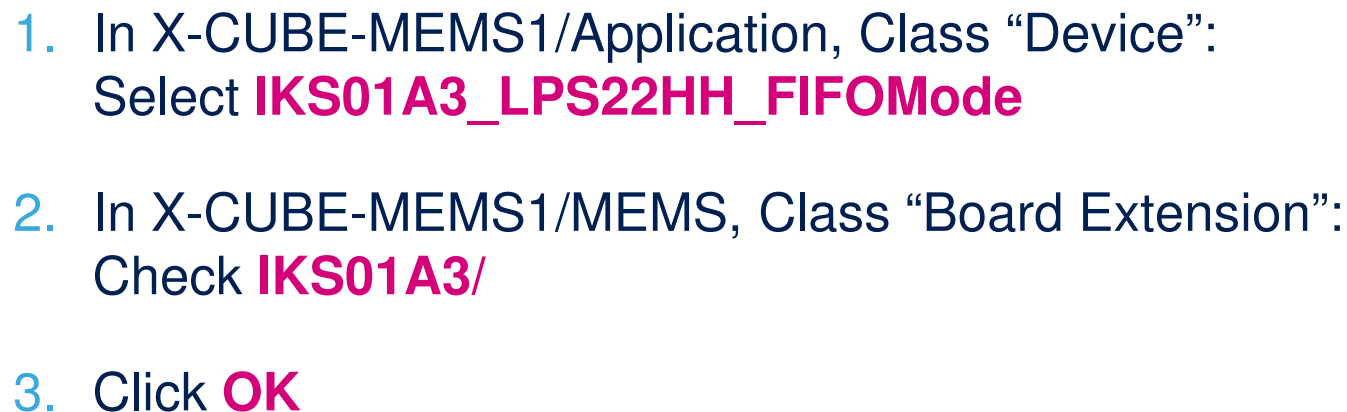
Lab2 – Select the MEMS Library

130

1. Click on **Additional Software**



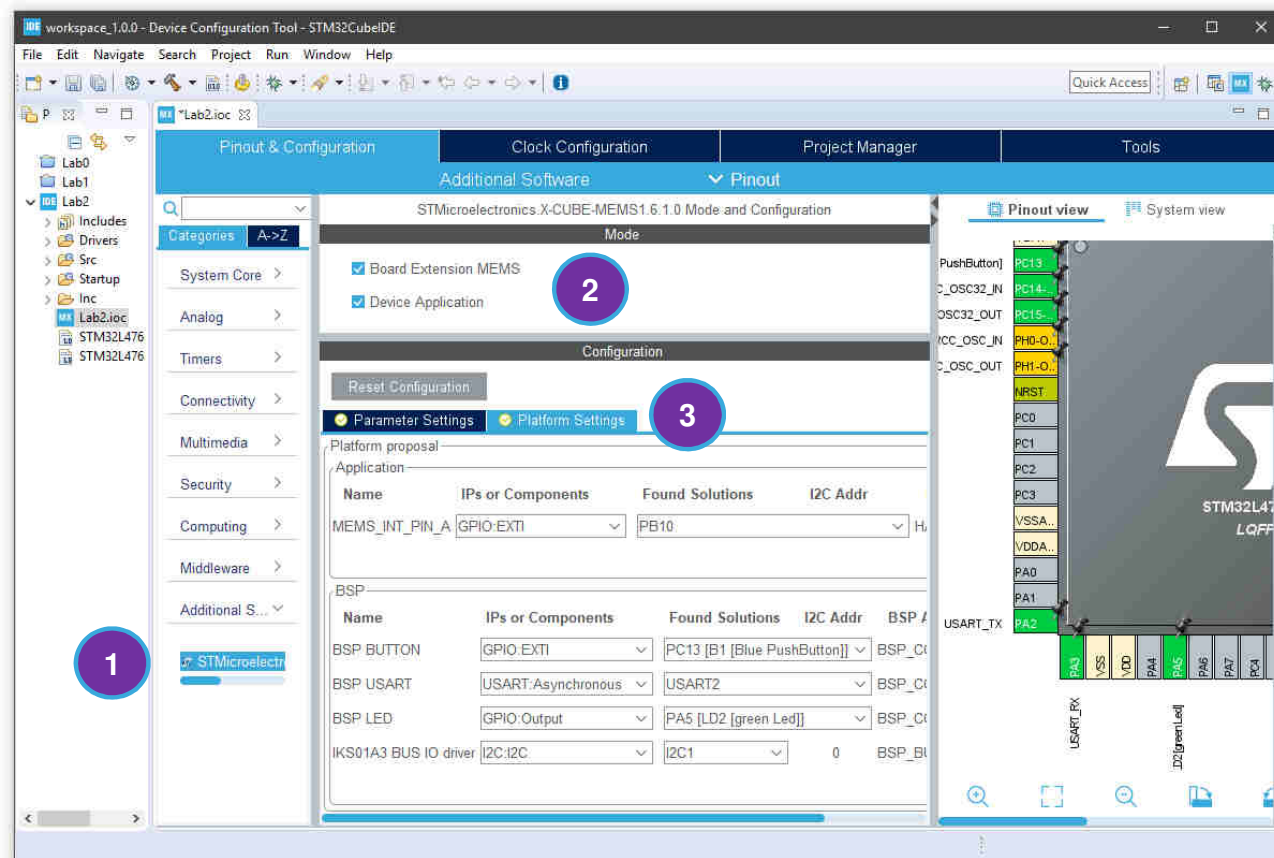
131



Lab2 – Configure the MEMS Library

132

1. Expand Additional Software and select the X-CUBE-MEMS1
2. Check both:
Board Extension MEMS
Device Application
3. Configure Platform Settings as in picture



Lab2 – Configure the MEMS Library

133

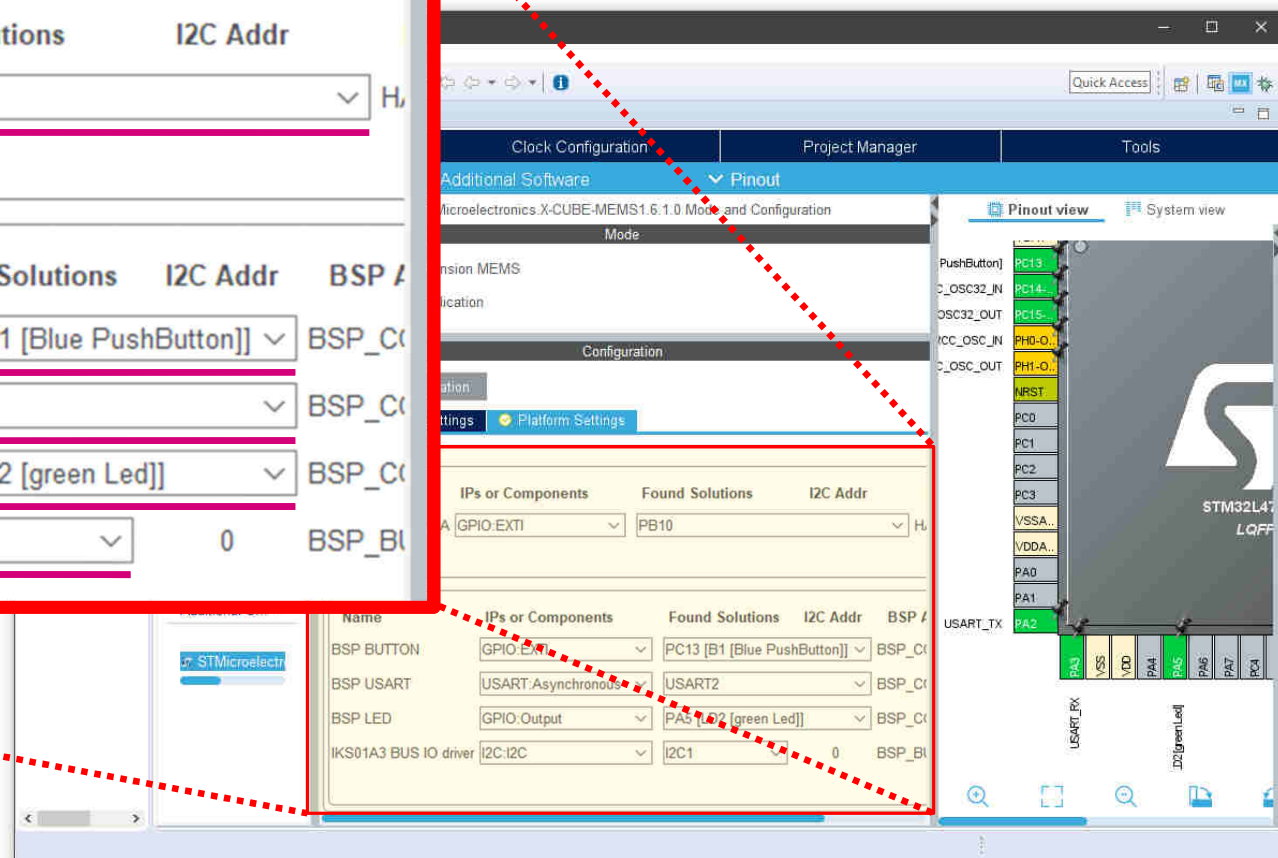
Platform proposal

Application

Name	IPs or Components	Found Solutions	I2C Addr
MEMS_INT_PIN_A	GPIO:EXTI	PB10	

BSP

Name	IPs or Components	Found Solutions	I2C Addr	BSP A
BSP BUTTON	GPIO:EXTI	PC13 [B1 [Blue PushButton]]		BSP_C
BSP USART	USART:Asynchronous	USART2		BSP_C
BSP LED	GPIO:Output	PA5 [LD2 [green Led]]		BSP_C
IKS01A3 BUS IO driver	I2C:I2C	I2C1	0	BSP_B



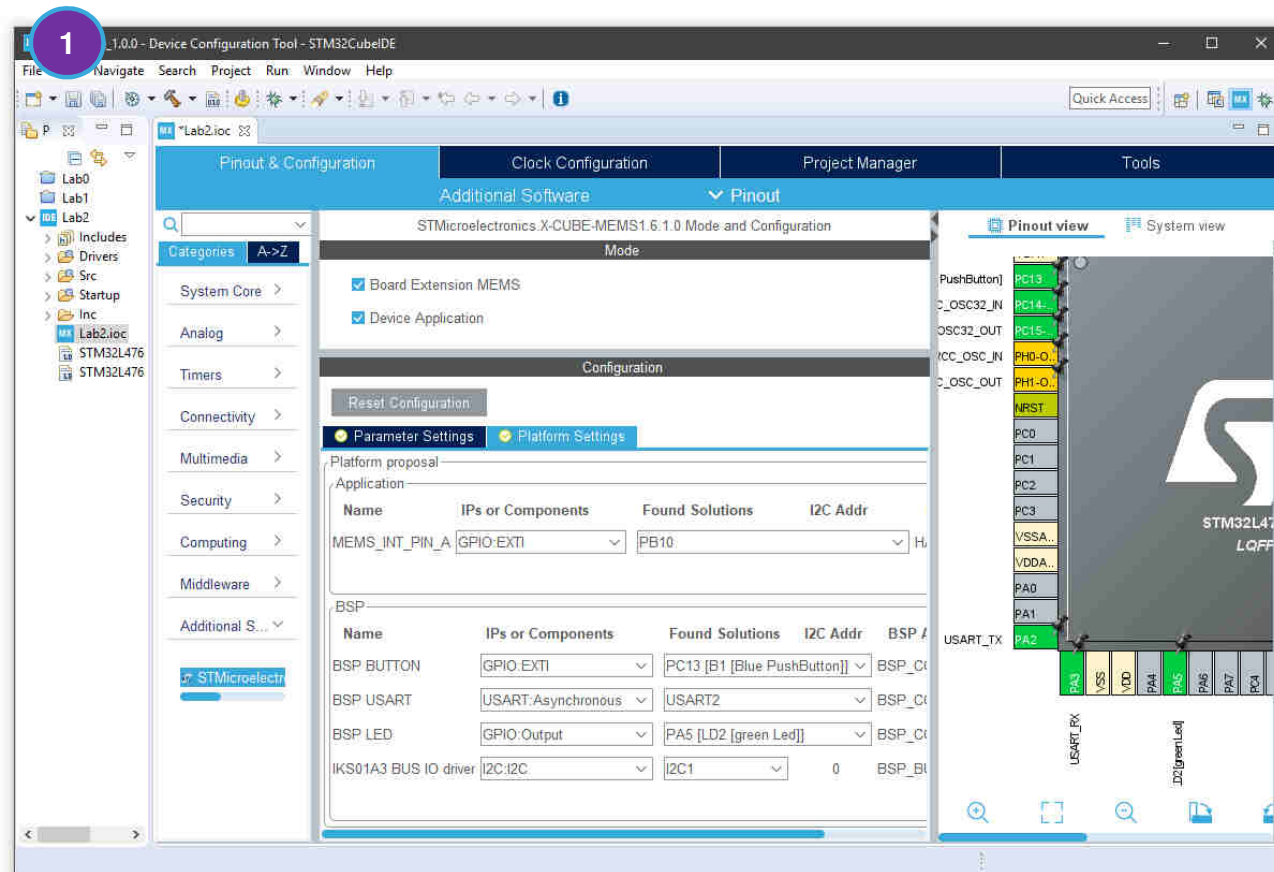
Lab2 – Save the Project

134

1. Click the save button



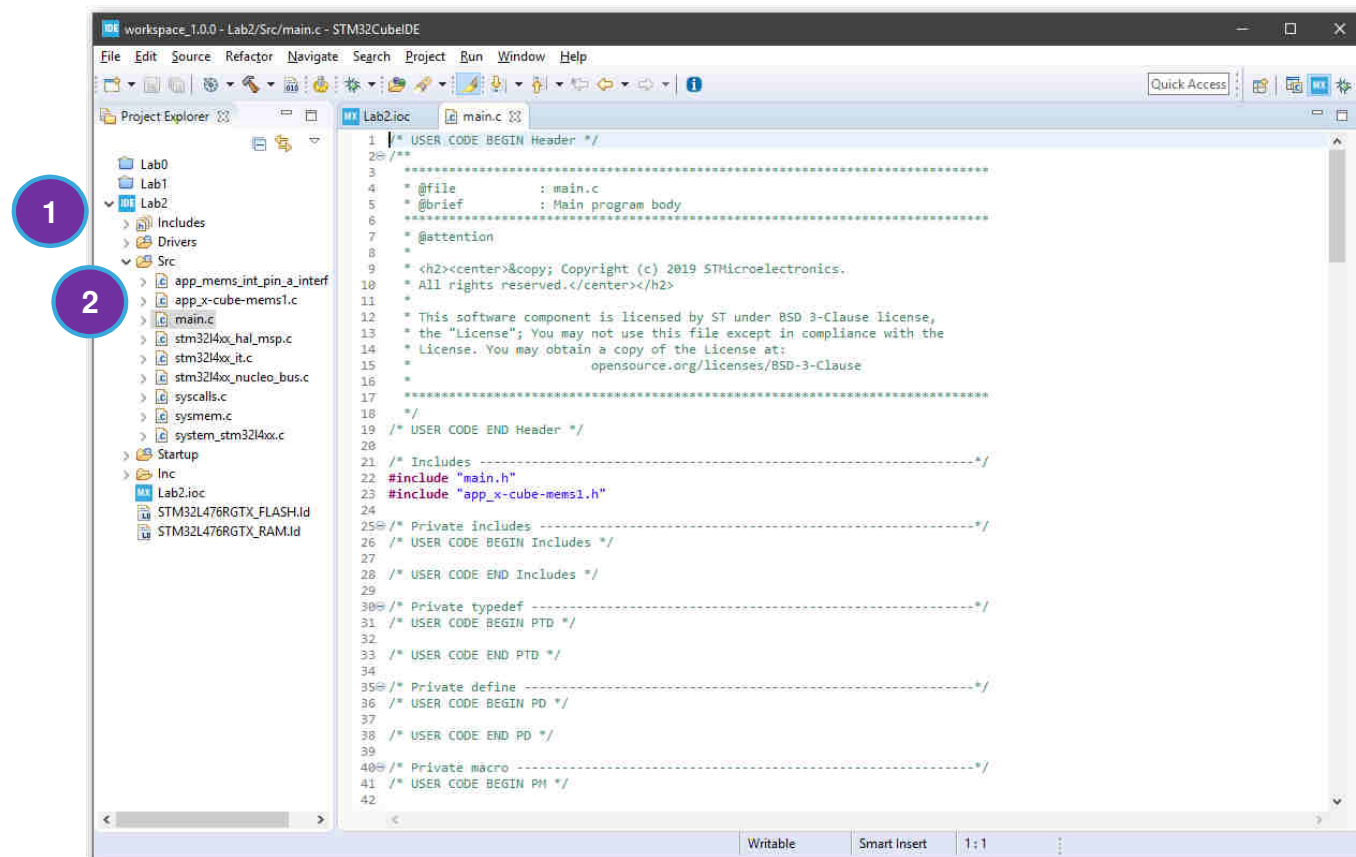
This action will generate the source code of this lab



Lab2 – Code Editing

135

1. Expand **Src** in folder **Lab2**
2. Double click on **main.c**

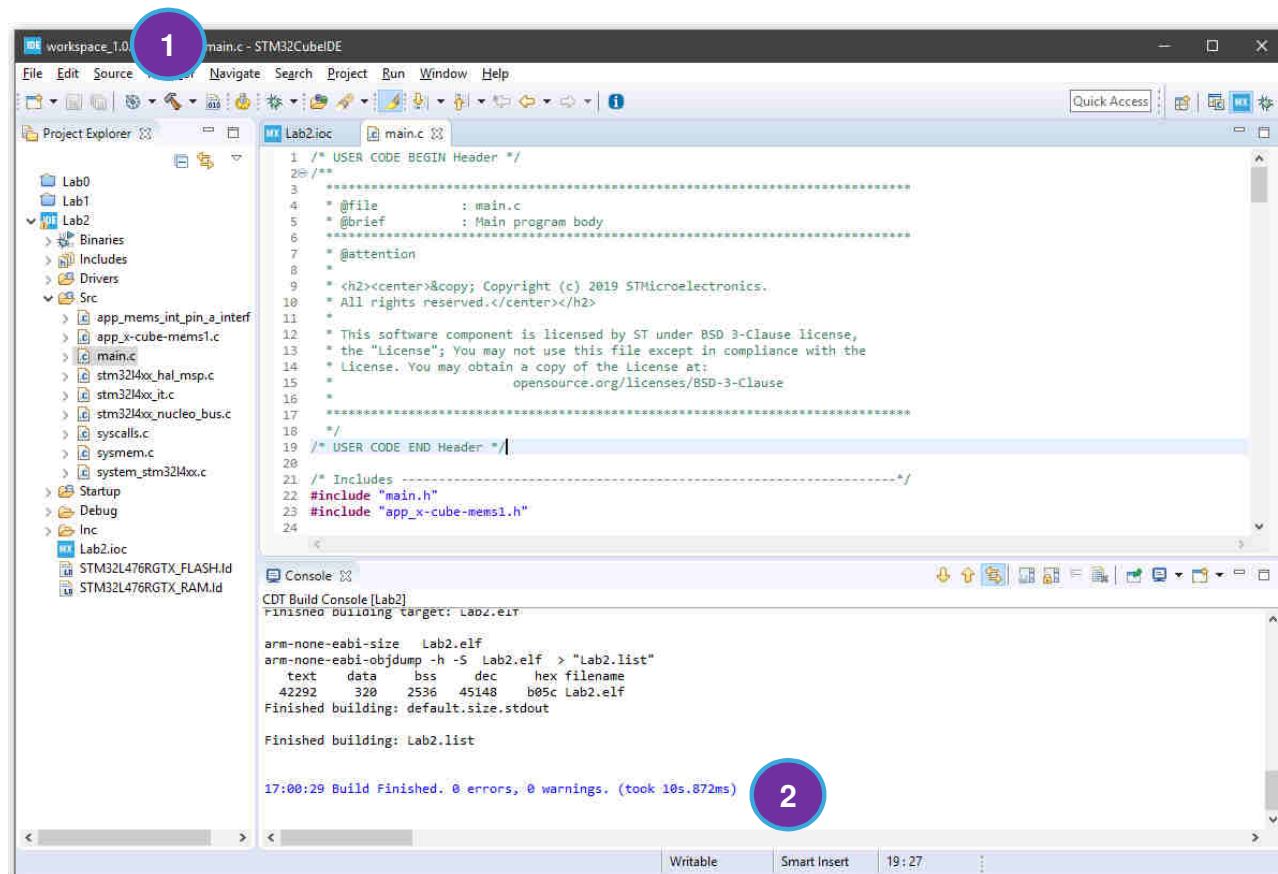


Lab2 - Compiling

136

1. Click on the hammer  to begin compilation, or press **CTRL+B**

2. Compilation should terminate with 0 errors and 0 warning



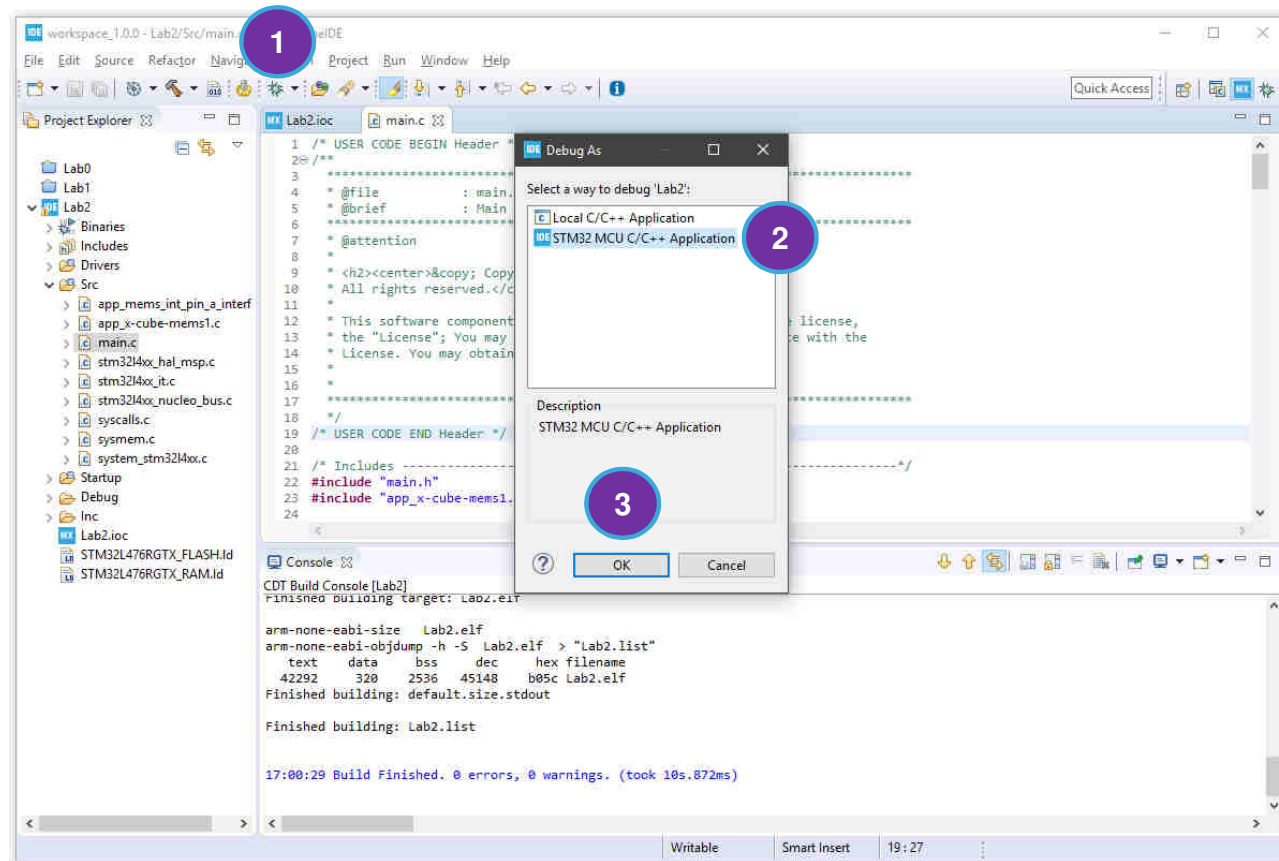
Lab2 - Debugging

137

1. Click on the bug  to begin debugging

2. Select **STM32 MCU C/C++ App**

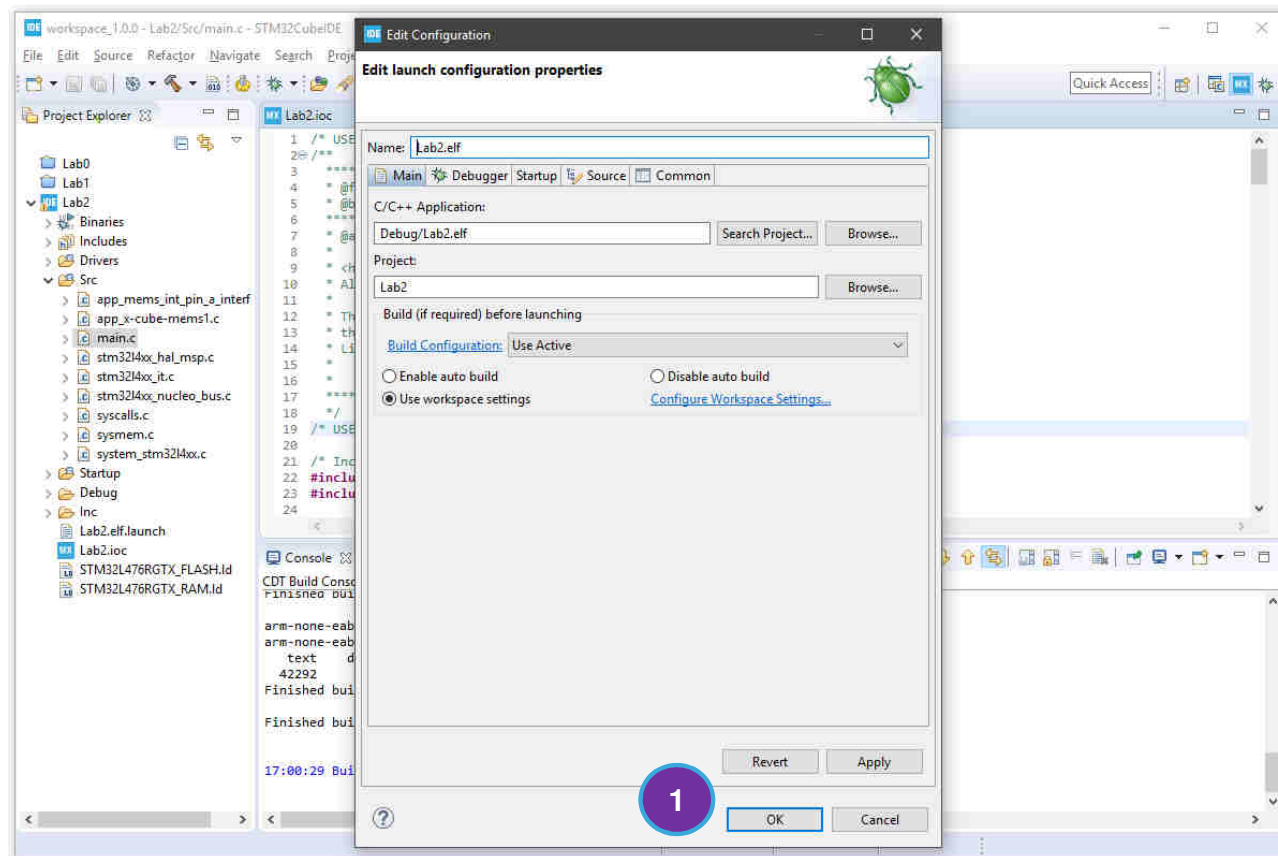
3. Click **OK**



Lab2 - Debugging

138

1. Click **OK**

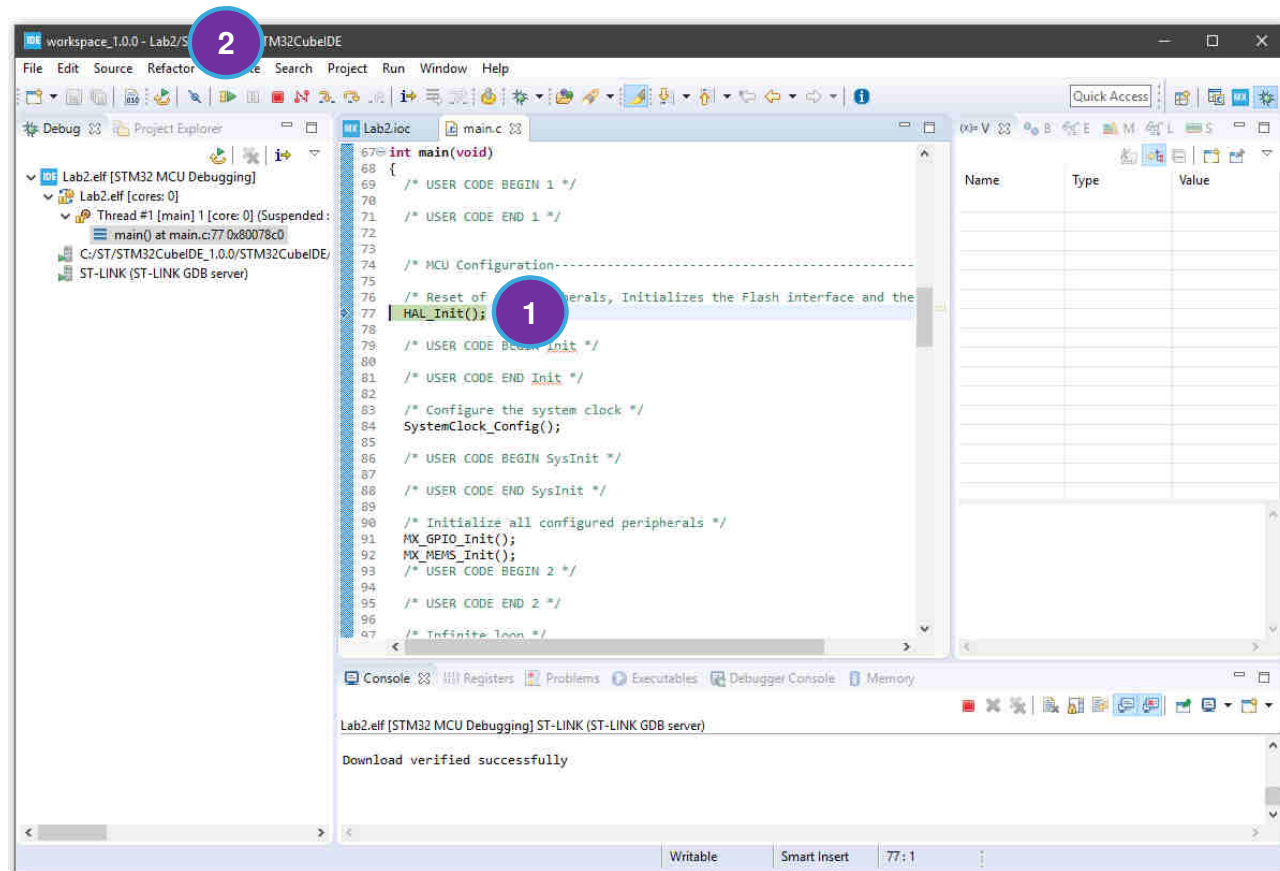


Lab2 - Debugging

139

1. Code start at the first line of the main function

2. Click play  button to run the code



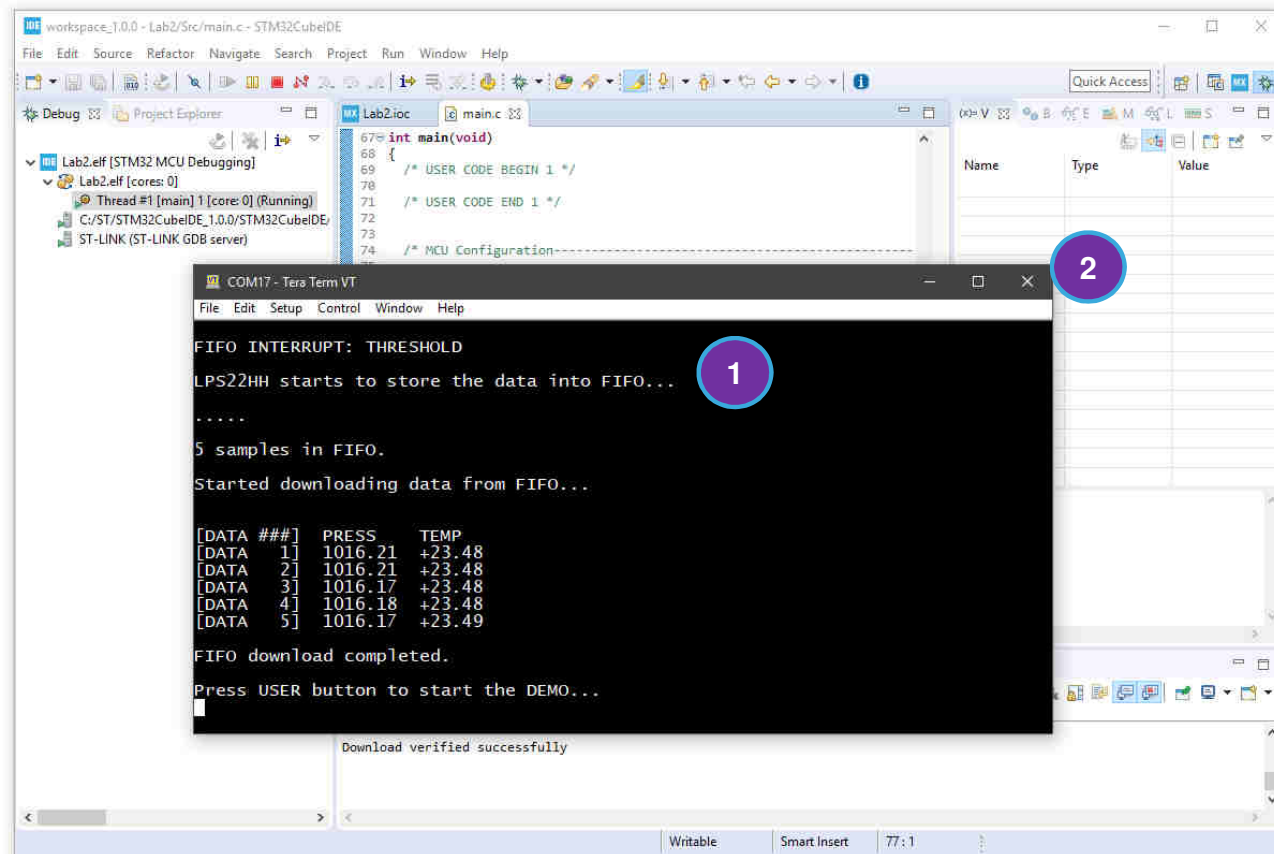
Lab2 - Testing

140

1. Open Tera Term to view the output

Press User button (blue) on Nucleo board

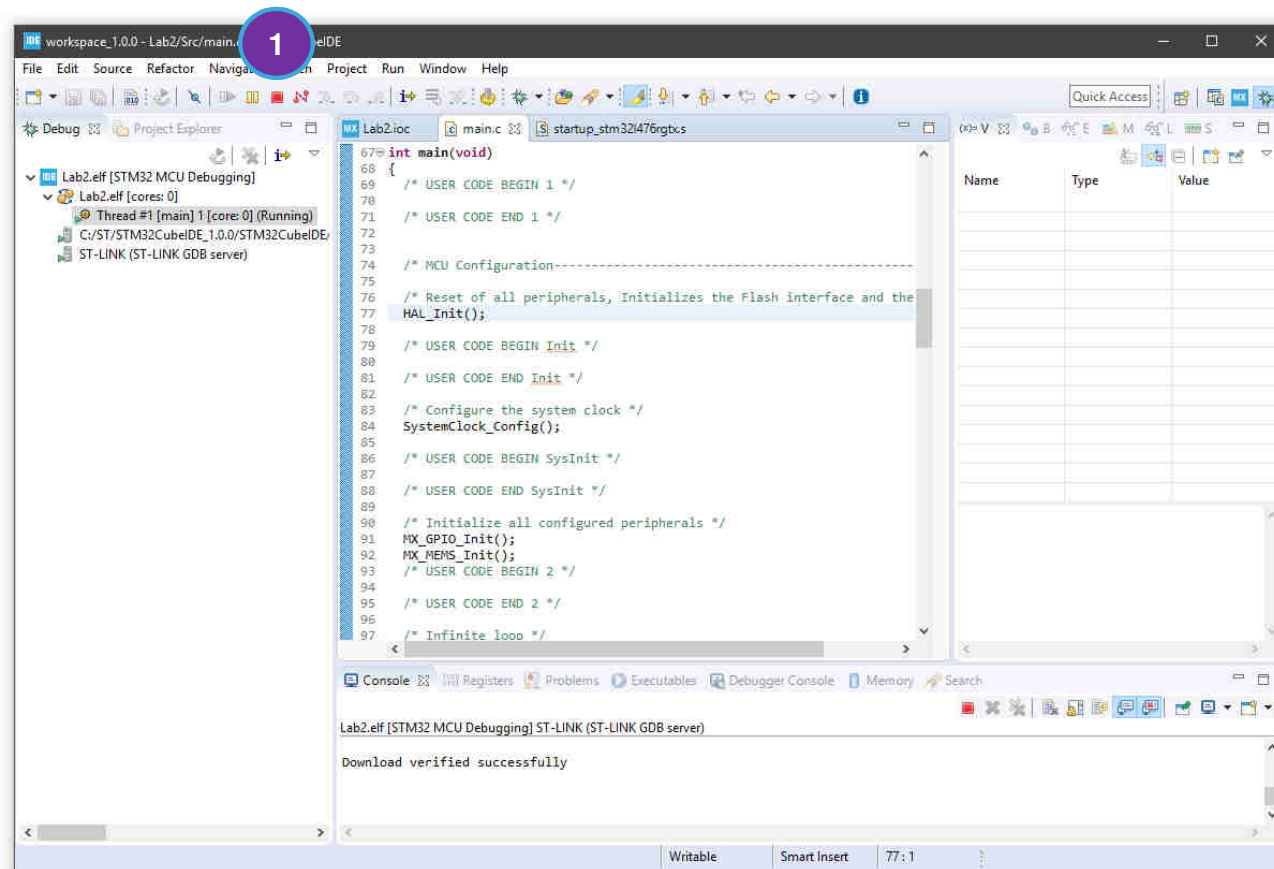
2. After testing close Tera Term by clicking **X**



Lab2 - Debugging

141

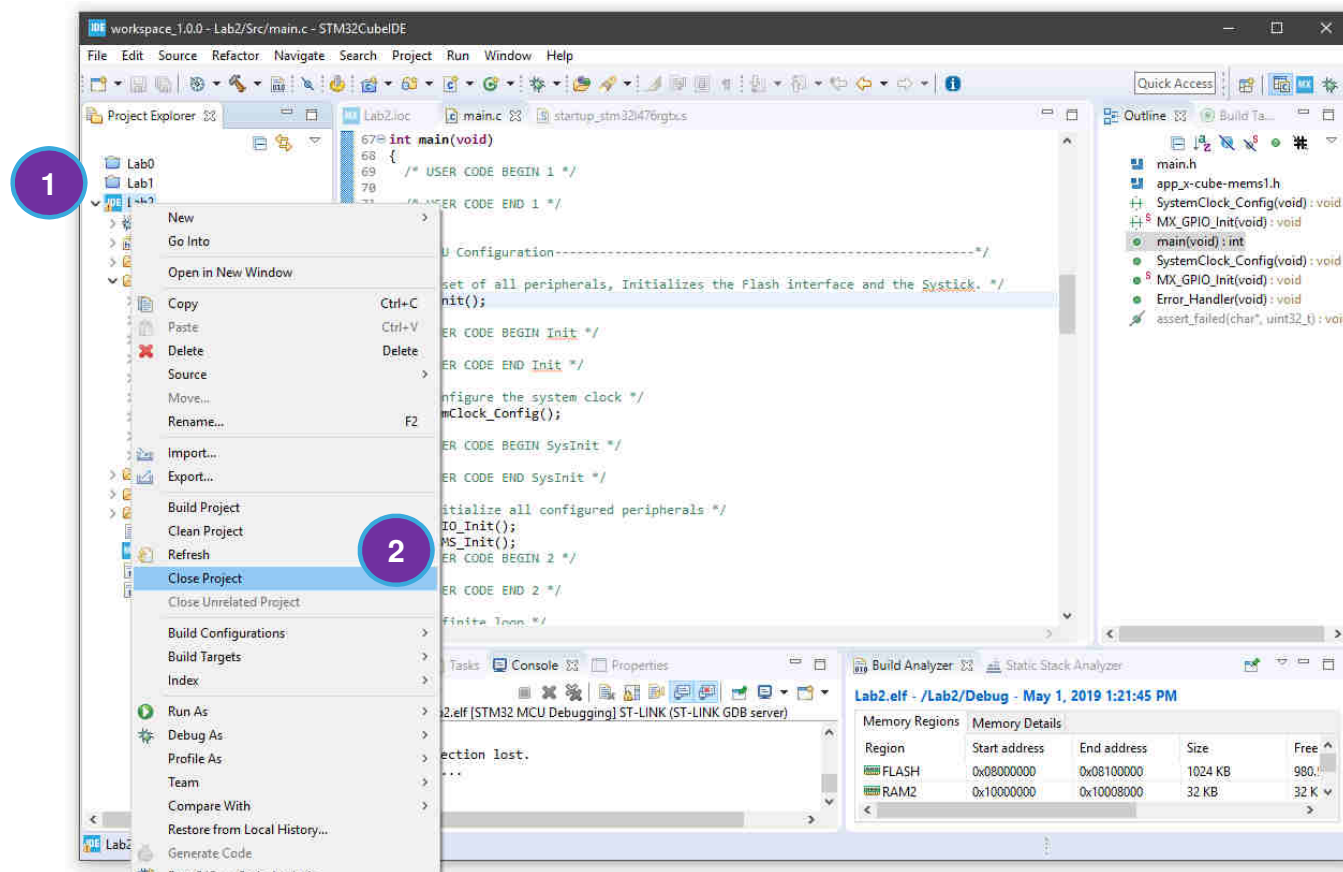
1. Click stop  button to interrupt the debugging



Lab2 – Closing the Project

142

1. Right-Click on **Lab2** project
2. Click on **Close Project**



LAB3

Goals:

- Configure a new project using X-CUBE-MEMS1
- Configure LSM6DSO accelerometer embedded step counter
- Enable interrupts in STM32CubeIDE



LSM6DSO

144

Accelerometer + Gyroscope Inertial Measurement Unit

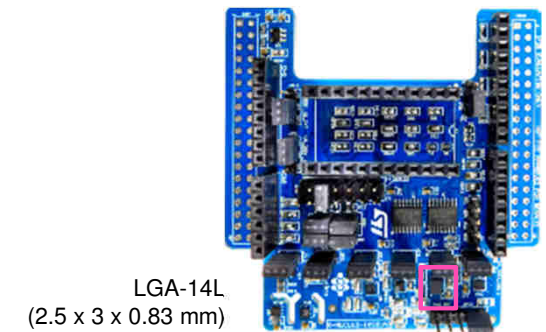
- 0.45mA power consumption (normal mode)
 - Accelerometer: 0.05mA, Gyroscope: 0.40mA
- Auxiliary SPI typically used for OIS / EIS or closed loop control; I3C Interface
- 9kB equivalent FIFO Memory for local data storage
- Finite State Machines (up to 16)
- Digital Features
 - Free fall
 - Pedometer 2.0
 - 6D / 4D
 - Tilt detection
 - Tap/ Double Tap

Lowest power consumption IMU → battery saving

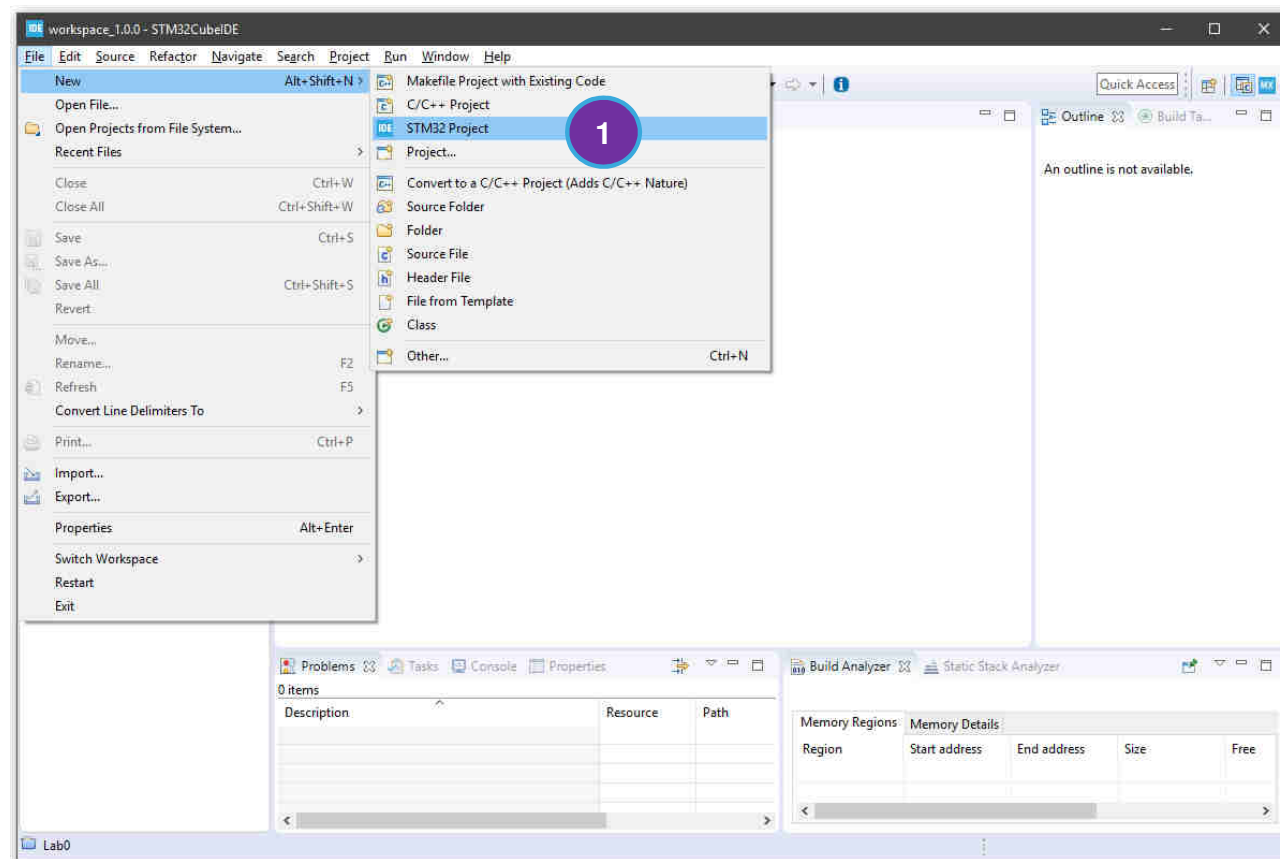
Design Flexibility and cost optimization

System power saving

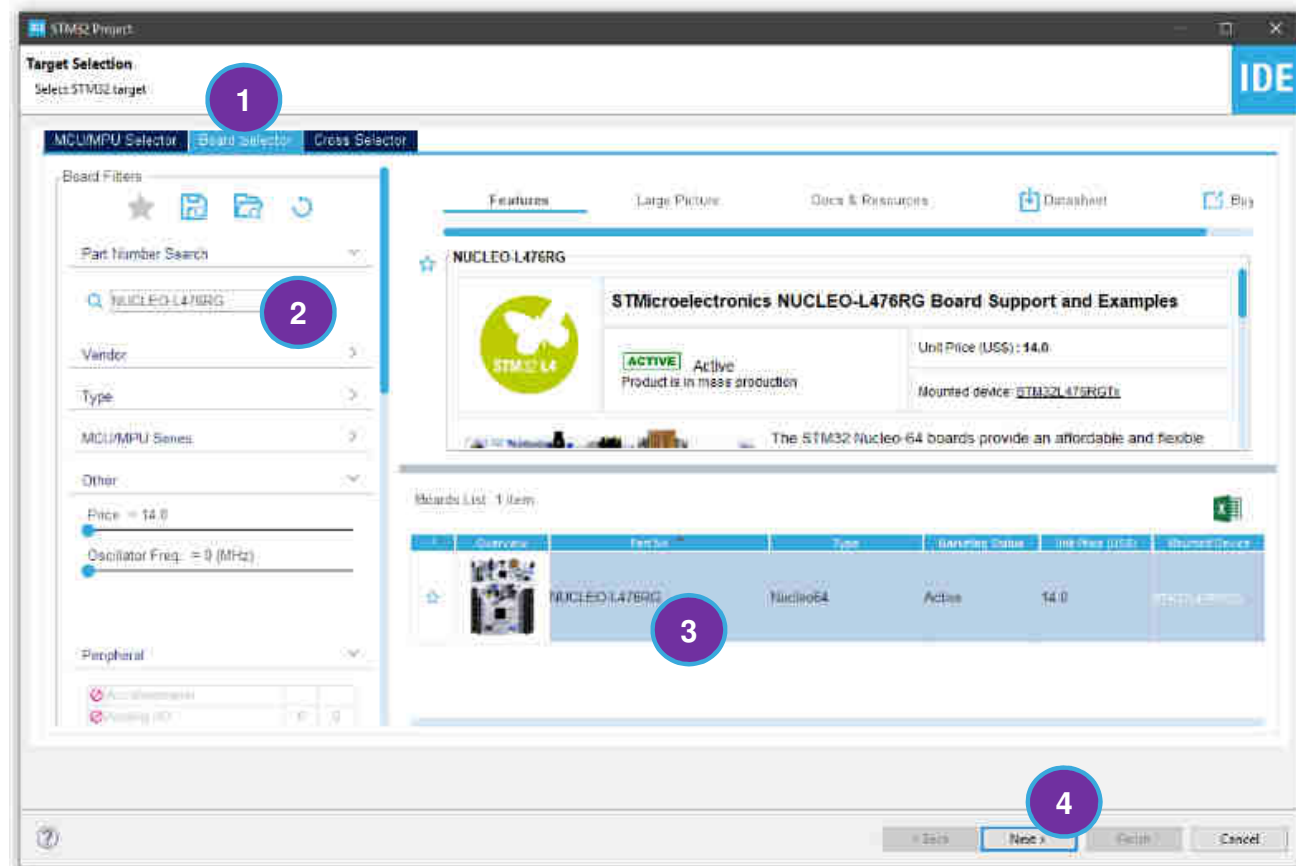
Smart Functions with High Flexibility



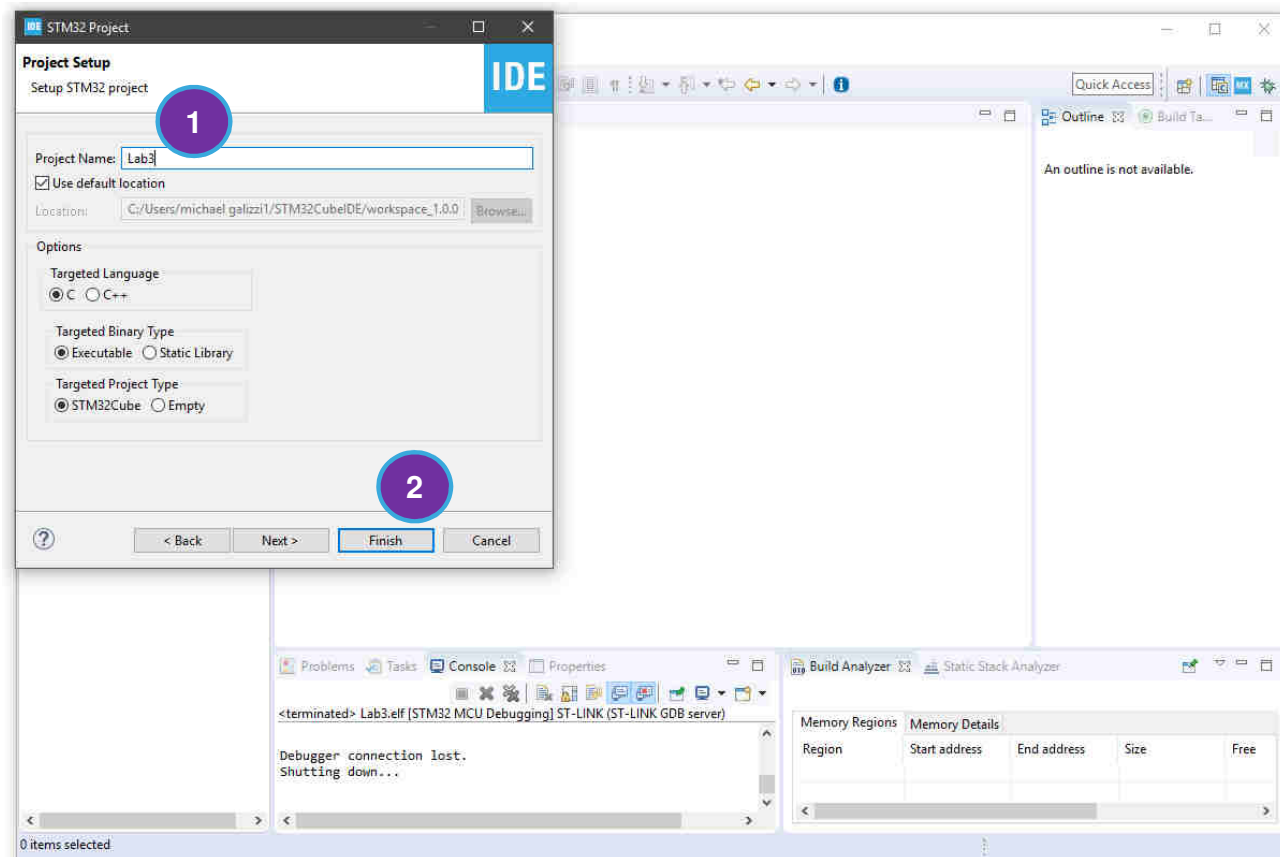
1. Click on **File > New > STM32 Project**



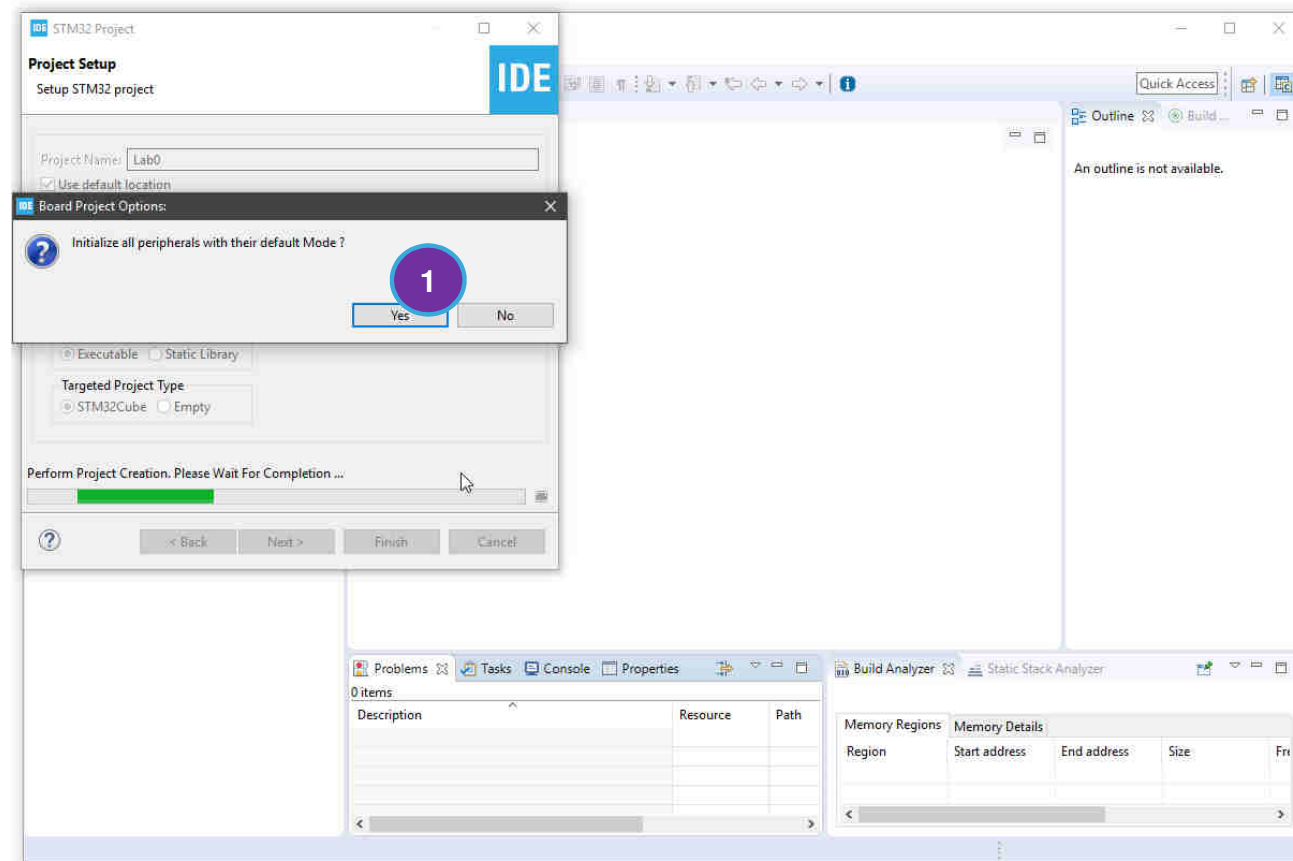
1. Click on **Board Selector**
2. Type **NUCLEO-L476RG**
3. Click on the board
4. Click **Next >**



1. Project Name **Lab3**
2. Click **Finish**



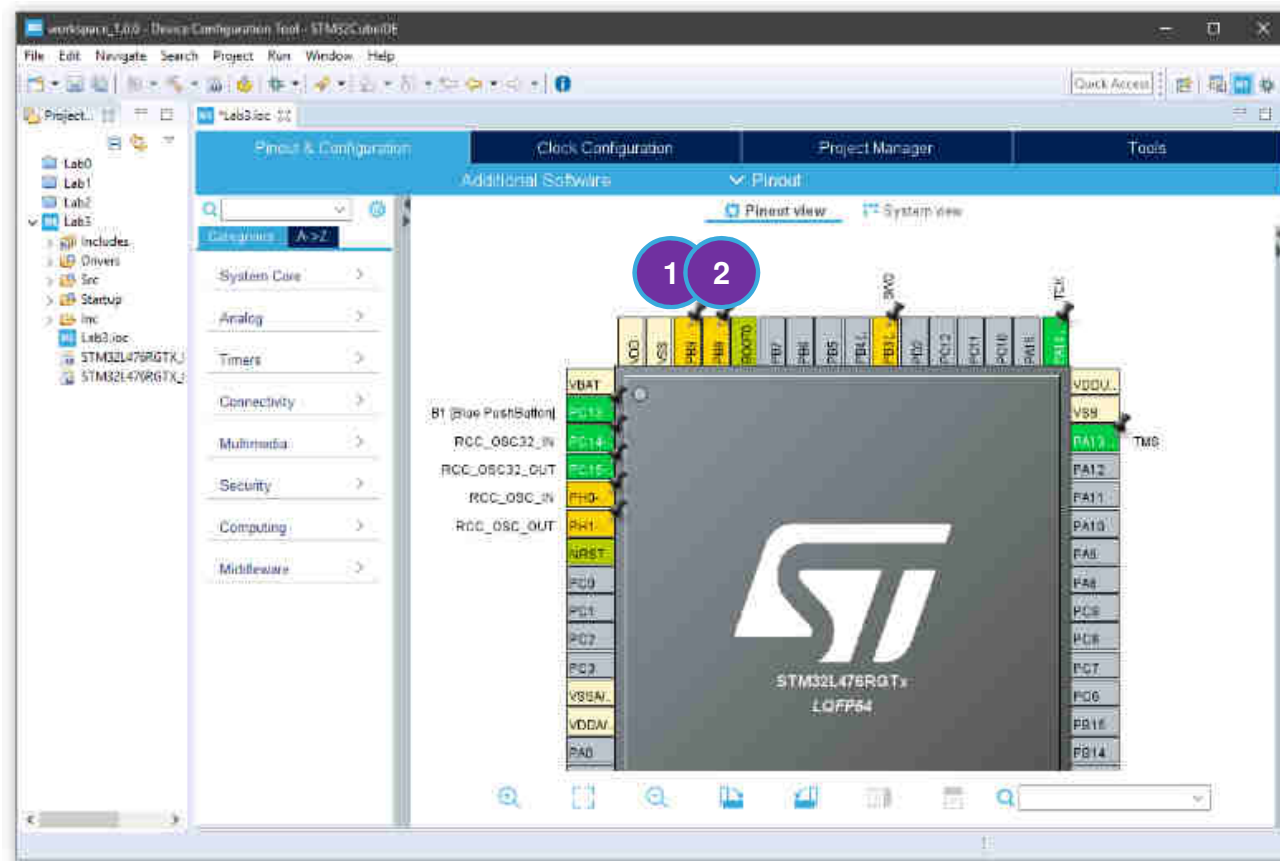
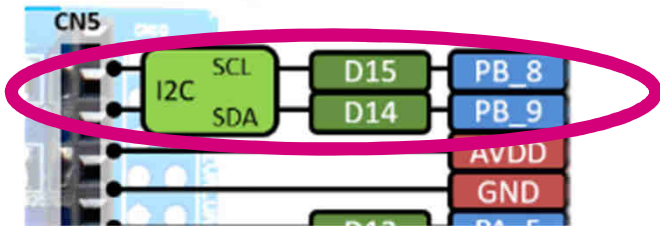
1. Click **Yes** to init peripherals in default mode



Lab3 – Configure the I2C Bus

149

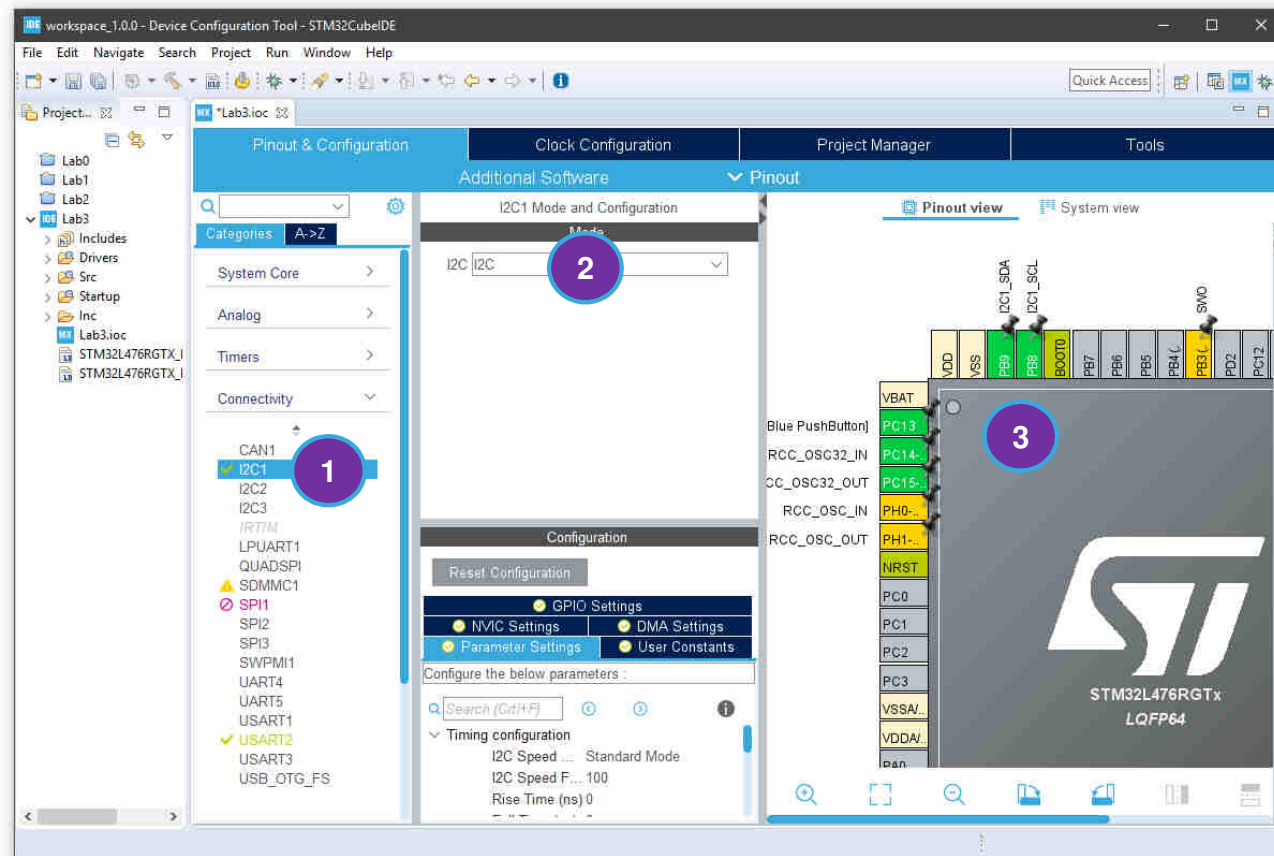
1. Left Click on **PB9** and select I2C1_SDA
2. Left Click on **PB8** and select I2C1_SCL



Lab3 – Configure the I2C Bus

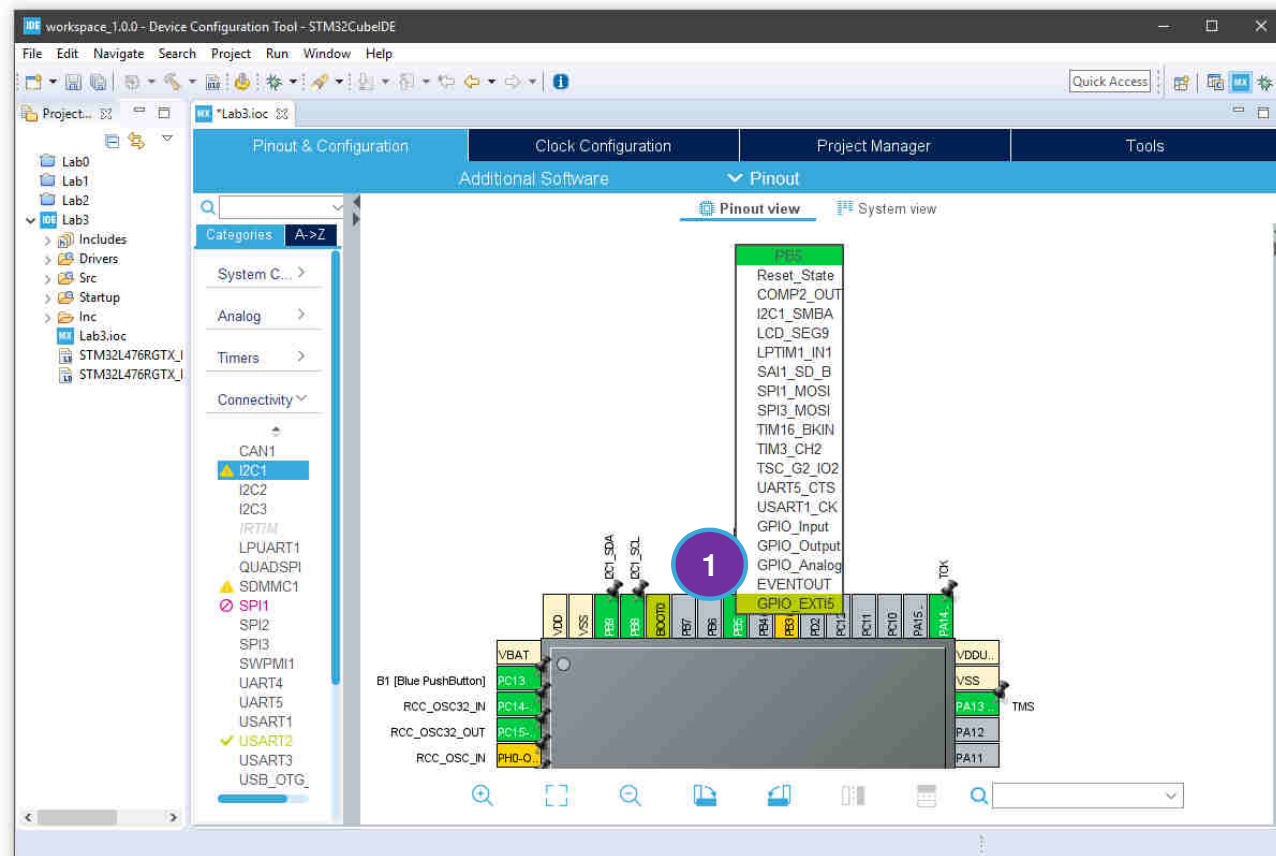
150

1. Expand *Connectivity* tab and check **I2C1**
2. Select **I2C** in *I2C1 Mode and Configuration*
3. PB8 and PB9 should now become green



151

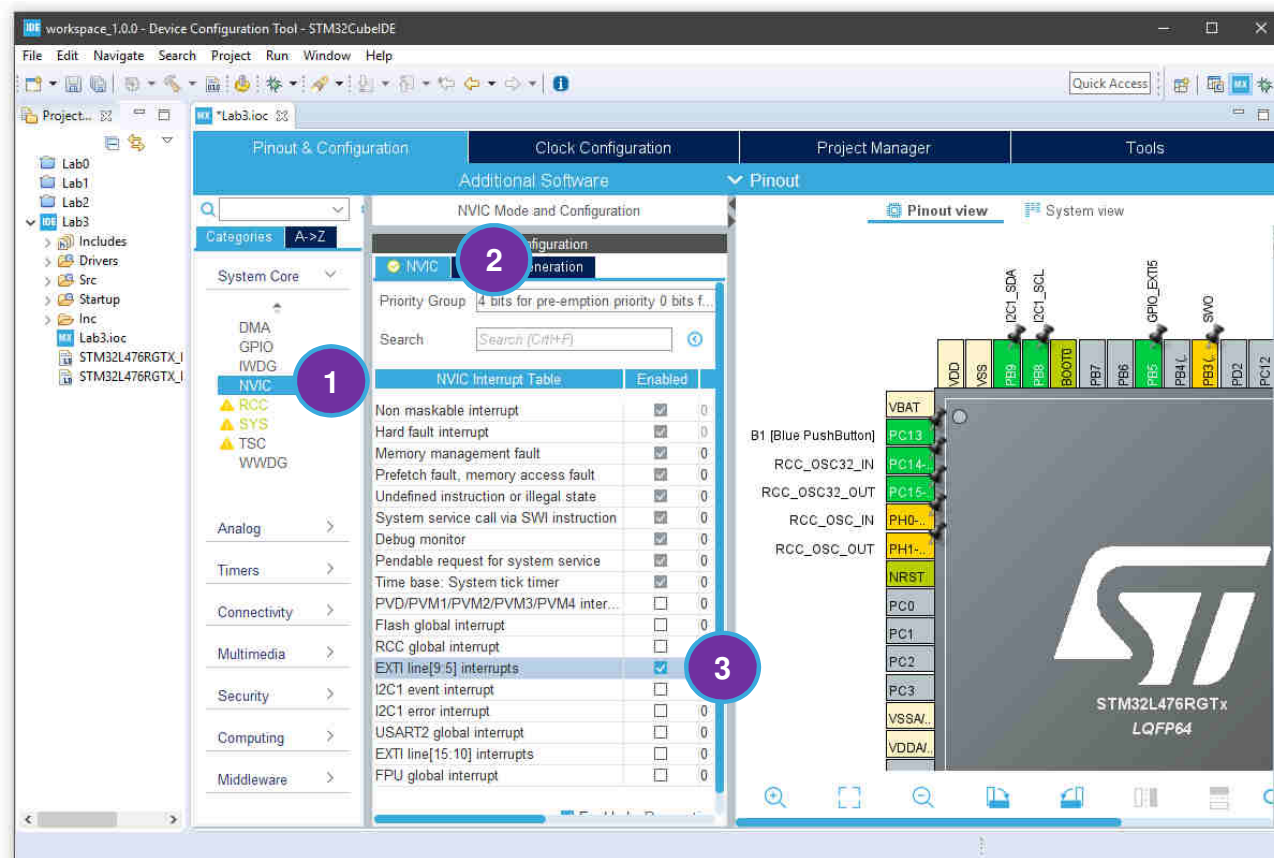
-
- The diagram shows the pin configuration for the STM32F103C8T6 microcontroller. The pins are connected to various functions as follows:
- | Pin | Function |
|-------|----------|
| PA_8 | PA_8 |
| PB_10 | PB_10 |
| PB_4 | PB_4 |
| PB_5 | PB_5 |
| PB_3 | PB_3 |
| PA_10 | PA_10 |
| PA_2 | PA_2 |
- The LSM6DSO INT1 pin is connected to PB_5, which is highlighted by a pink oval.



Lab3 – Configure LSM6DSO Interrupt

152

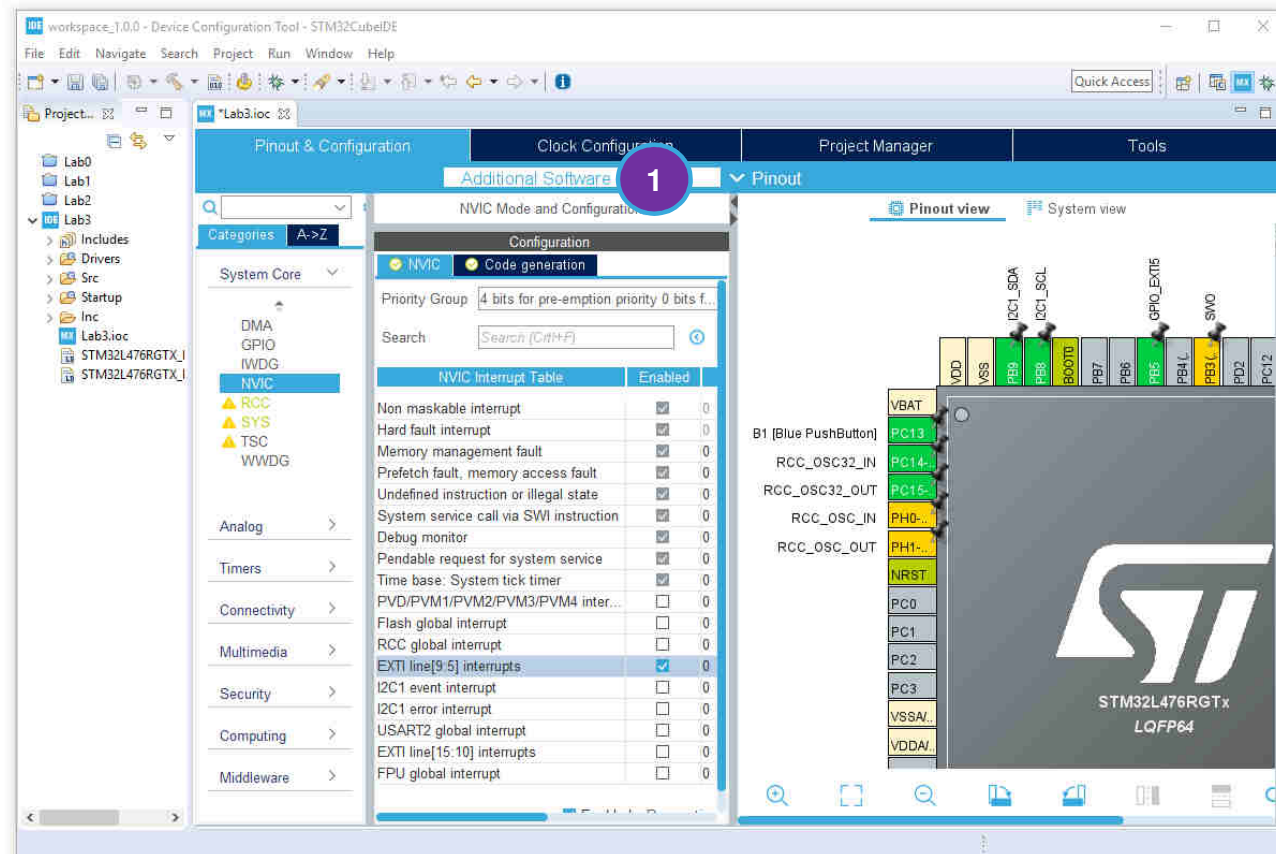
1. Check **NVIC** in tab System Core
2. Select **NVIC** in NVIC Mode and Configuration
3. Enable **EXTI line[9:5] interrupt**



Lab3 – Select the MEMS Library

153

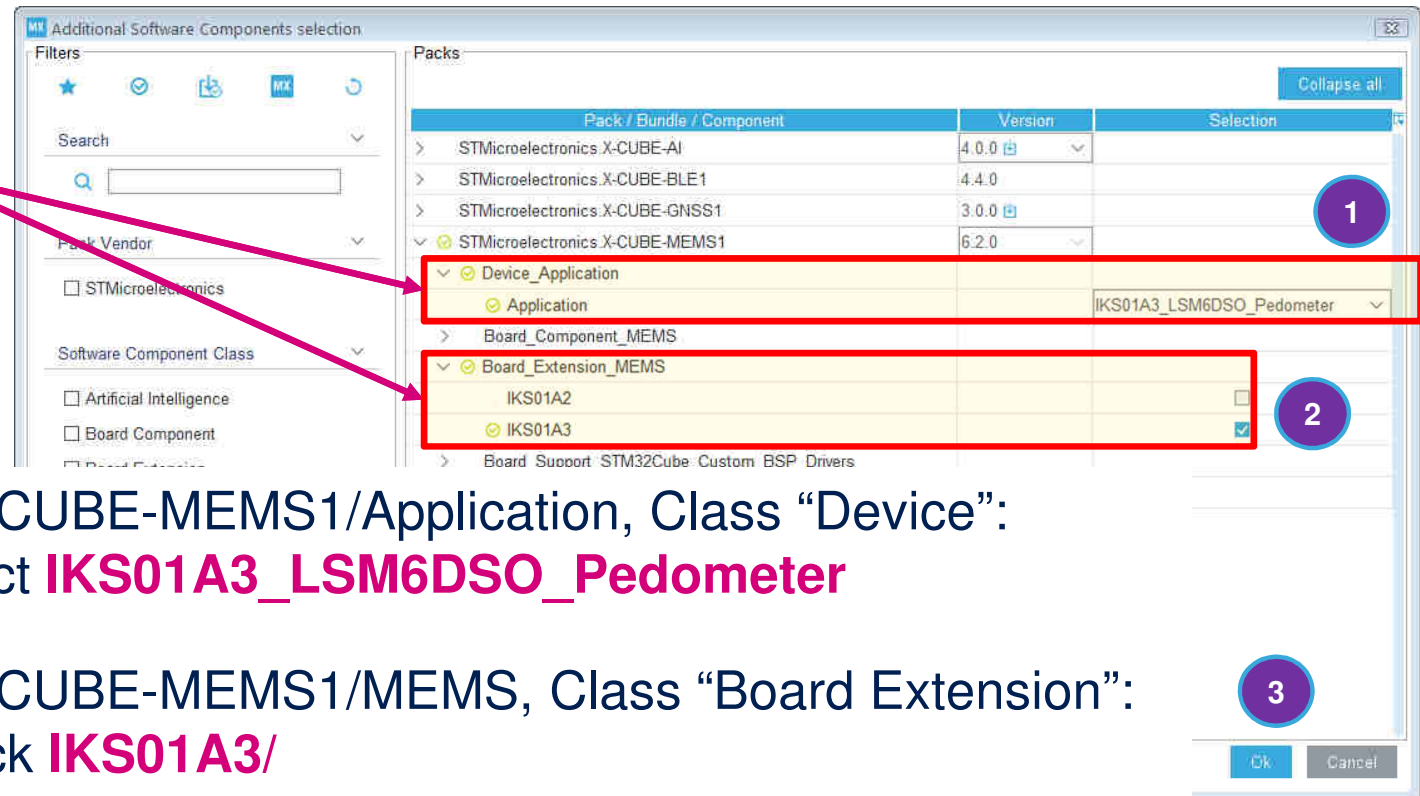
1. Click on **Additional Software**



Lab3 – Select the MEMS Library

154

Click to
expand tree

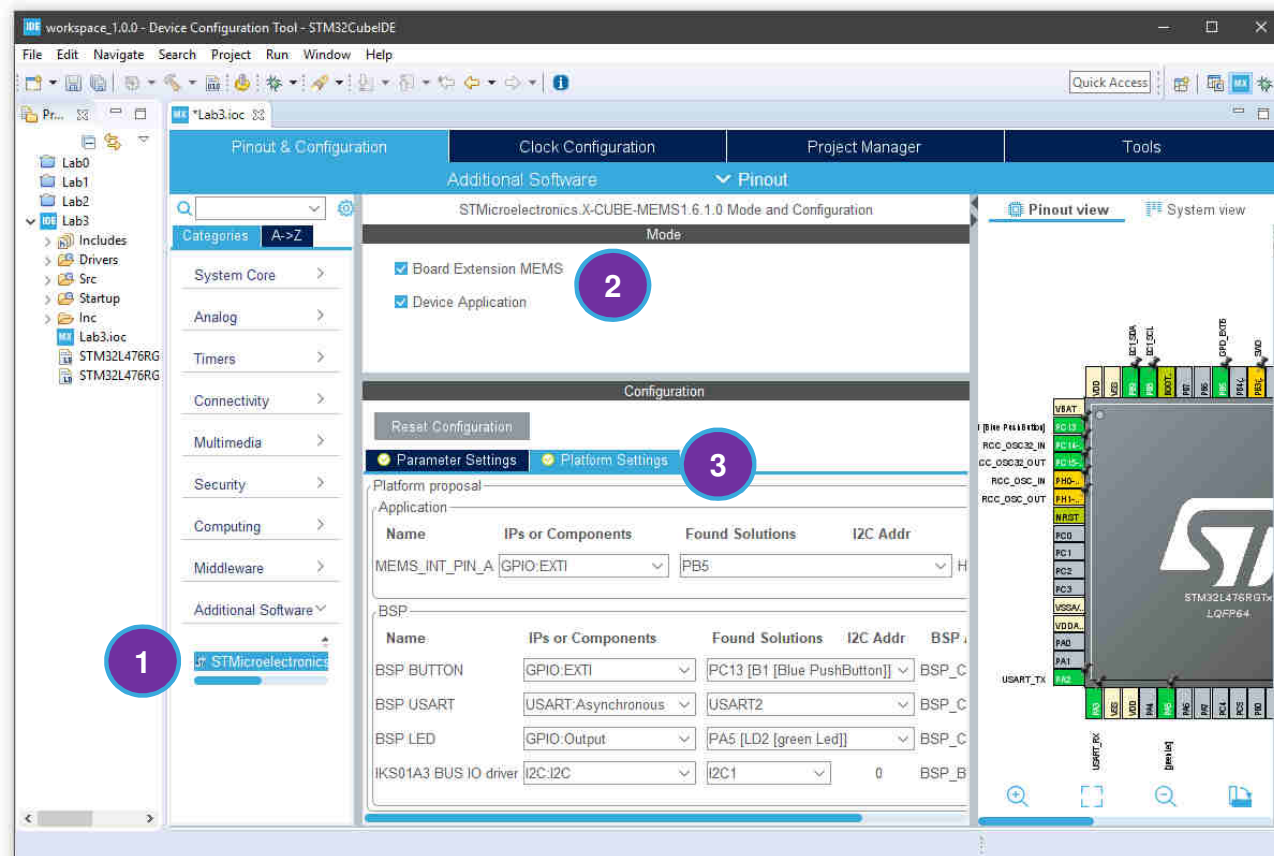


1. In X-CUBE-MEMS1/Application, Class “Device”:
Select **IKS01A3_LSM6DSO_Pedometer**
2. In X-CUBE-MEMS1/MEMS, Class “Board Extension”:
Check **IKS01A3/**
3. Click **OK**

Lab3 – Configure the MEMS Library

155

1. Expand Additional Software and select the X-CUBE-MEMS1
2. Check both:
Board Extension MEMS
Device Application
3. Configure Platform Settings as in picture



Lab3 – Configure the MEMS Library

156

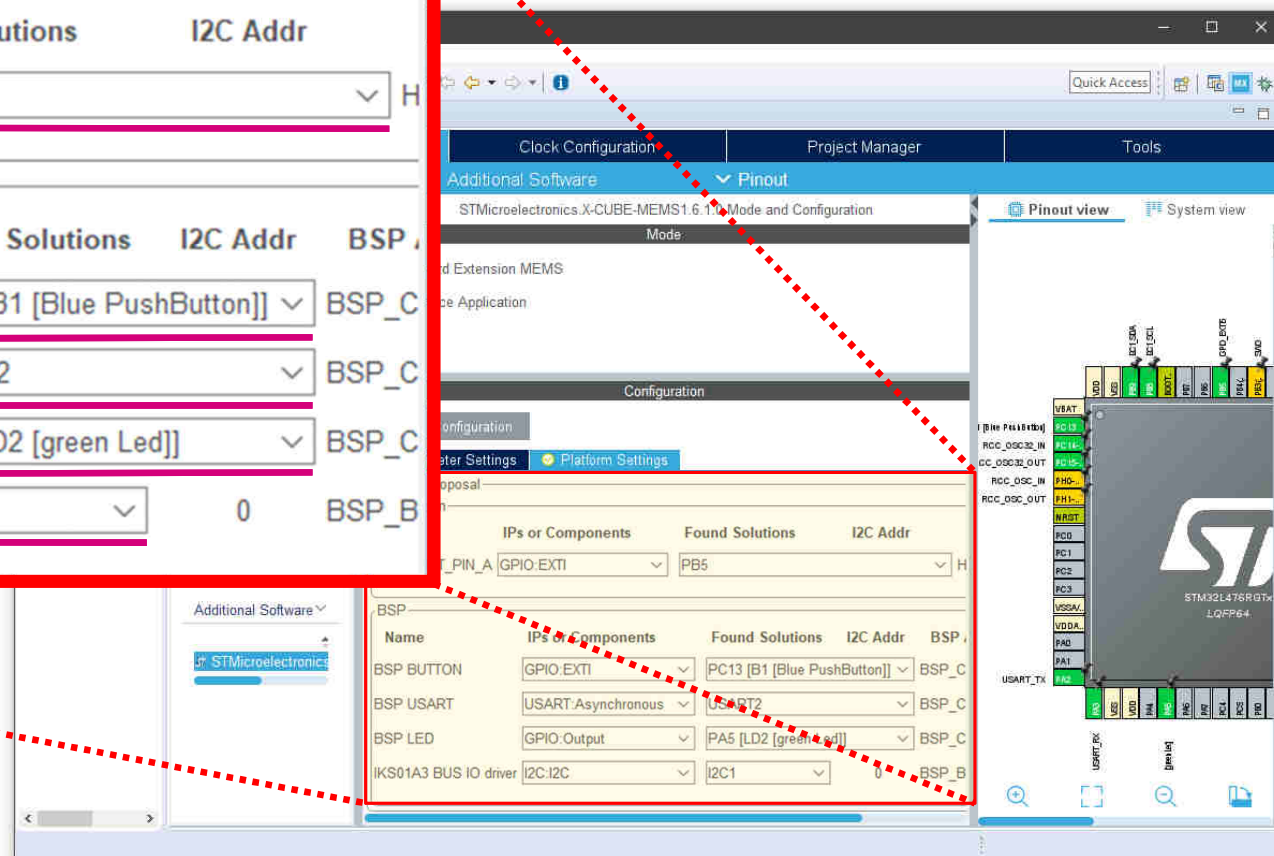
Platform proposal

Application

Name	IPs or Components	Found Solutions	I2C Addr
MEMS_INT_PIN_A	GPIO:EXTI	PB5	

BSP

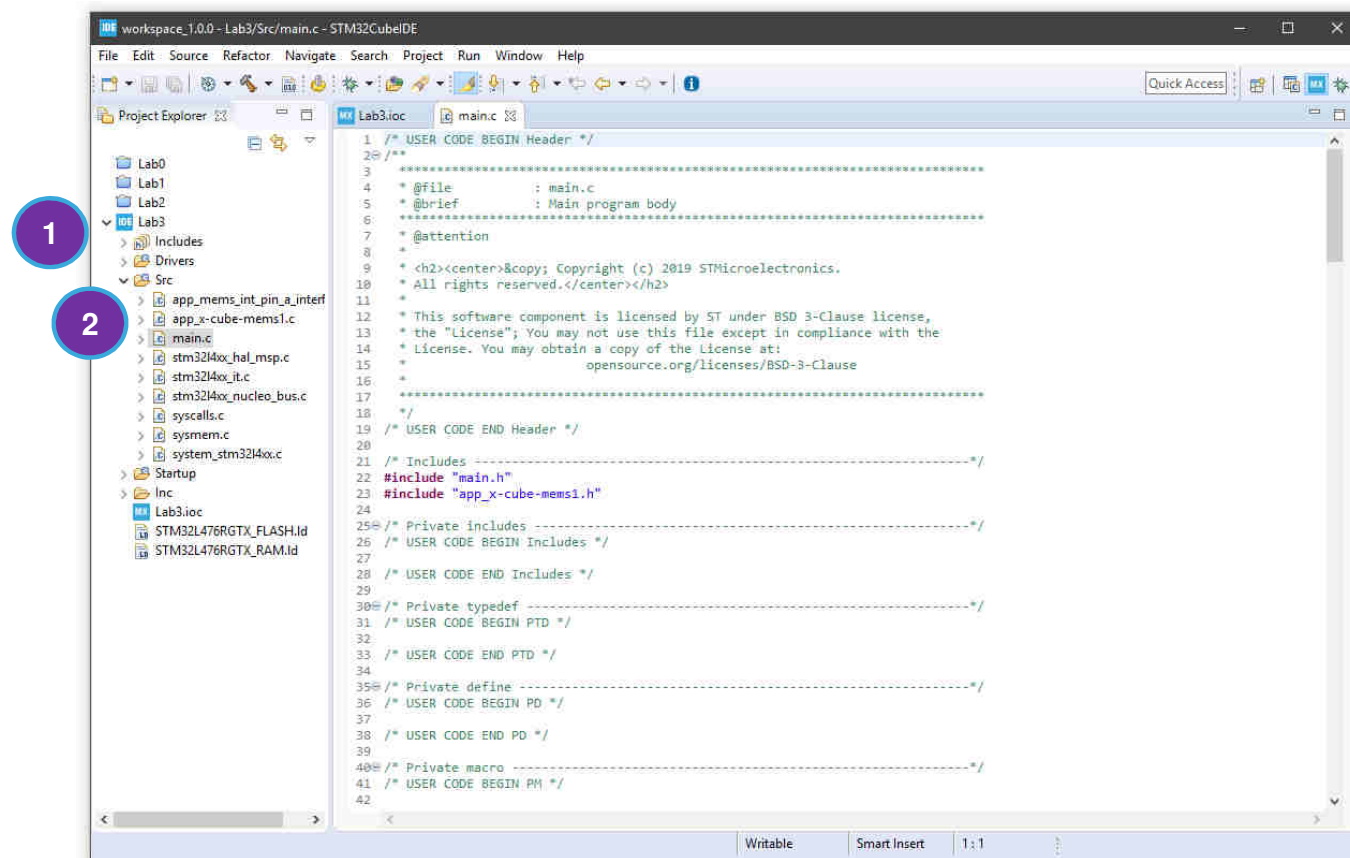
Name	IPs or Components	Found Solutions	I2C Addr	BSP
BSP BUTTON	GPIO:EXTI	PC13 [B1 [Blue PushButton]]		BSP_C
BSP USART	USART:Asynchronous	USART2		BSP_C
BSP LED	GPIO:Output	PA5 [LD2 [green Led]]		BSP_C
IKS01A3 BUS IO driver	I2C:I2C	I2C1	0	BSP_B



Lab3 – Code Editing

158

1. Expand **Src** in folder **Lab3**
2. Double click on **main.c**

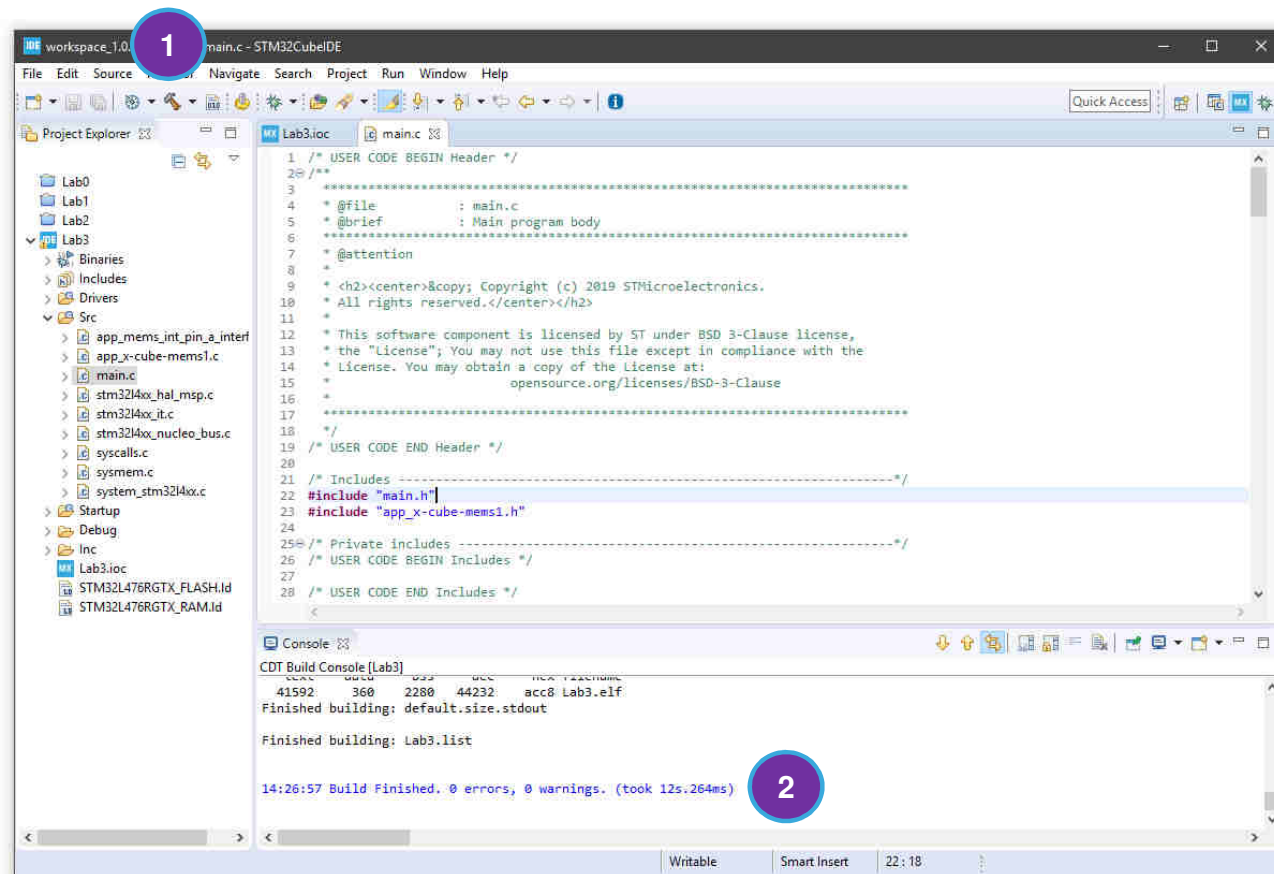


Lab3 - Compiling

159

1. Click on the hammer  to begin compilation, or press **CTRL+B**

2. Compilation should terminate with 0 errors and 0 warning



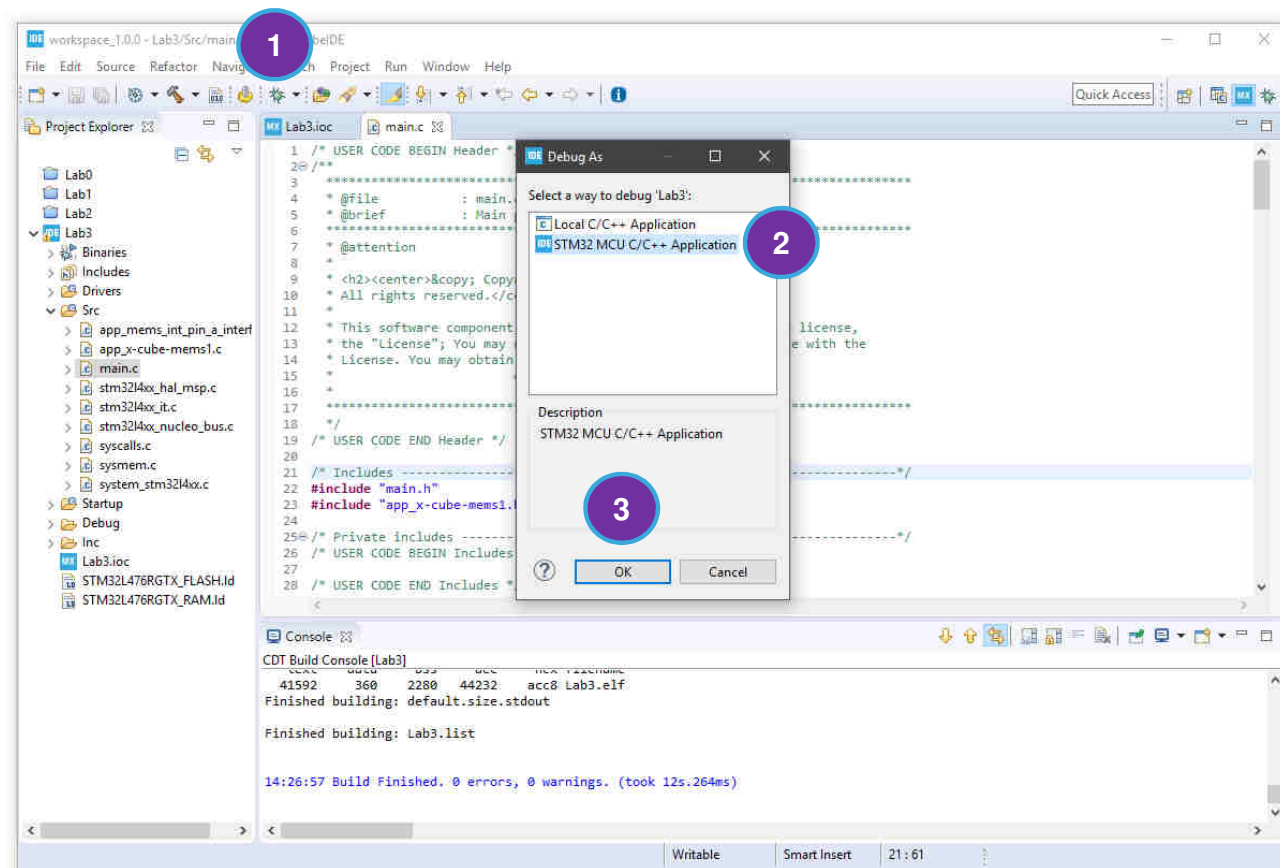
Lab3 - Debugging

160

1. Click on the bug  to begin debugging

2. Select **STM32 MCU C/C++ App**

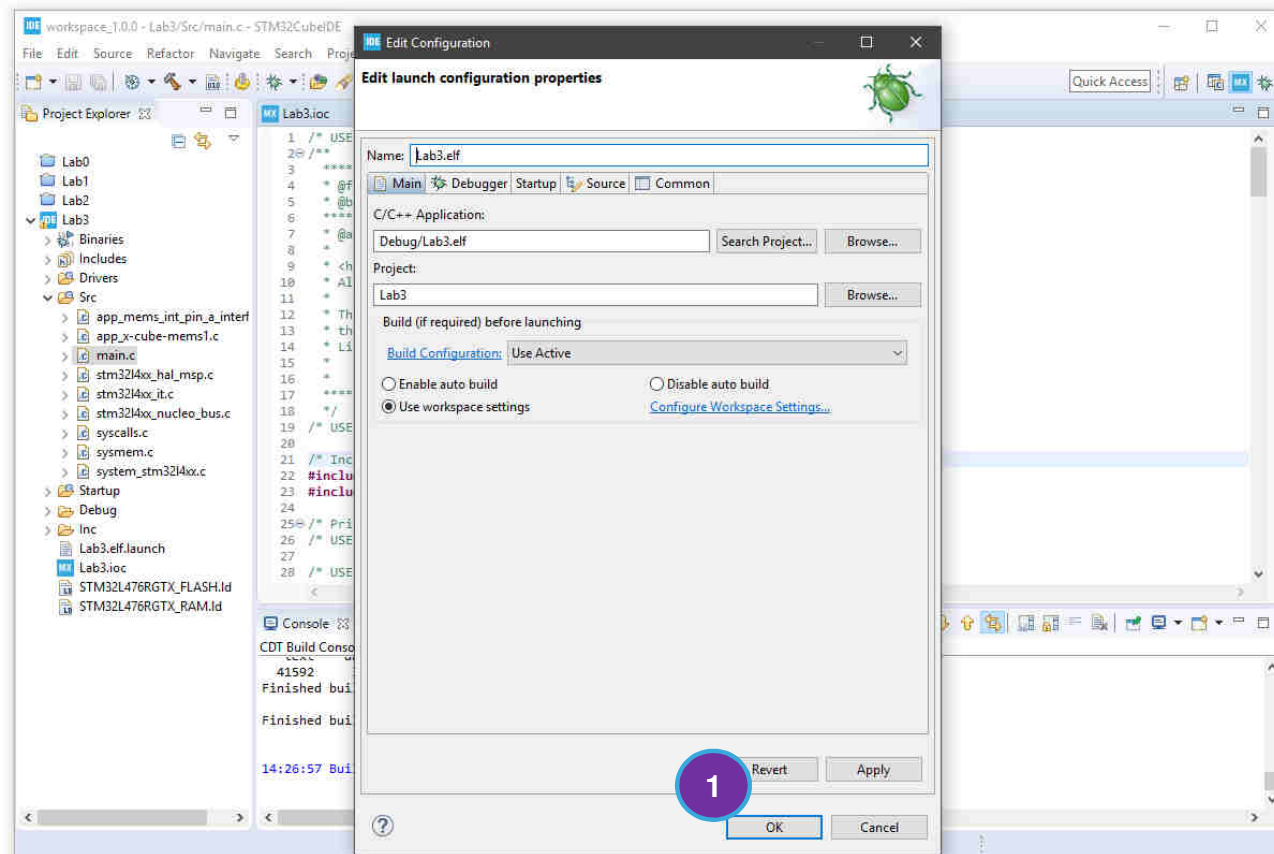
3. Click **OK**



Lab3 - Debugging

161


1. Click **OK**

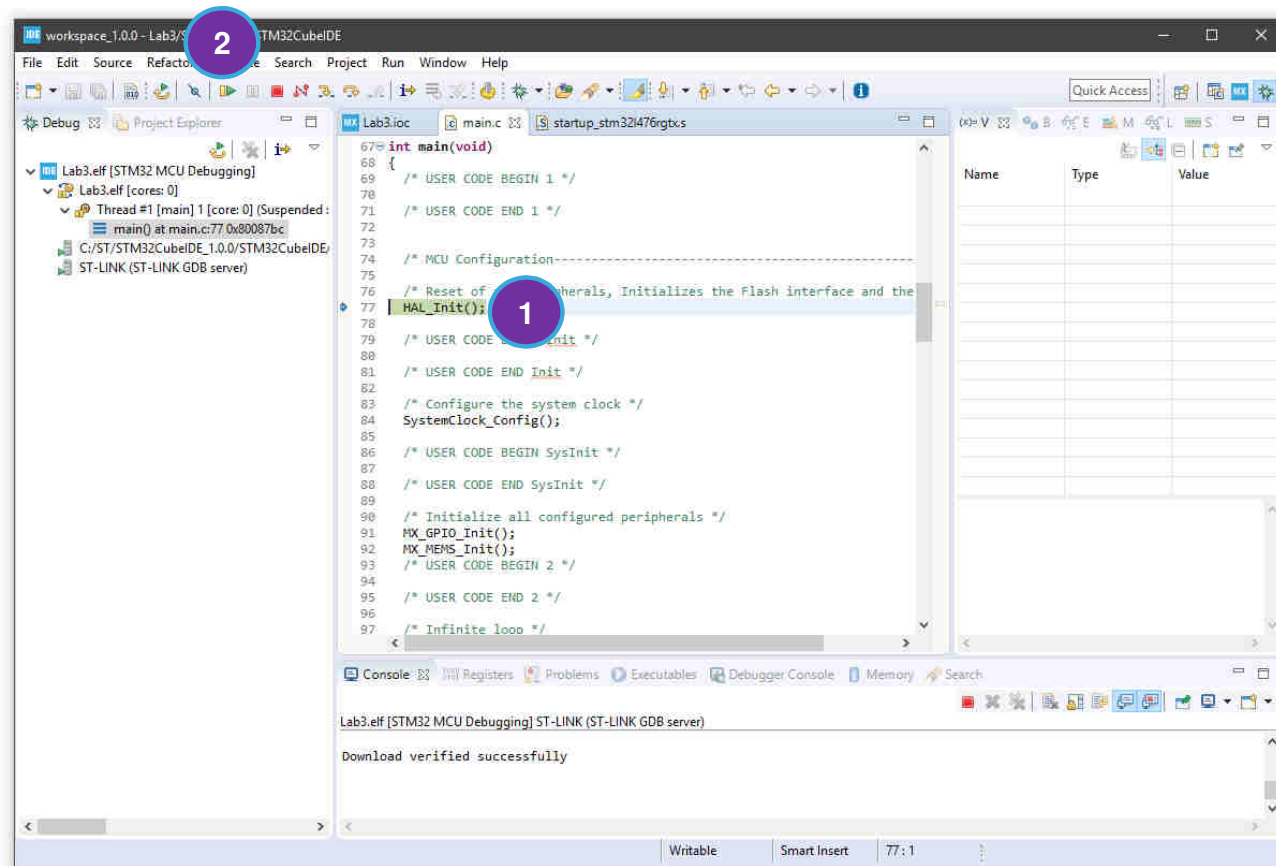


Lab3 - Debugging

162

1. Code start at the first line of the main function

2. Click play  button to run the code



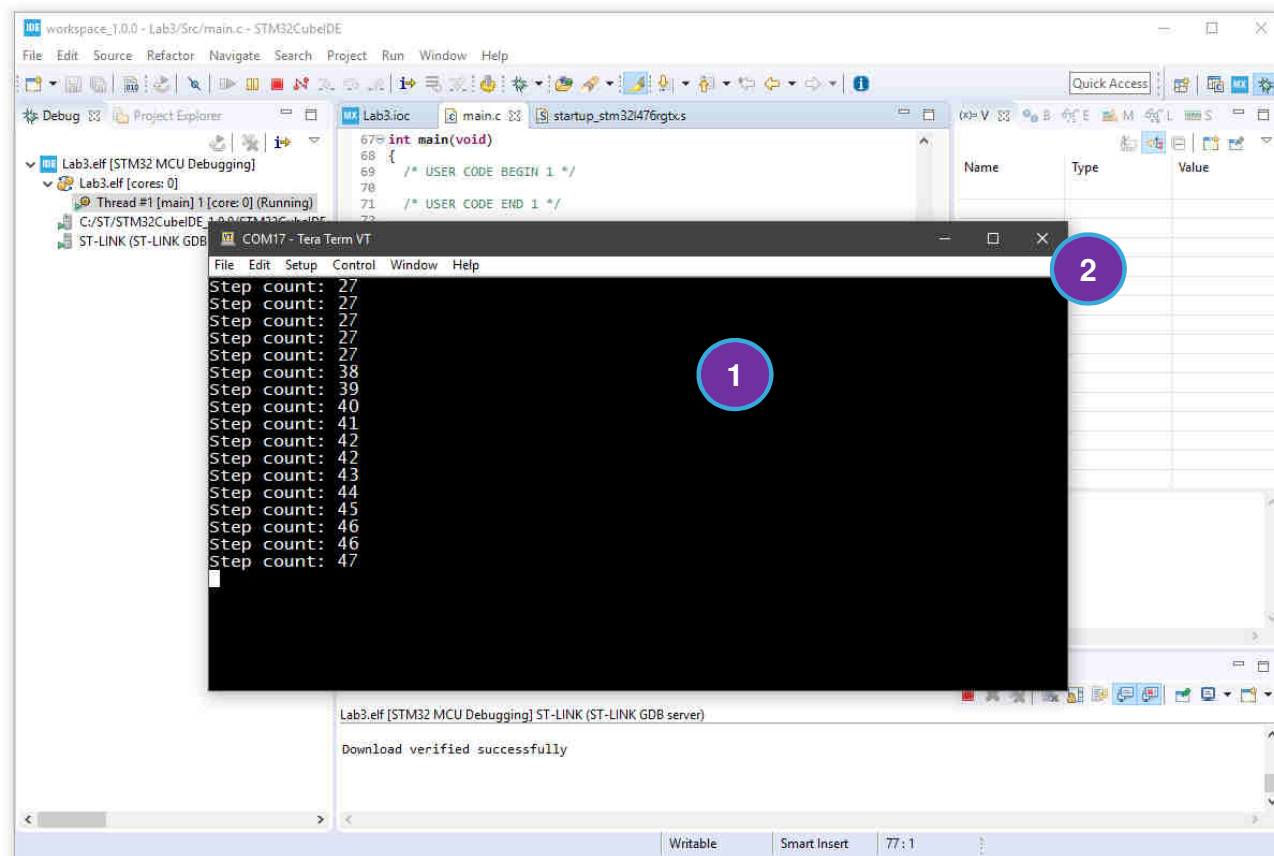
Lab3 - Testing

163

1. Open Tera Term to view the output

Simulate a walk by giving up/down movement to the board. Steps will be updated after about 10 steps

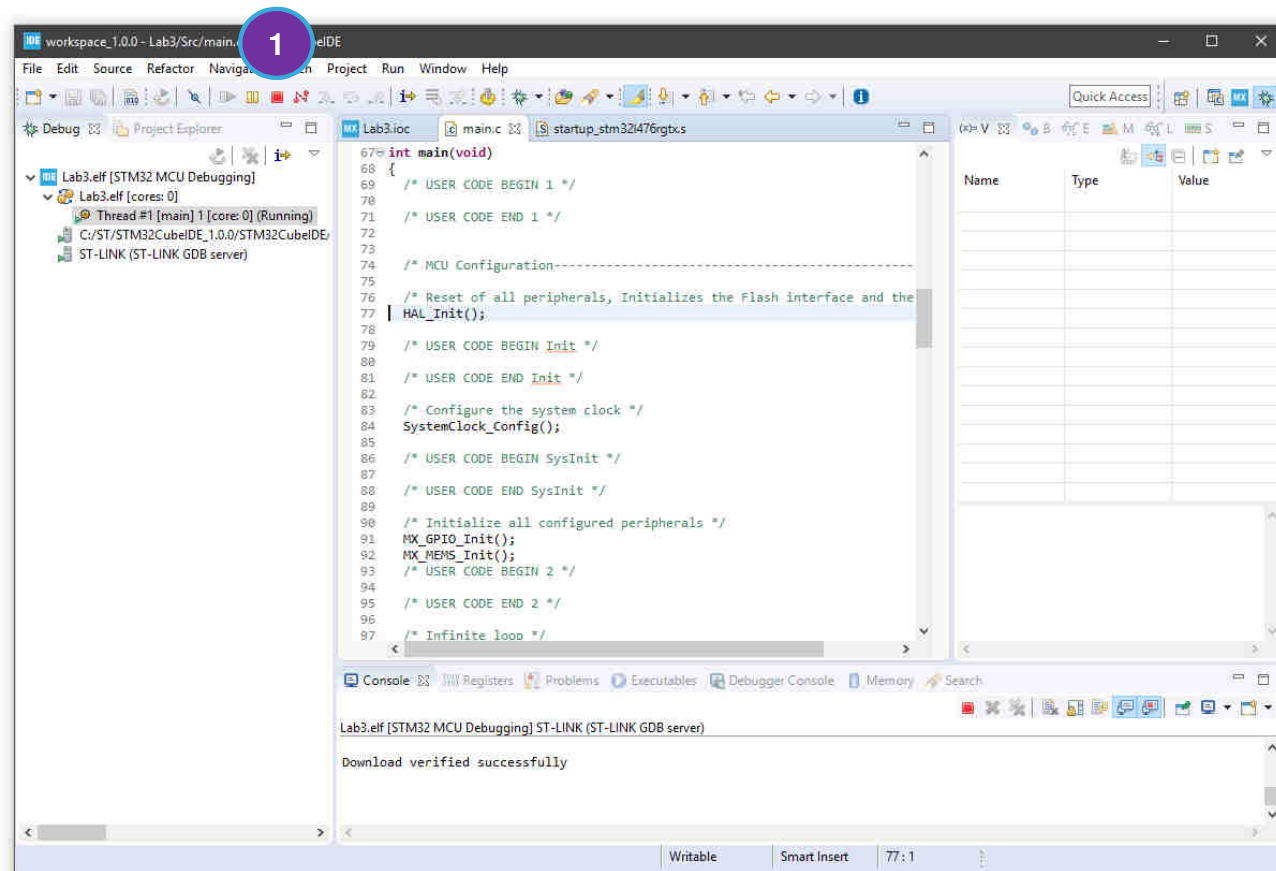
2. After testing close Tera Term by clicking **X**



Lab3 - Debugging

164

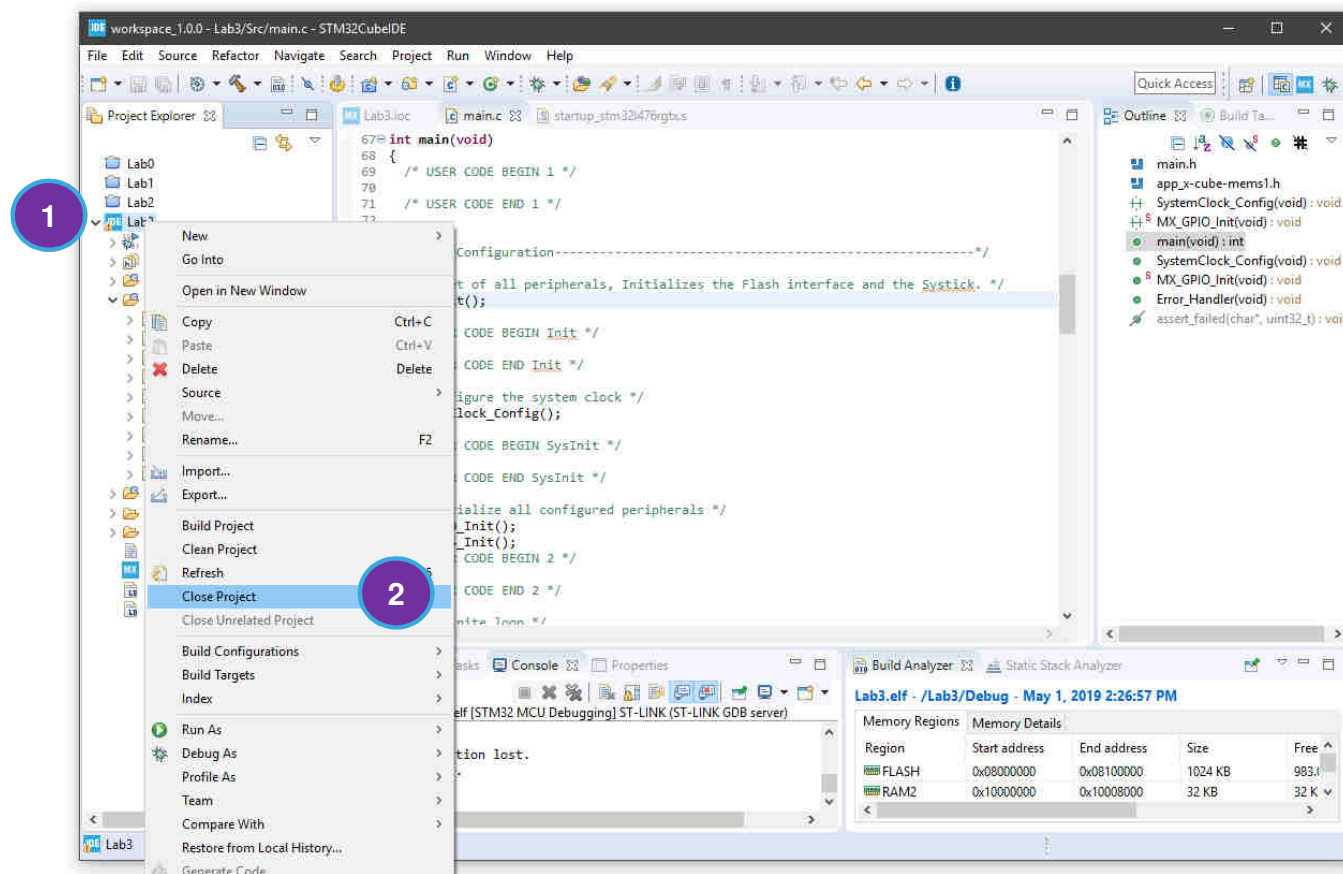
1. Click stop  button to interrupt the debugging



Lab3 – Closing the Project

165

1. Right-Click on **Lab3** project
2. Click on **Close Project**



LAB4

Goals:

- Configure a new project using X-CUBE-MEMS1
- Configure LIS2DW12 accelerometer in order to generate an interrupt when an acceleration is detected
- Enable interrupts in STM32CubeIDE
- Turn the led ON at wake-up

Power saving and flexible Accelerometer

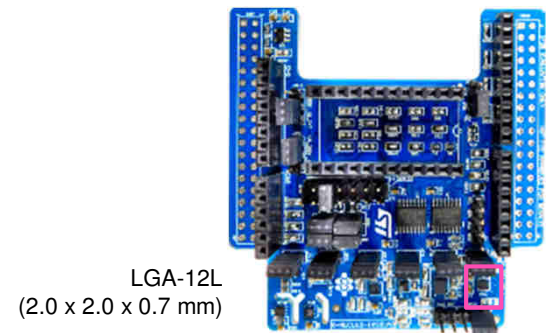
- Down to **0.38 μ A** power consumption (1.6Hz ODR)
- High Perf. mode: up to 1600Hz with noise density **90 μ g/ $\sqrt{\text{Hz}}$**
- **5 Power Modes + 2 Noise Modes**
- 32-level **FIFO** buffer
- **Digital Features**
 - Free fall
 - **Wake-up**
 - 6D / 4D
 - Stationary/Motion detection
 - Double Tap

Enabling battery saving

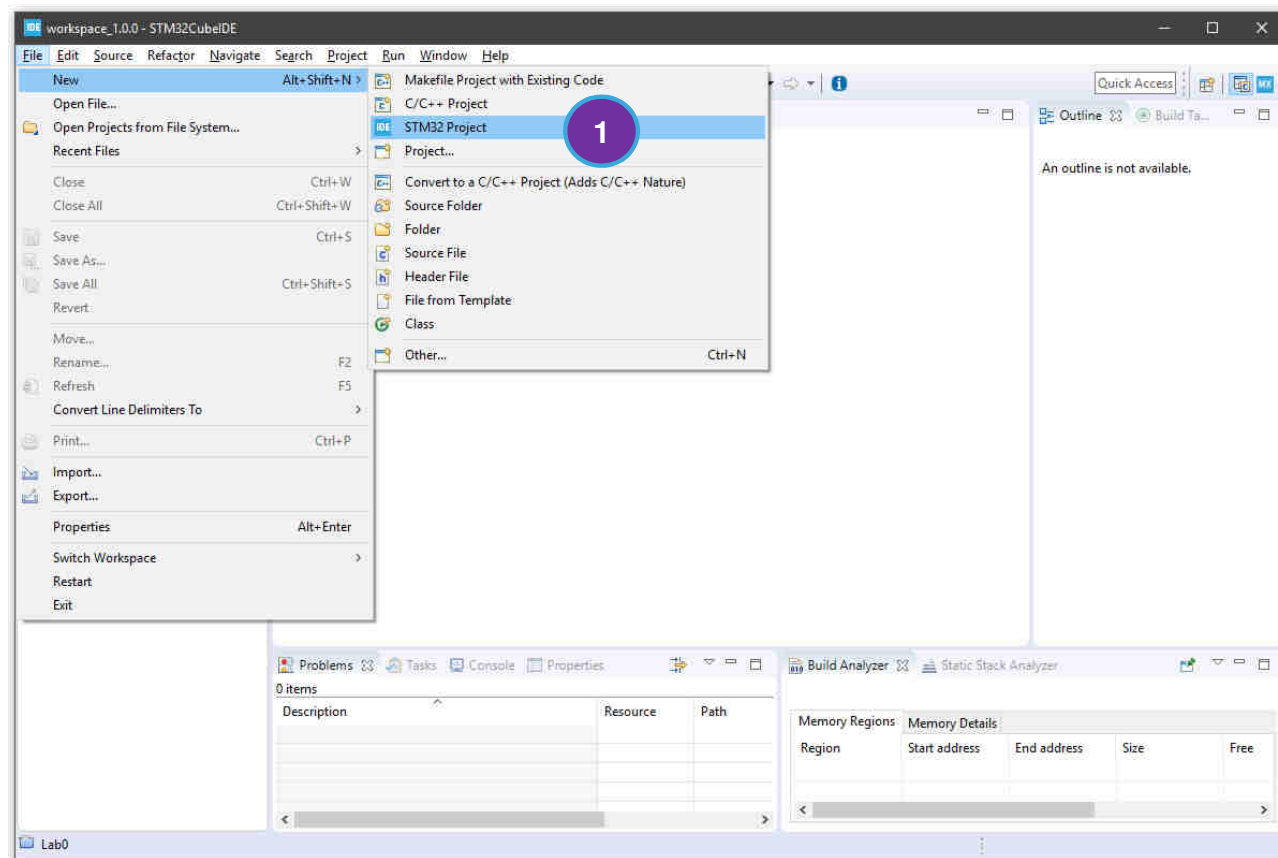
Accuracy

High Flexibility

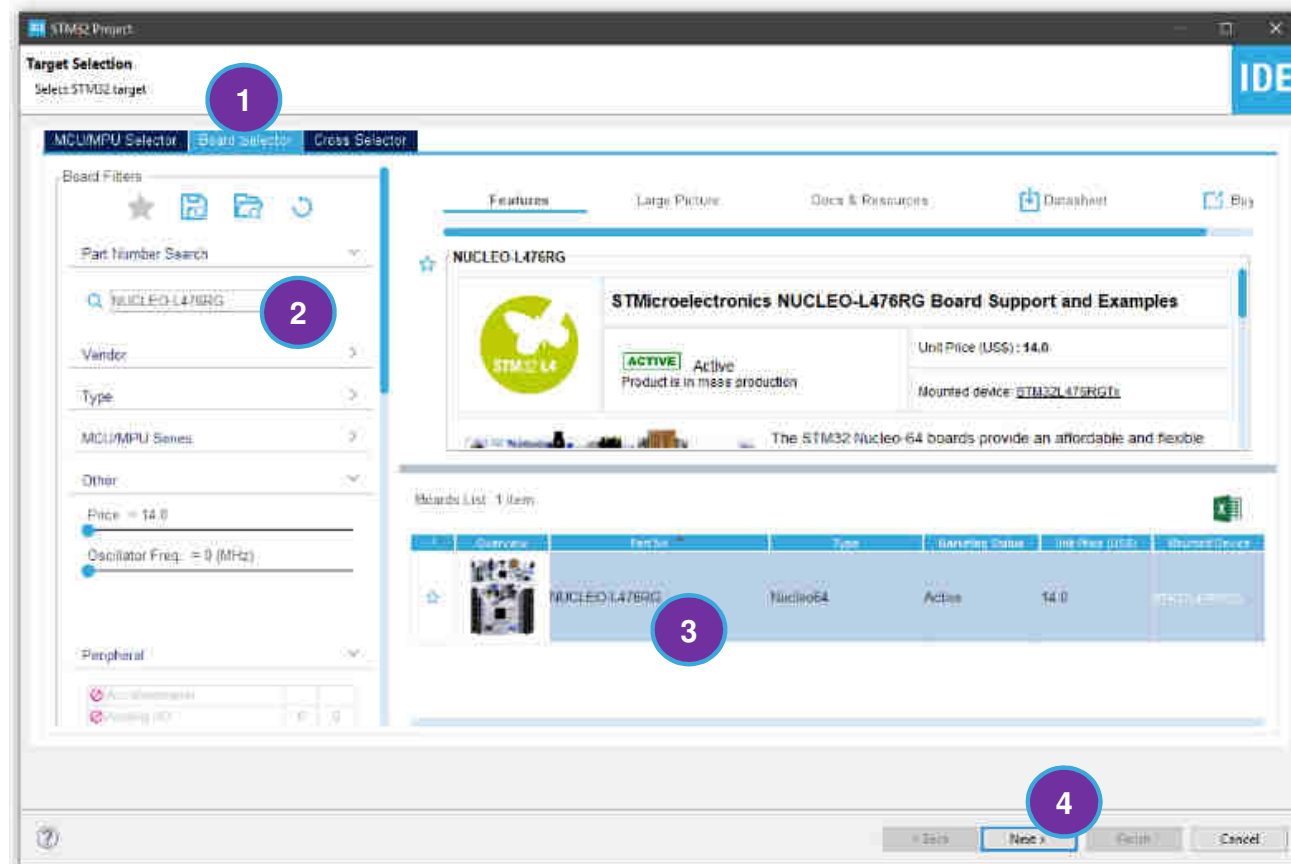
System Power Saving & Smart Functions



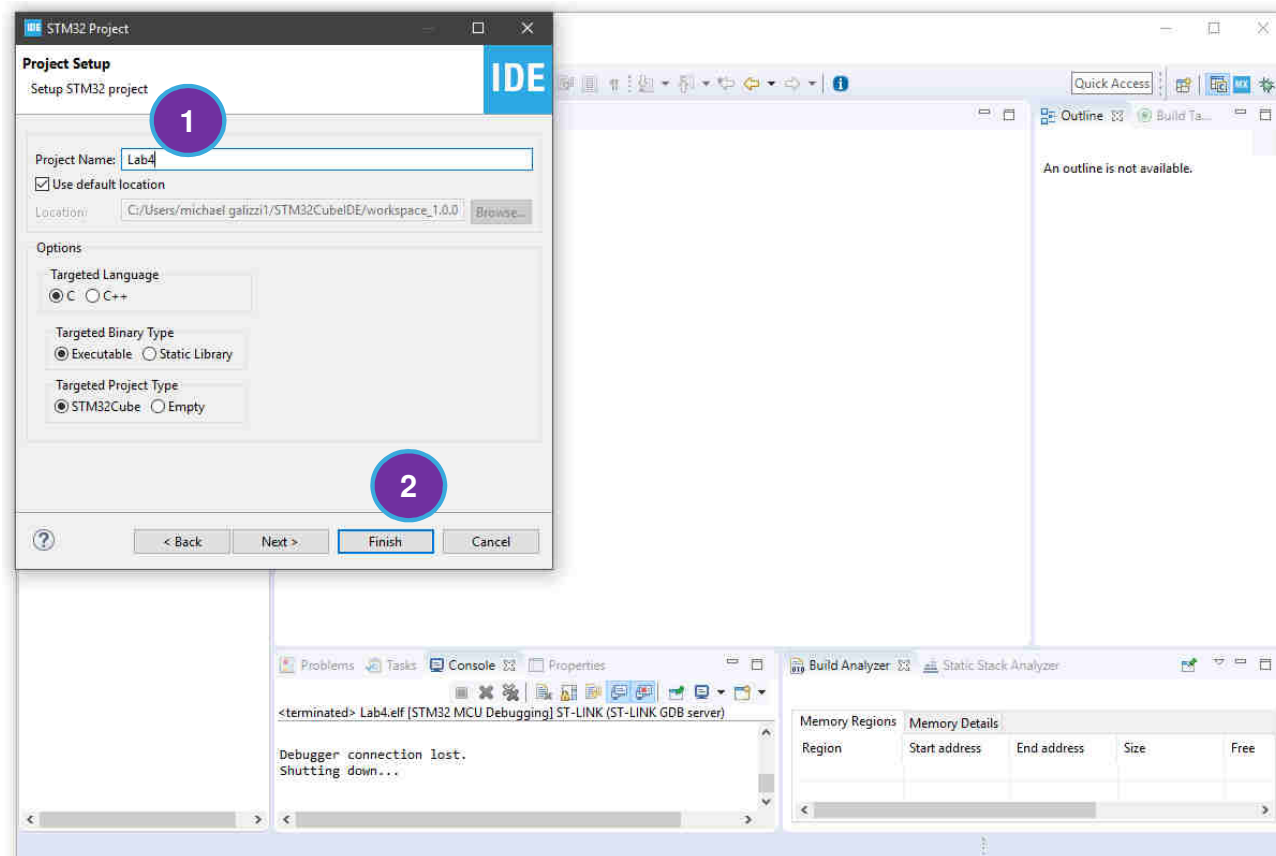
1. Click on **File > New > STM32 Project**



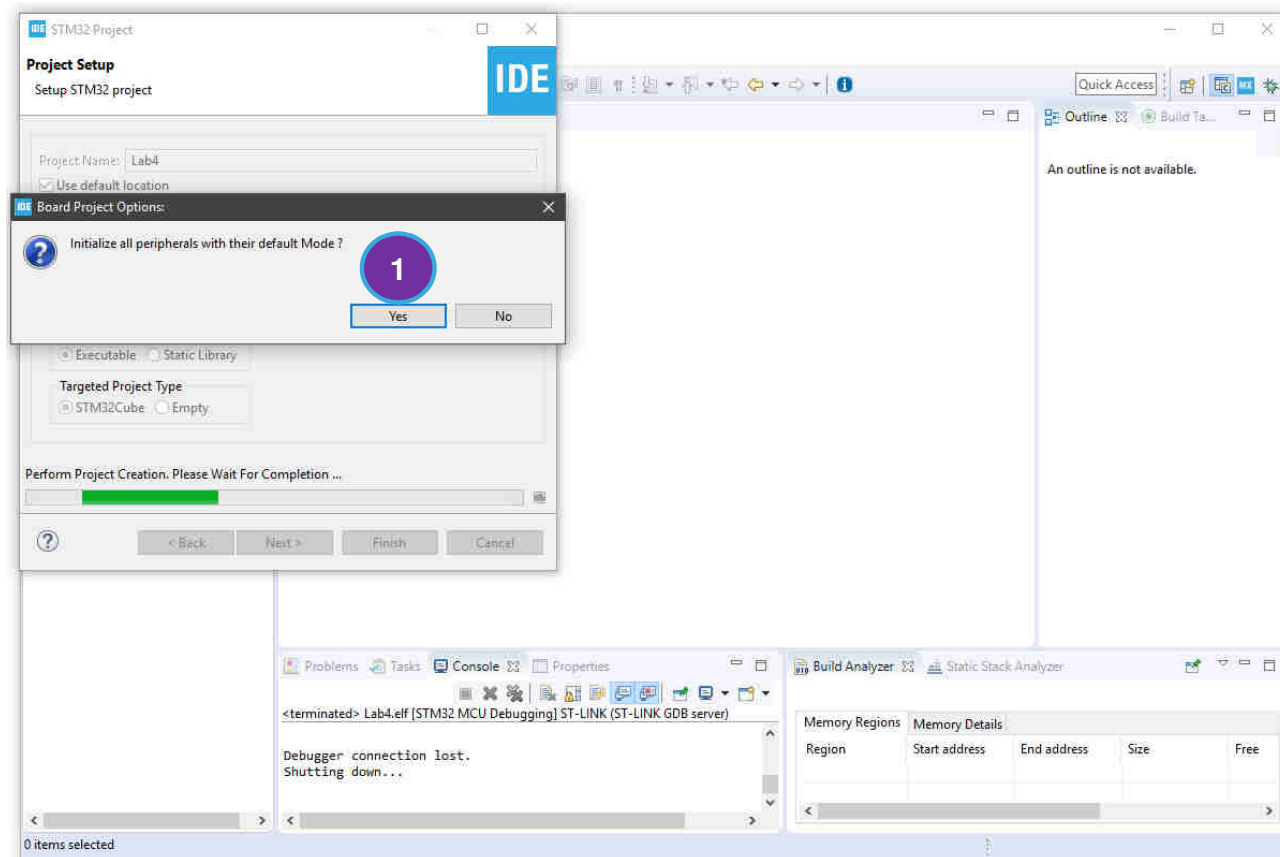
1. Click on **Board Selector**
2. Type **NUCLEO-L476RG**
3. Click on the board
4. Click **Next >**



1. Project Name **Lab4**
2. Click **Finish**

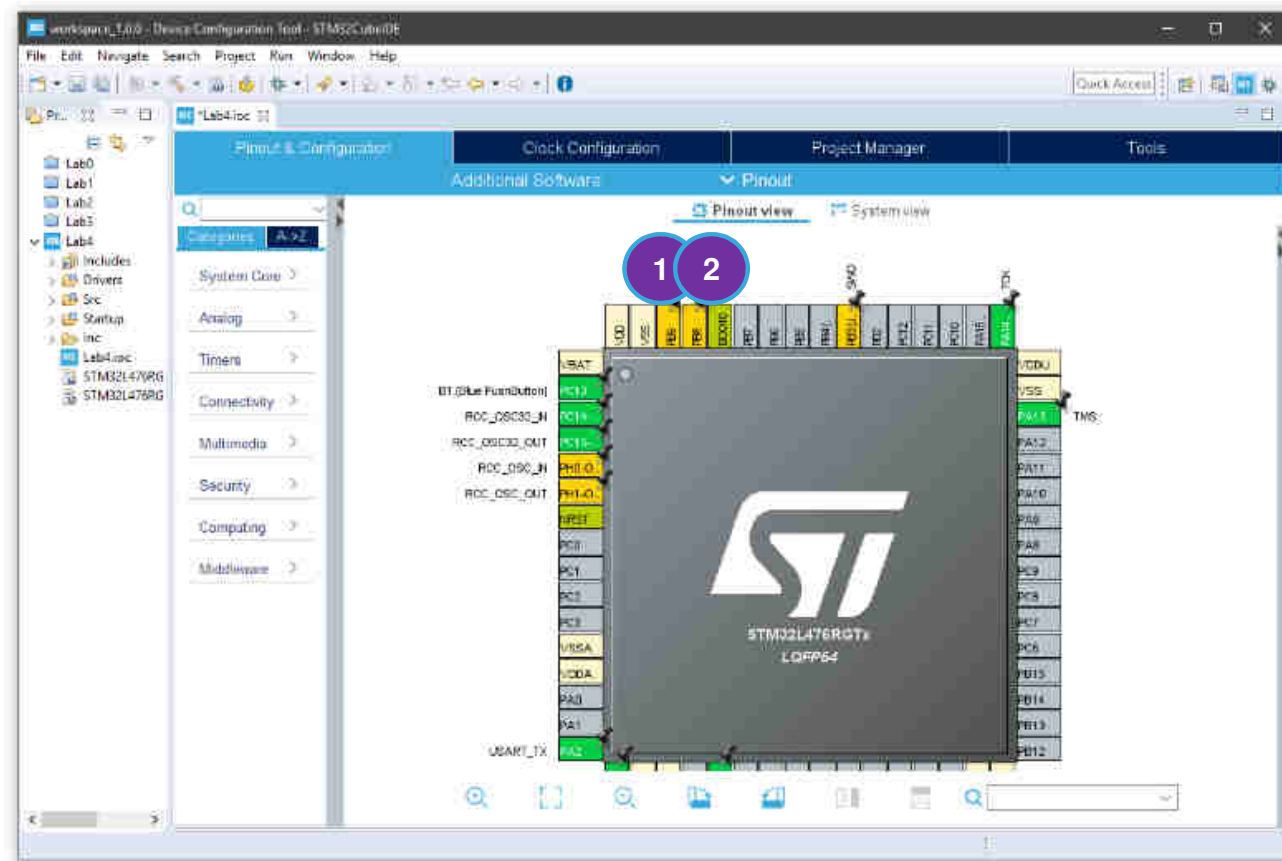
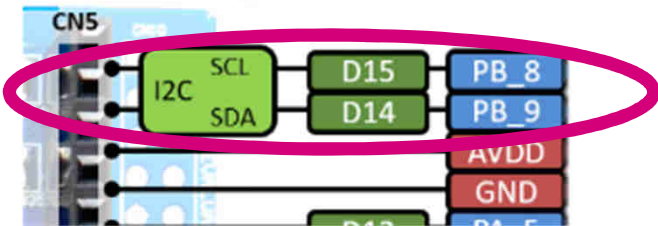


1. Click **Yes** to init peripherals in default mode



172

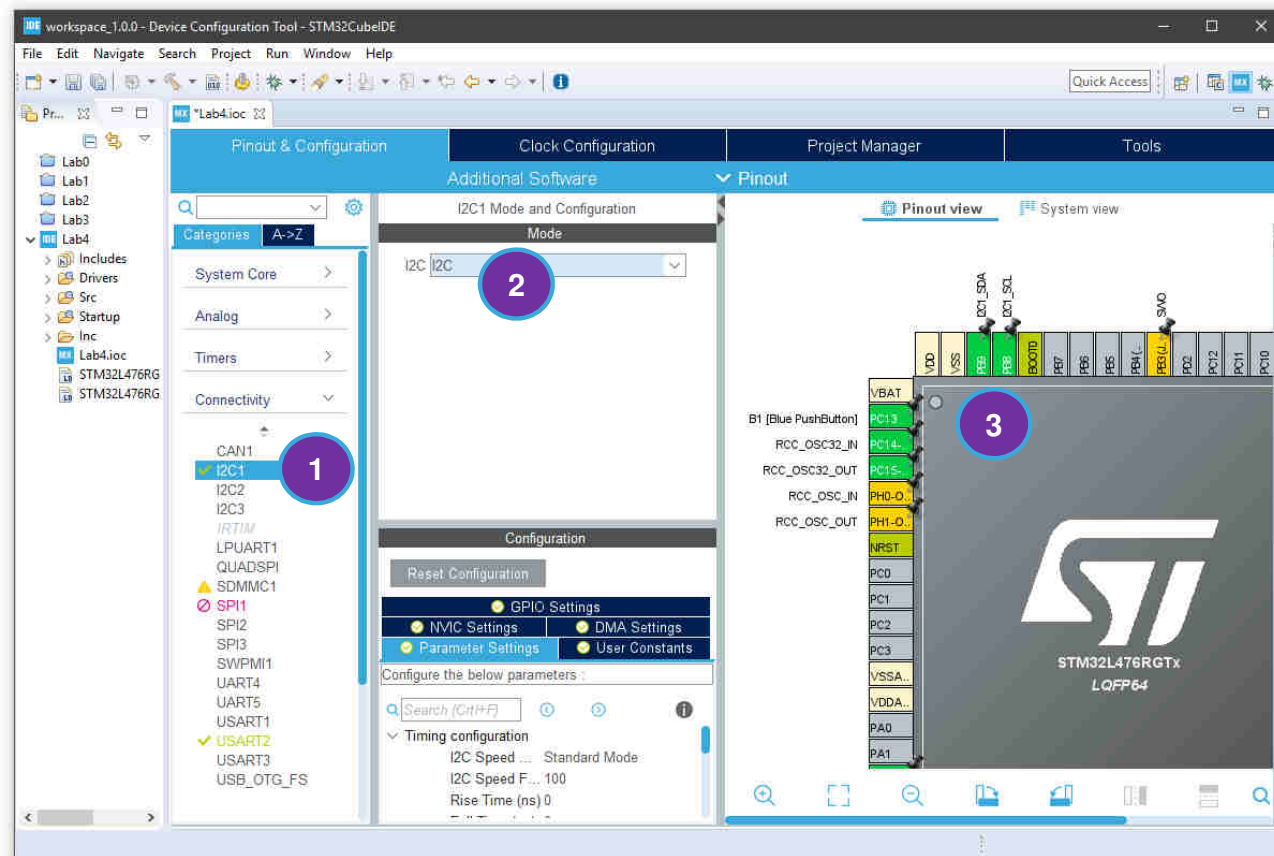
2. Left Click on **PB8** and select I2C1_SCL



Lab4 – Configure the I2C Bus

173

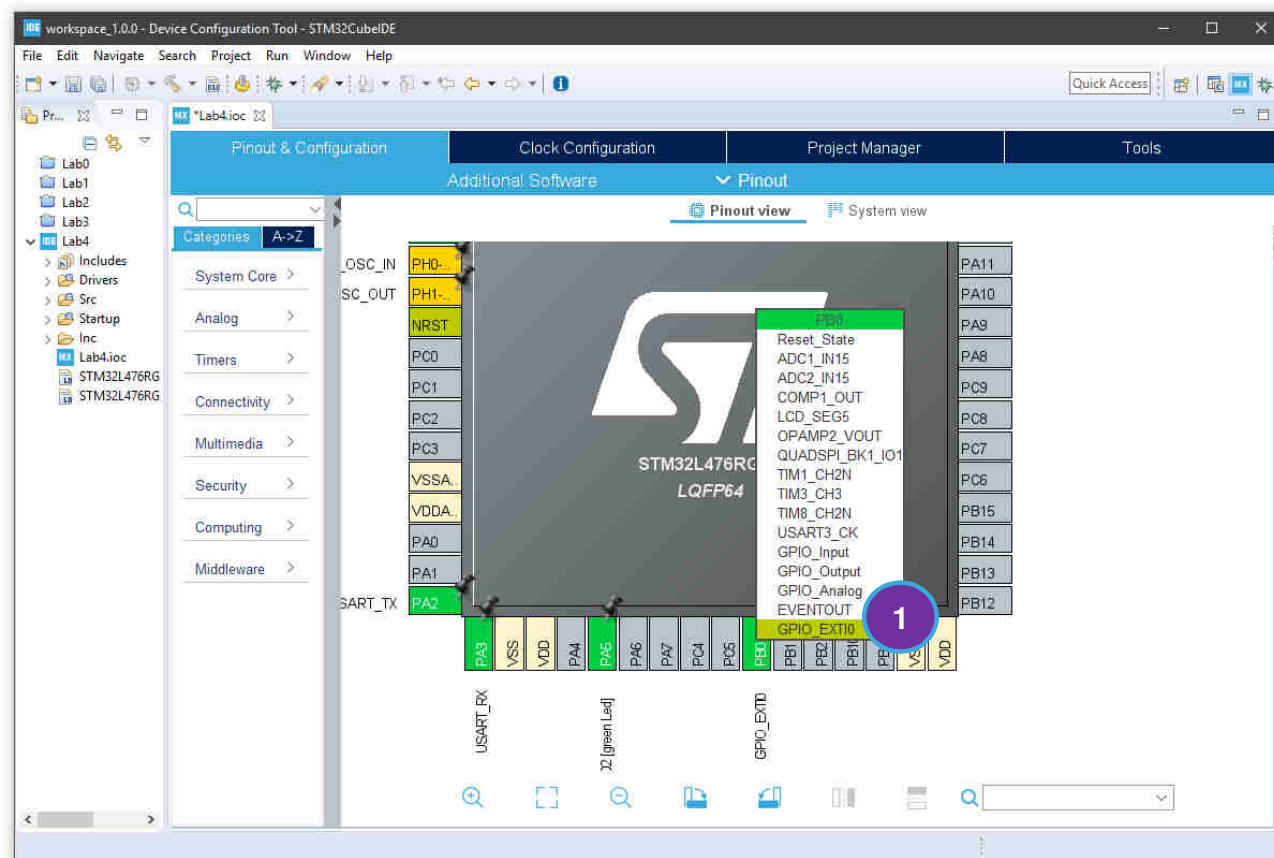
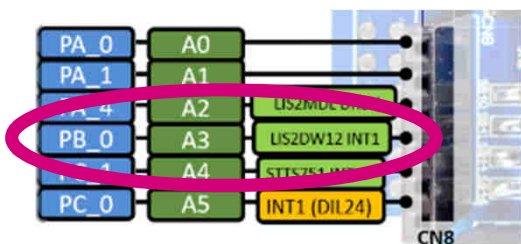
1. Expand *Connectivity* tab and check **I2C1**
2. Select **I2C** in *I2C1 Mode and Configuration*
3. PB8 and PB9 should now become green



Lab4 – Configure LIS2DW12 Interrupt

174

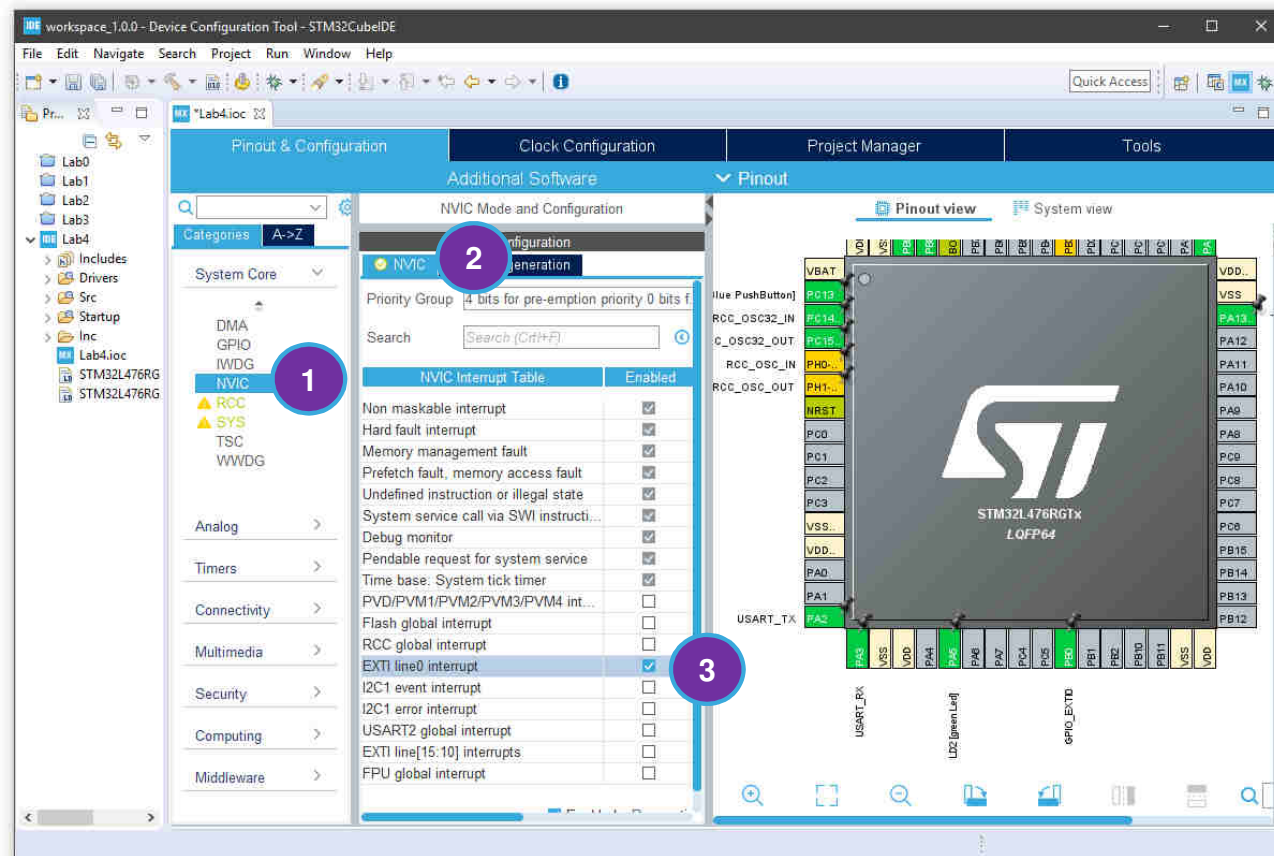
1. Left Click on **PB0** and select **GPIO_EXTI0**



Lab4 – Configure LIS2DW12 Interrupt

175

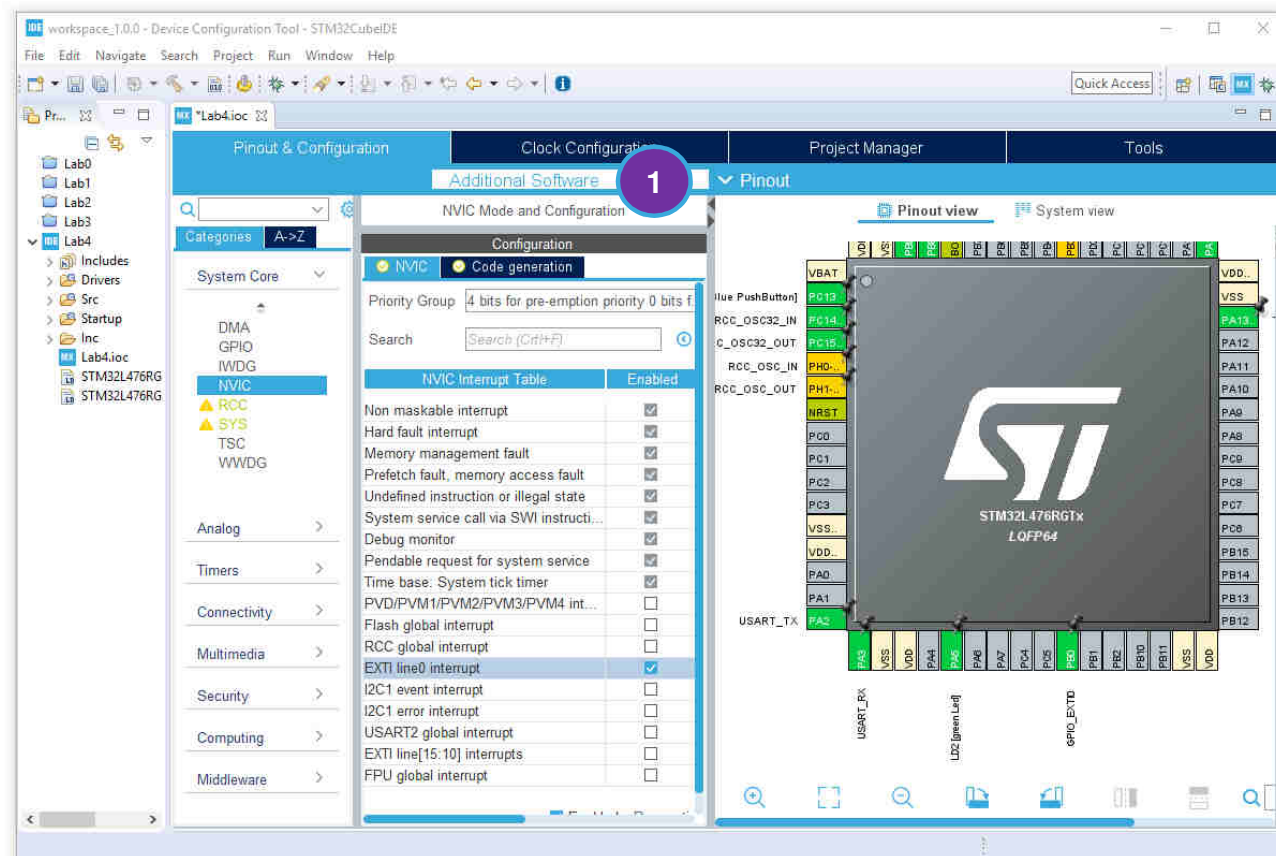
1. Check **NVIC** in tab System Core
2. Select **NVIC** in NVIC Mode and Configuration
3. Enable **EXTI line0 interrupt**



Lab4 – Select the MEMS Library

176

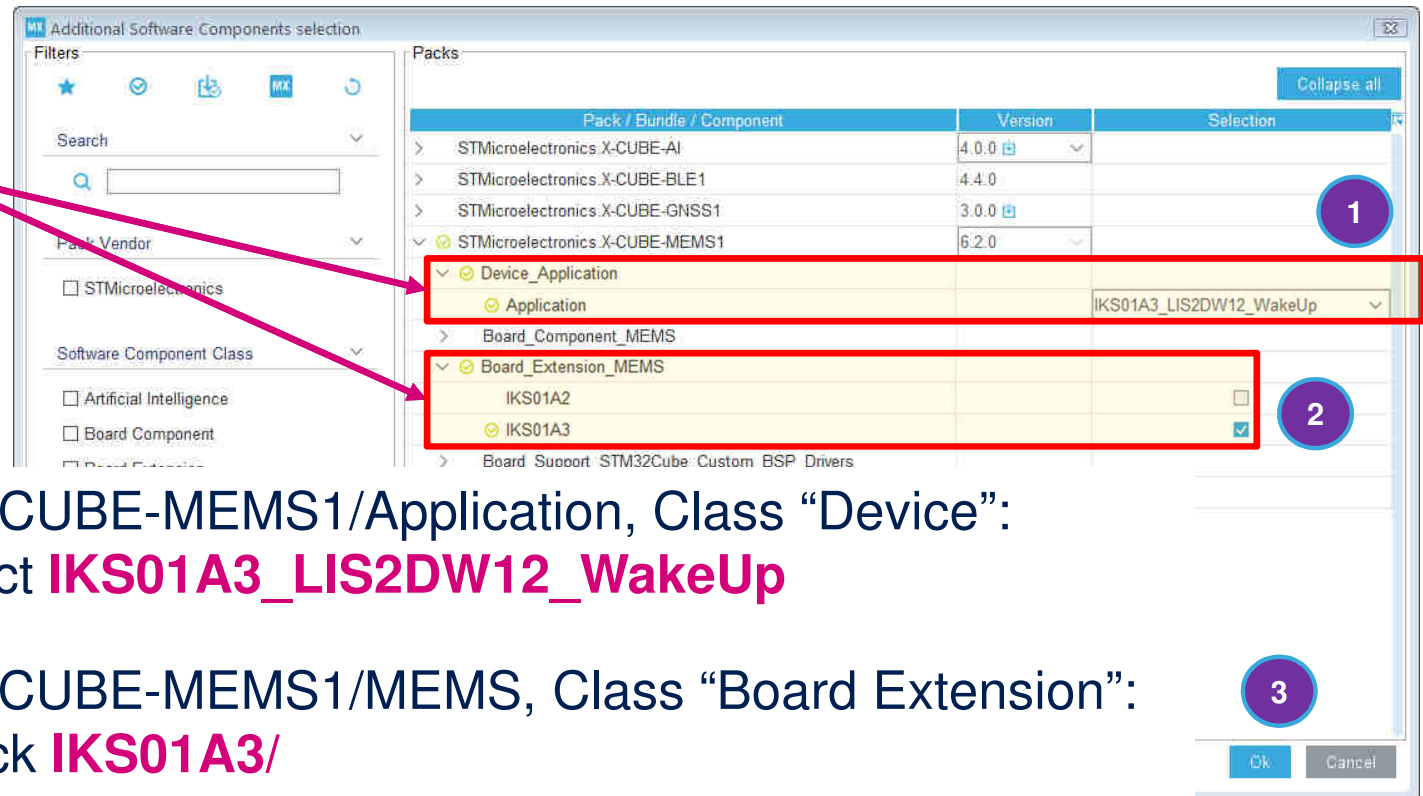
1. Click on **Additional Software**



Lab4 – Select the MEMS Library

177

Click to
expand tree

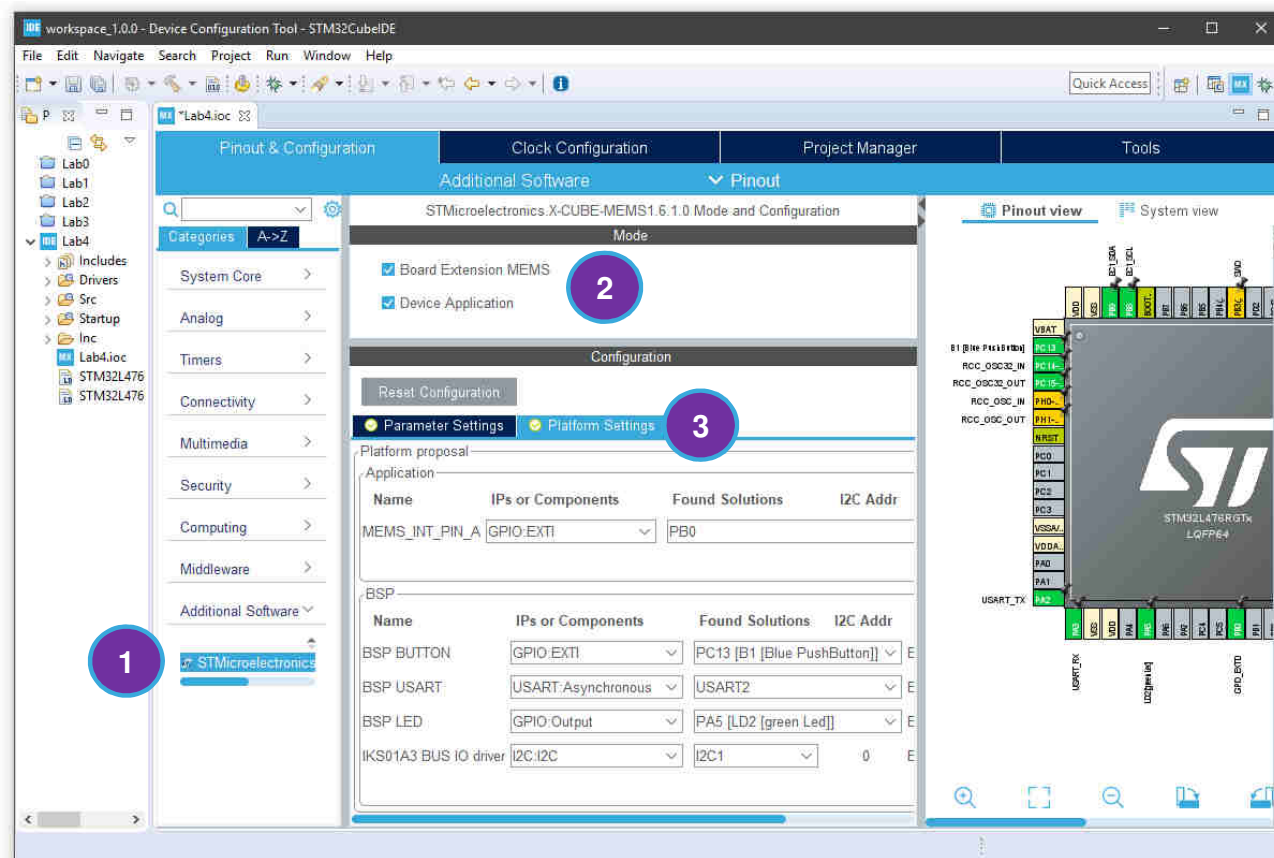


1. In X-CUBE-MEMS1/Application, Class “Device”:
Select **IKS01A3_LIS2DW12_WakeUp**
2. In X-CUBE-MEMS1/MEMS, Class “Board Extension”:
Check **IKS01A3/**
3. Click **OK**

Lab4 – Configure the MEMS Library

178

1. Expand Additional Software and select the X-CUBE-MEMS1
2. Check both:
Board Extension MEMS
Device Application
3. Configure Platform Settings as in picture

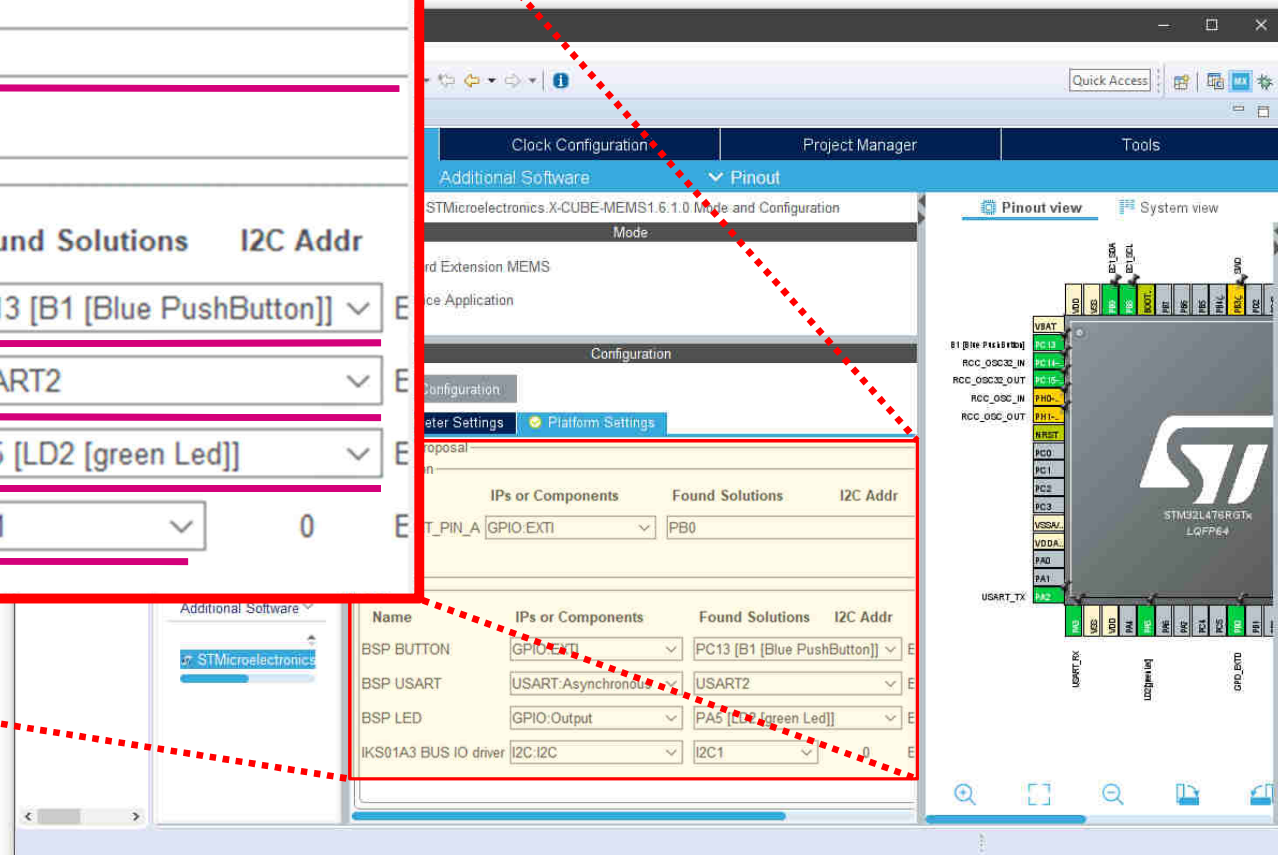


Lab4 – Configure the MEMS Library

179

Application			
Name	IPs or Components	Found Solutions	I2C Addr
MEMS_INT_PIN_A	GPIO:EXTI	PB0	

BSP			
Name	IPs or Components	Found Solutions	I2C Addr
BSP BUTTON	GPIO:EXTI	PC13 [B1 [Blue PushButton]]	
BSP USART	USART:Asynchronous	USART2	
BSP LED	GPIO:Output	PA5 [LD2 [green Led]]	
IKS01A3 BUS IO driver	I2C:I2C	I2C1	0



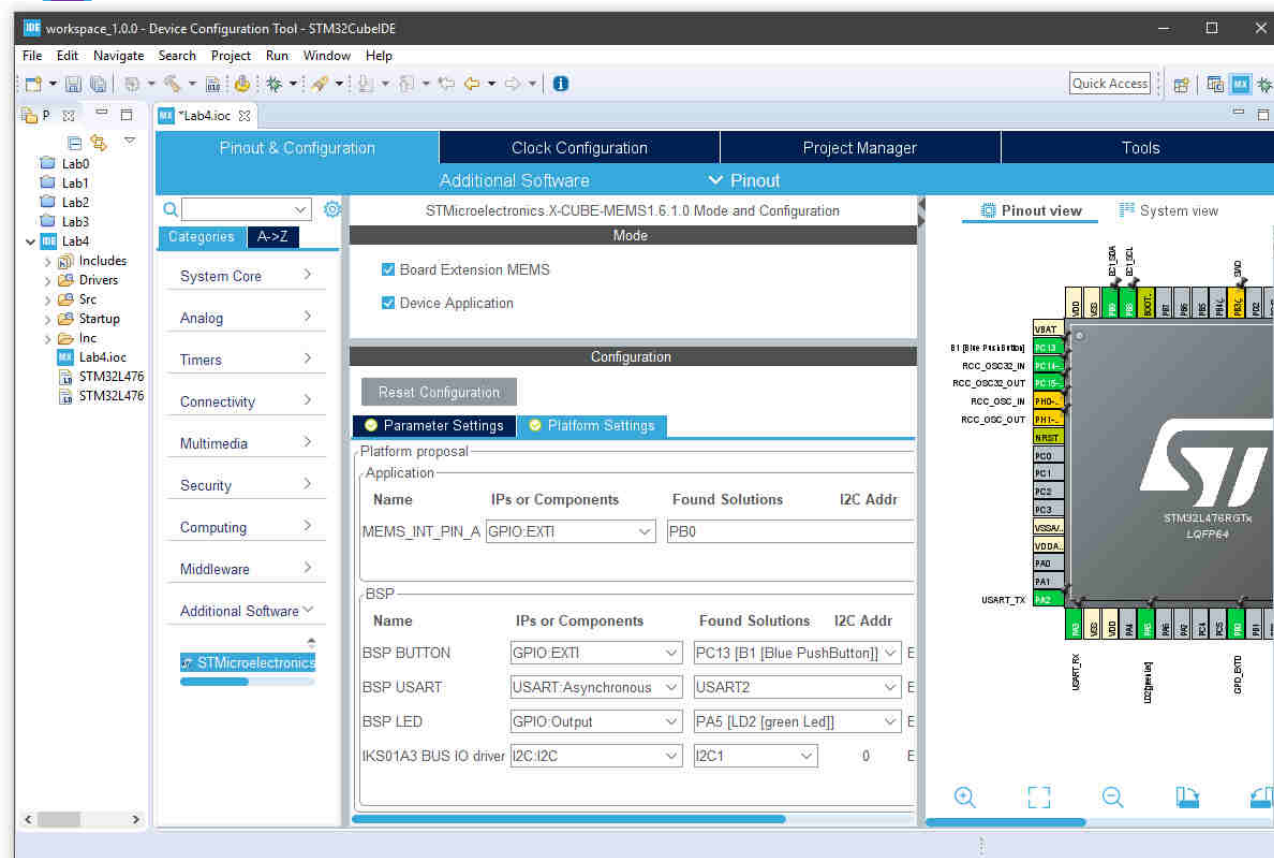
Lab4 – Save the Project

180

1. Click the save button



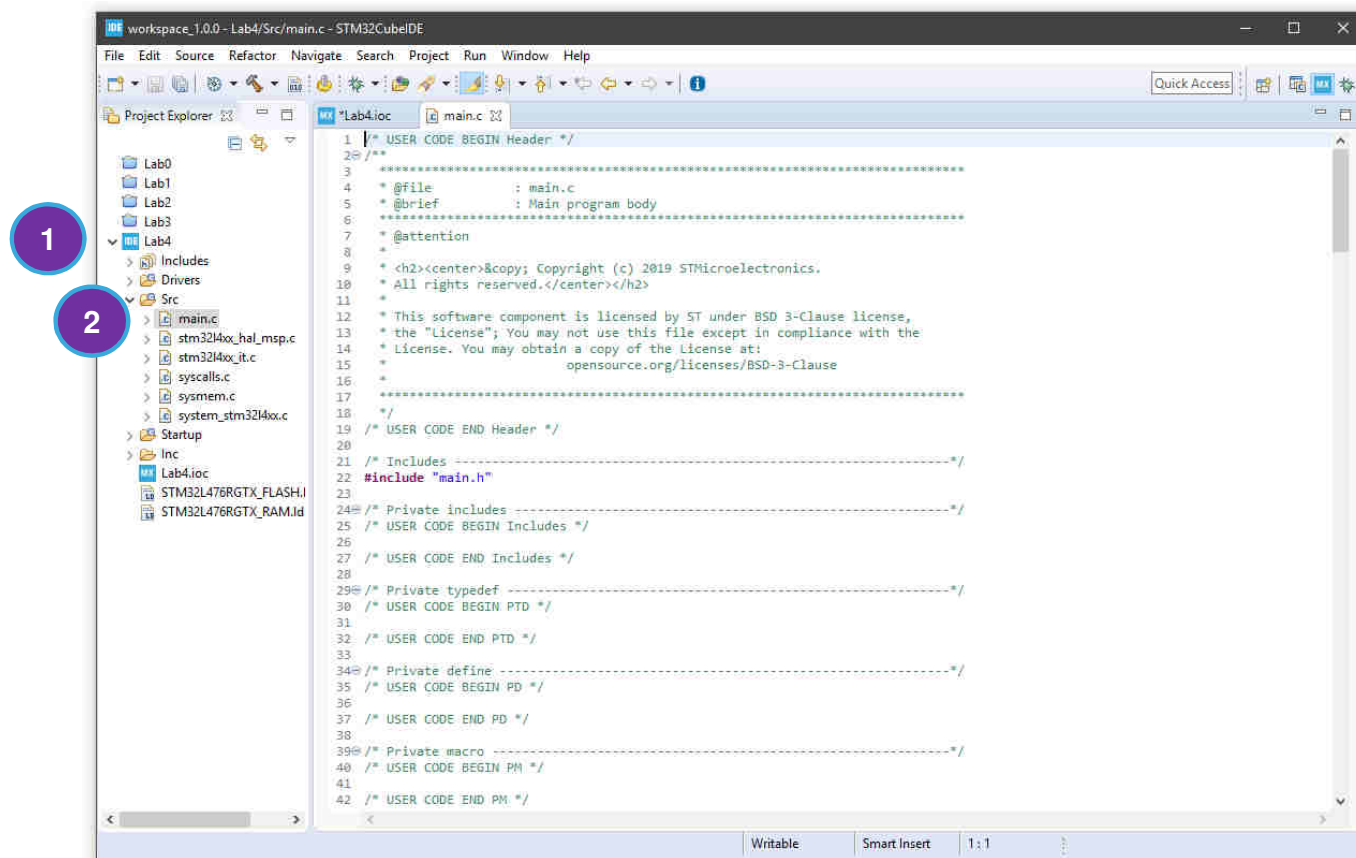
This action will generate the source code of this lab



Lab4 – Code Editing

181

1. Expand **Src** in folder **Lab4**
2. Double click on **main.c**

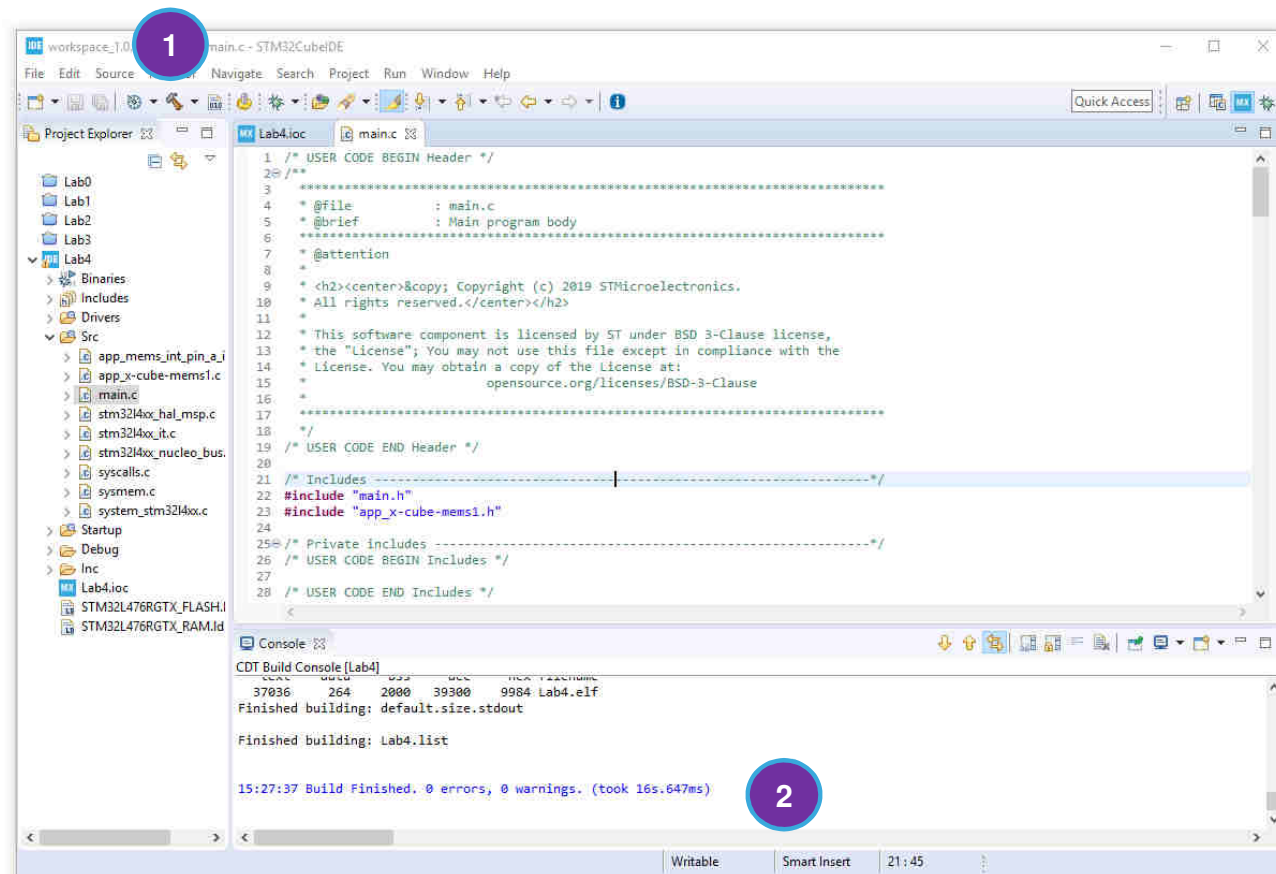


Lab4 - Compiling

182

1. Click on the hammer  to begin compilation, or press **CTRL+B**

2. Compilation should terminate with 0 errors and 0 warning



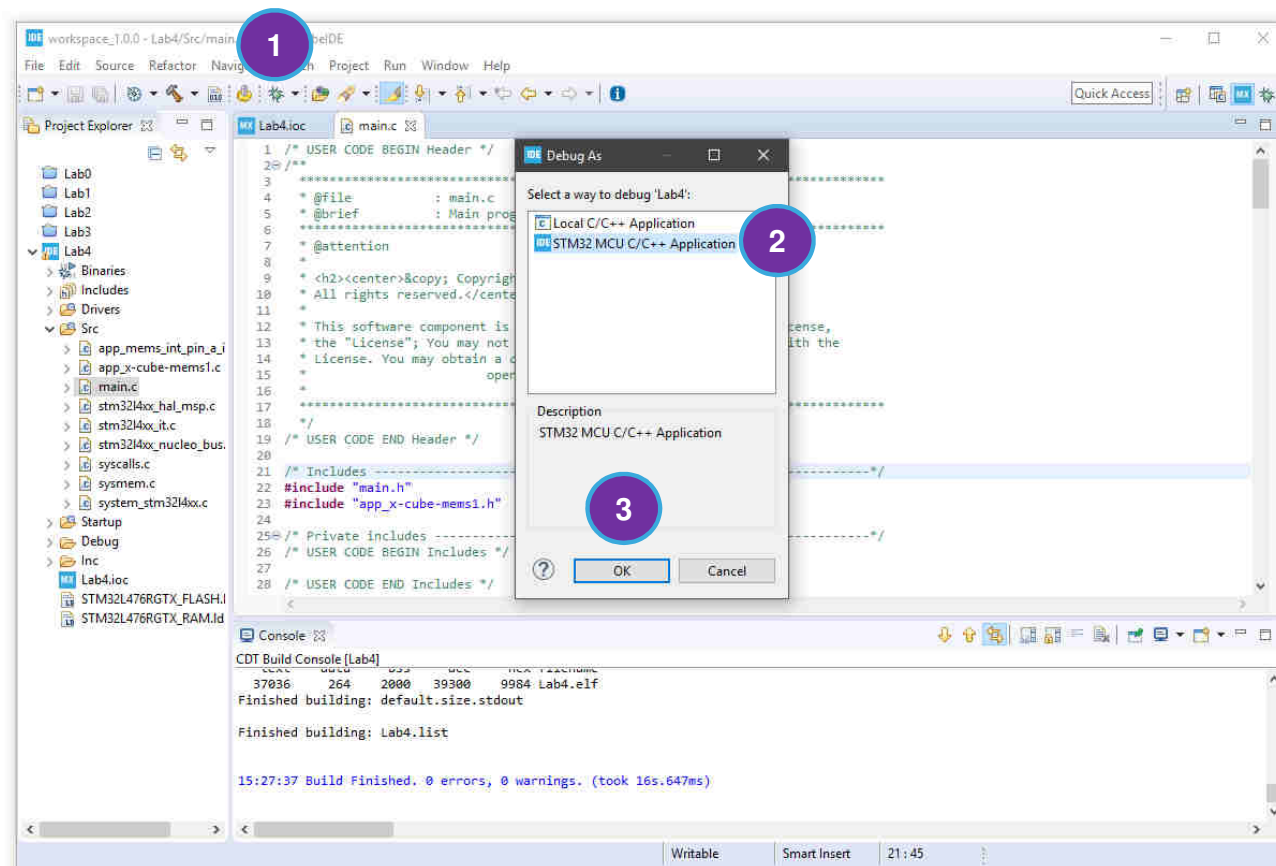
Lab4 - Debugging

183

1. Click on the bug  to begin debugging

2. Select **STM32 MCU C/C++ App**

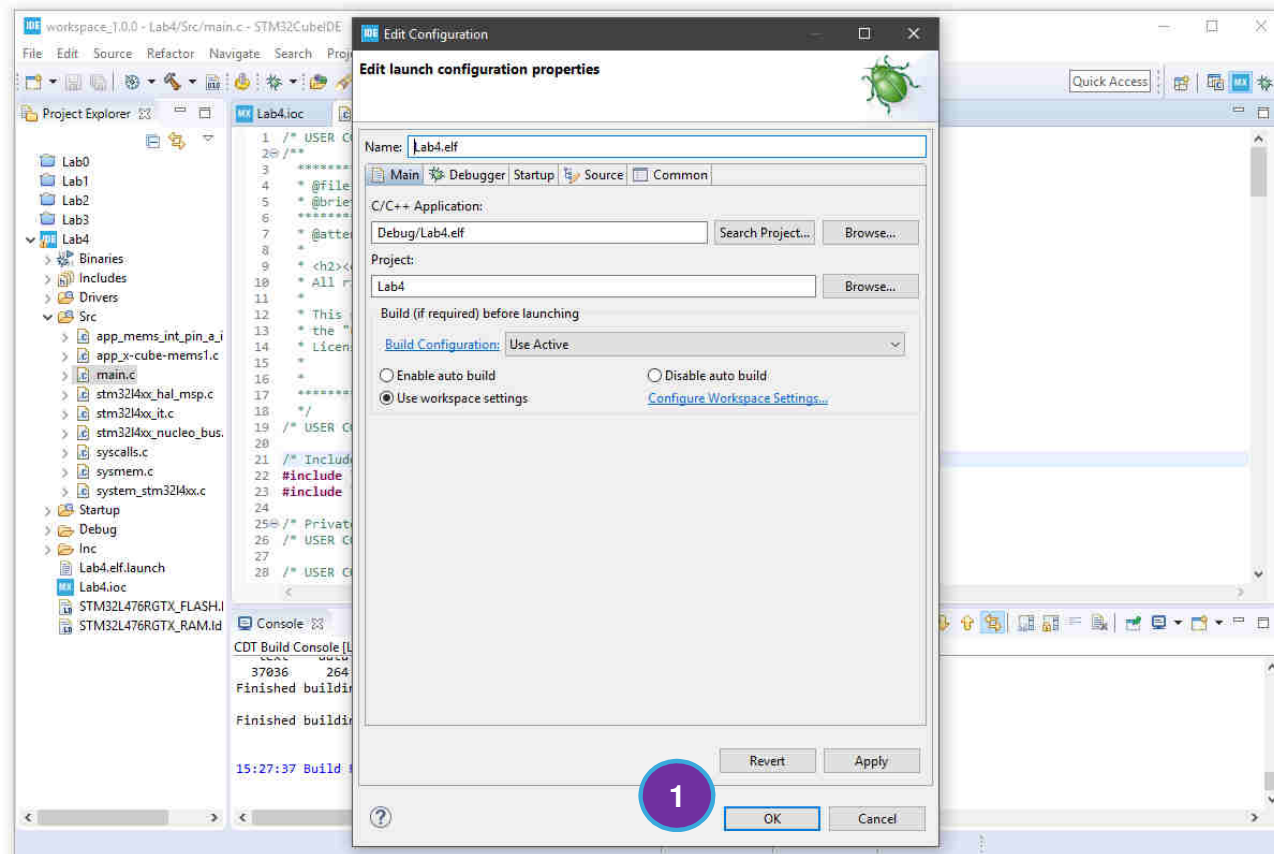
3. Click **OK**



Lab4 - Debugging

184

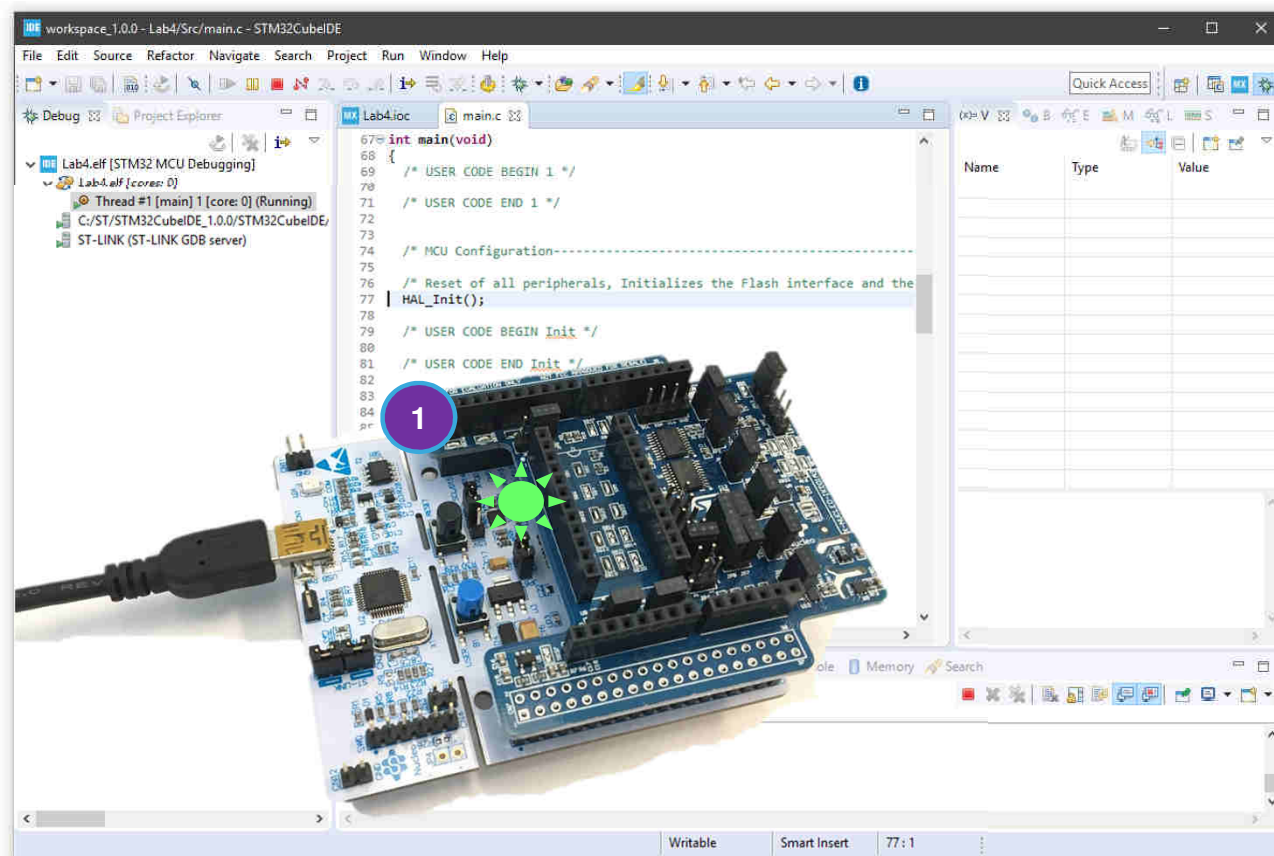
1. Click **OK**



Lab4 - Testing

186

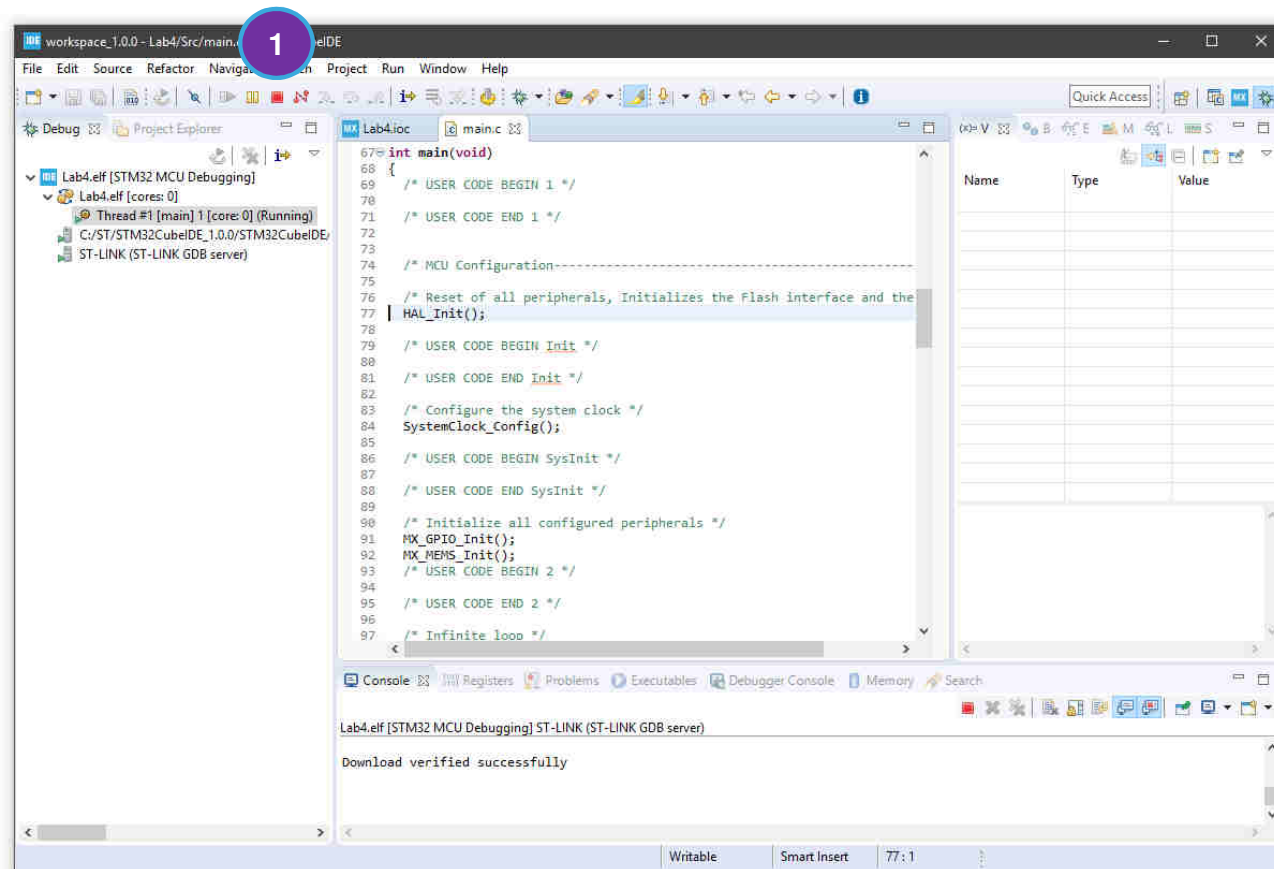
1. Shake the board and the GREEN led will turn ON



Lab4 - Debugging

187

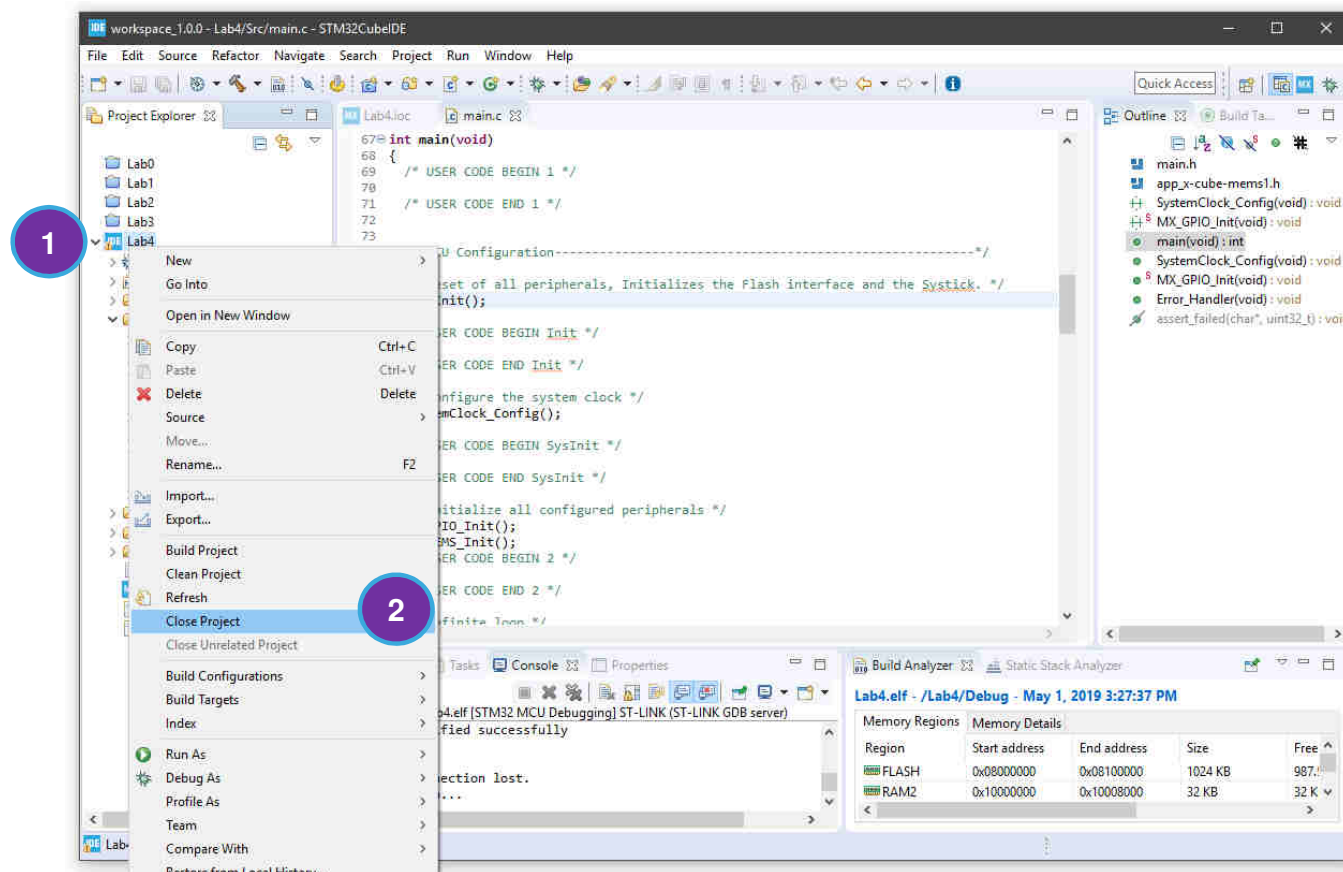
1. Click stop  button to interrupt the debugging



Lab4 – Closing the Project

188

1. Right-Click on **Lab4** project
2. Click on **Close Project**



LAB5

Goals:

- Configure a new project using X-CUBE-MEMS1
- **Configure LSM6DSO single and double tap detection**
- Enable interrupts in STM32CubeIDE
- Change tap threshold to increase sensitivity



LSM6DSO

190

Accelerometer + Gyroscope Inertial Measurement Unit

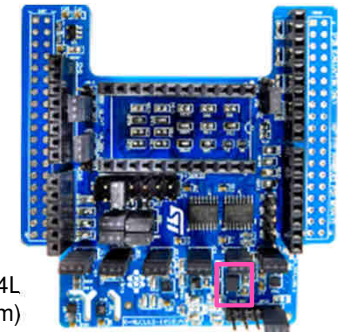
- 0.45mA power consumption (normal mode)
 - Accelerometer: 0.05mA, Gyroscope: 0.40mA
- Auxiliary SPI typically used for OIS / EIS or closed loop control; I3C Interface
- 9kB equivalent FIFO Memory for local data storage
- Finite State Machines (up to 16)
- Digital Features
 - Free fall
 - Pedometer 2.0
 - 6D / 4D
 - Tilt detection
 - Tap/ Double Tap

Lowest power consumption IMU → battery saving

Design Flexibility and cost optimization

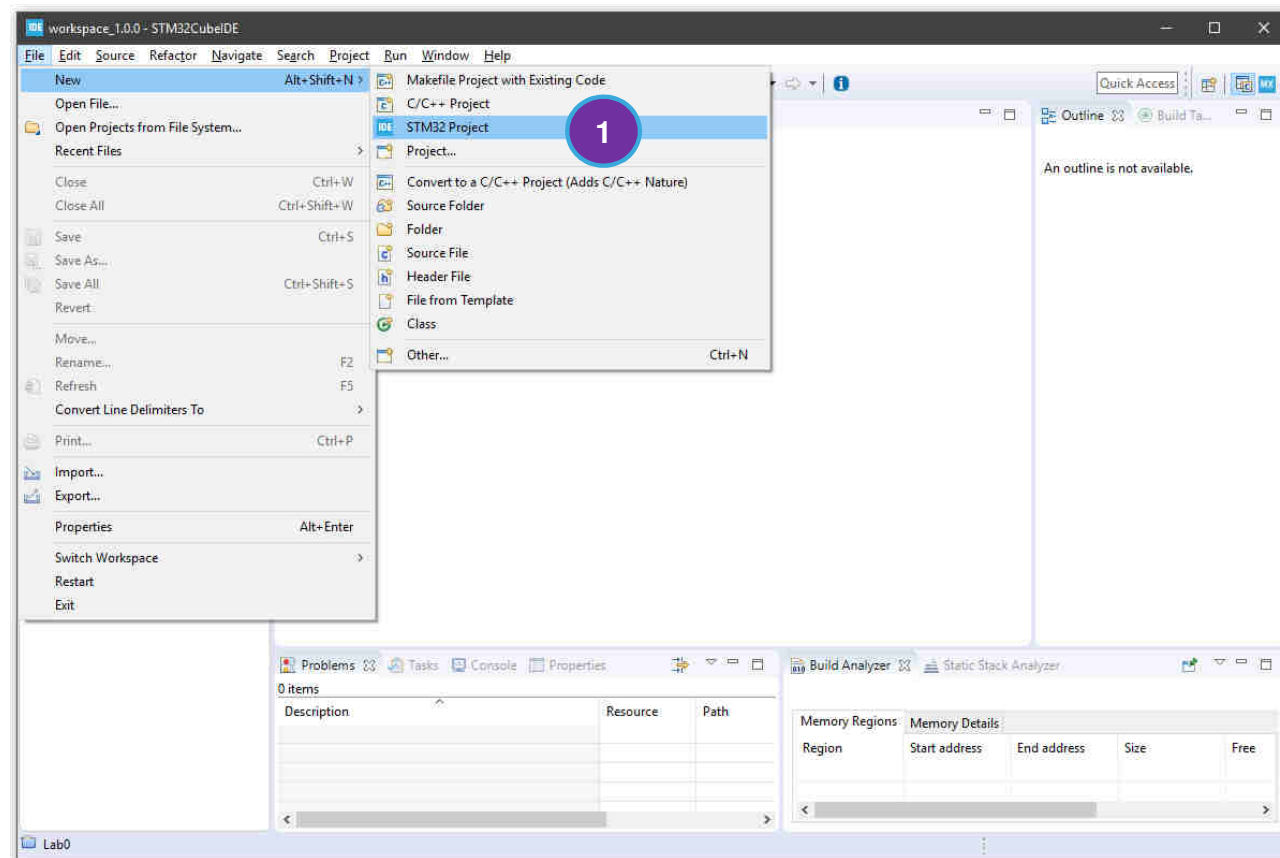
System power saving

Smart Functions with High Flexibility

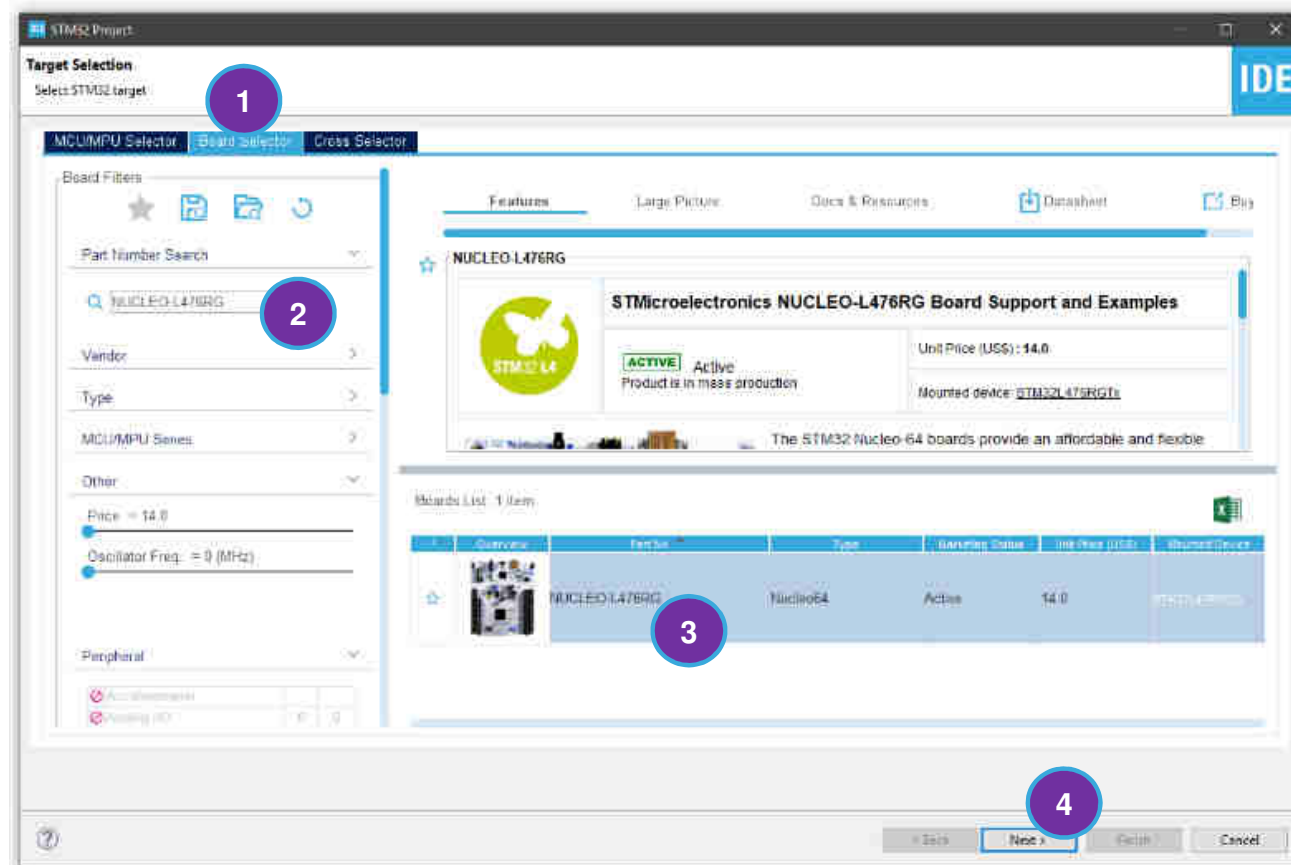


LGA-14L
(2.5 x 3 x 0.83 mm)

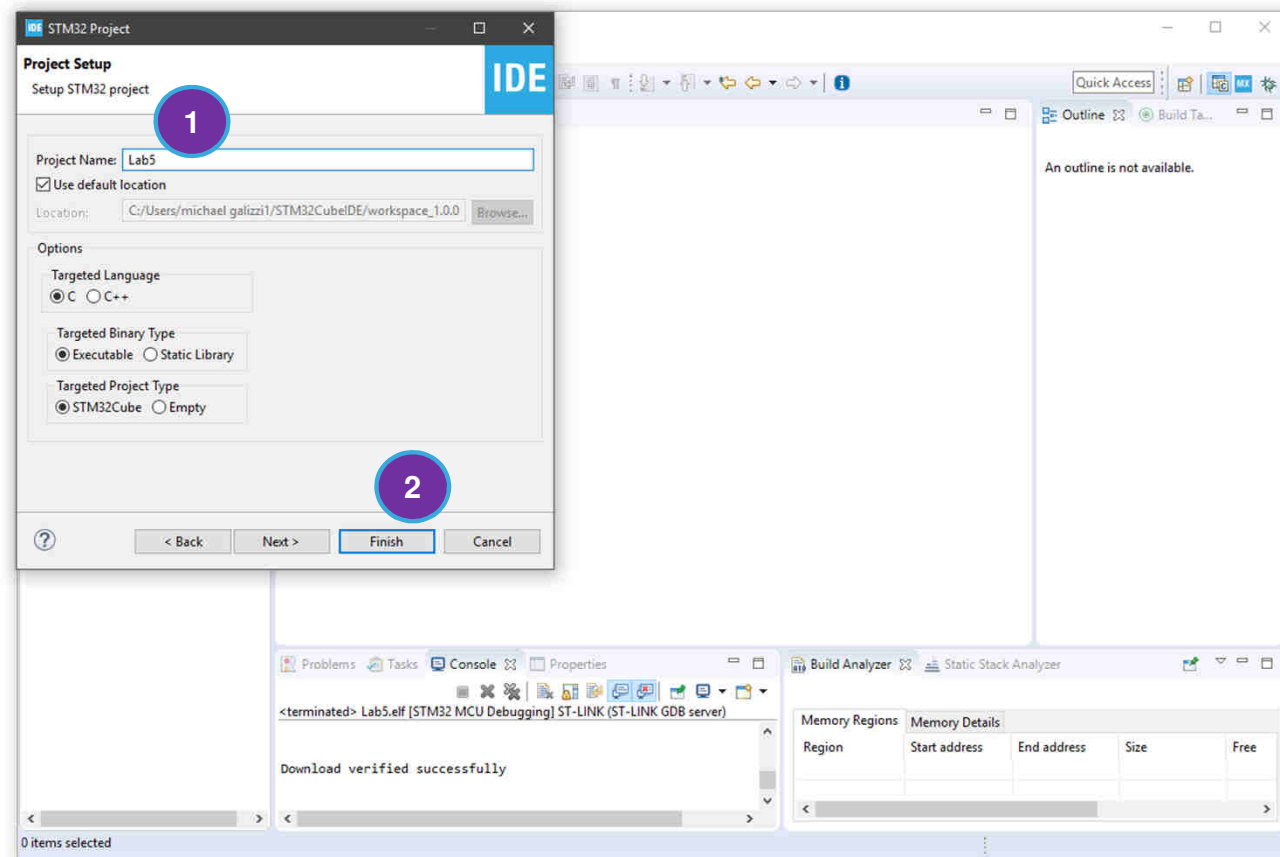
1. Click on **File > New > STM32 Project**



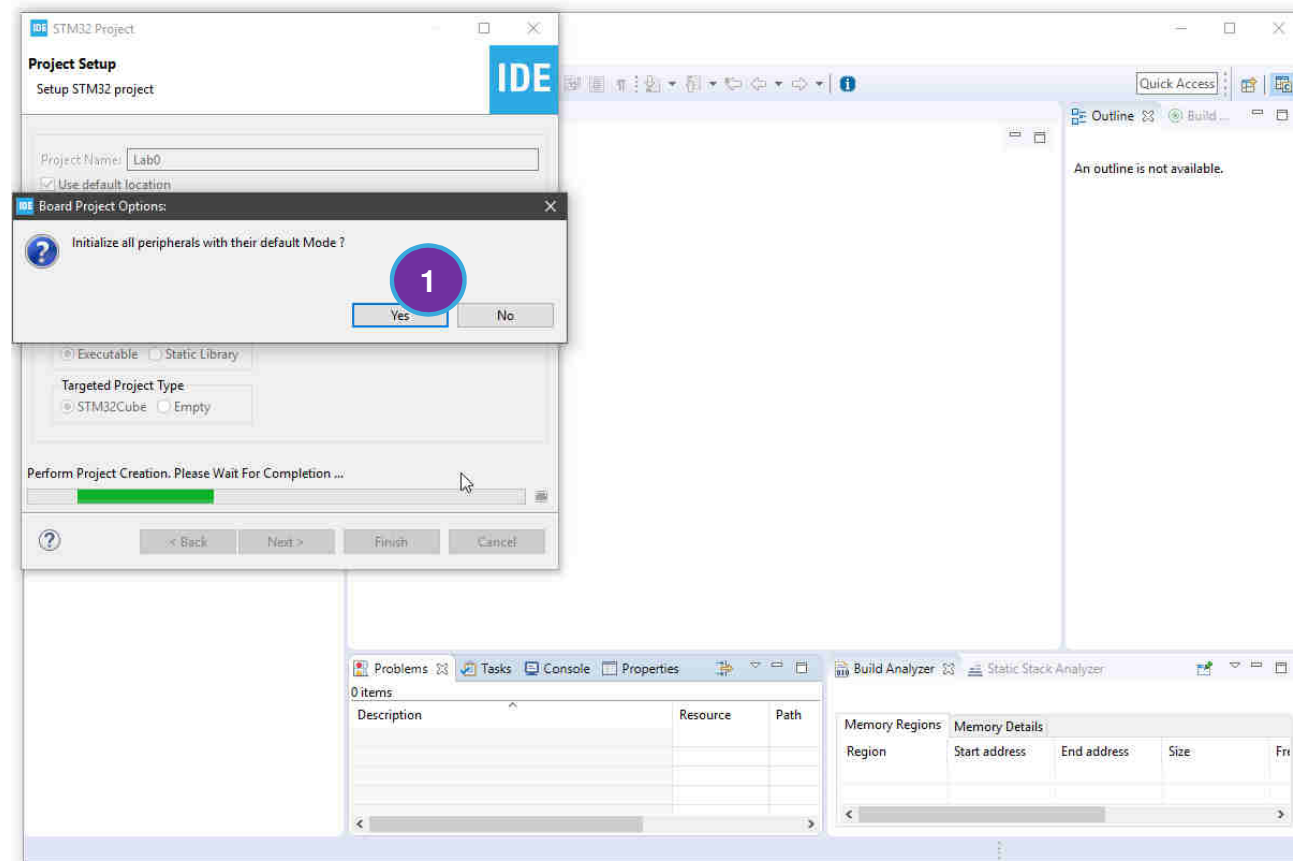
1. Click on **Board Selector**
2. Type **NUCLEO-L476RG**
3. Click on the board
4. Click **Next >**



1. Project Name **Lab5**
2. Click **Finish**



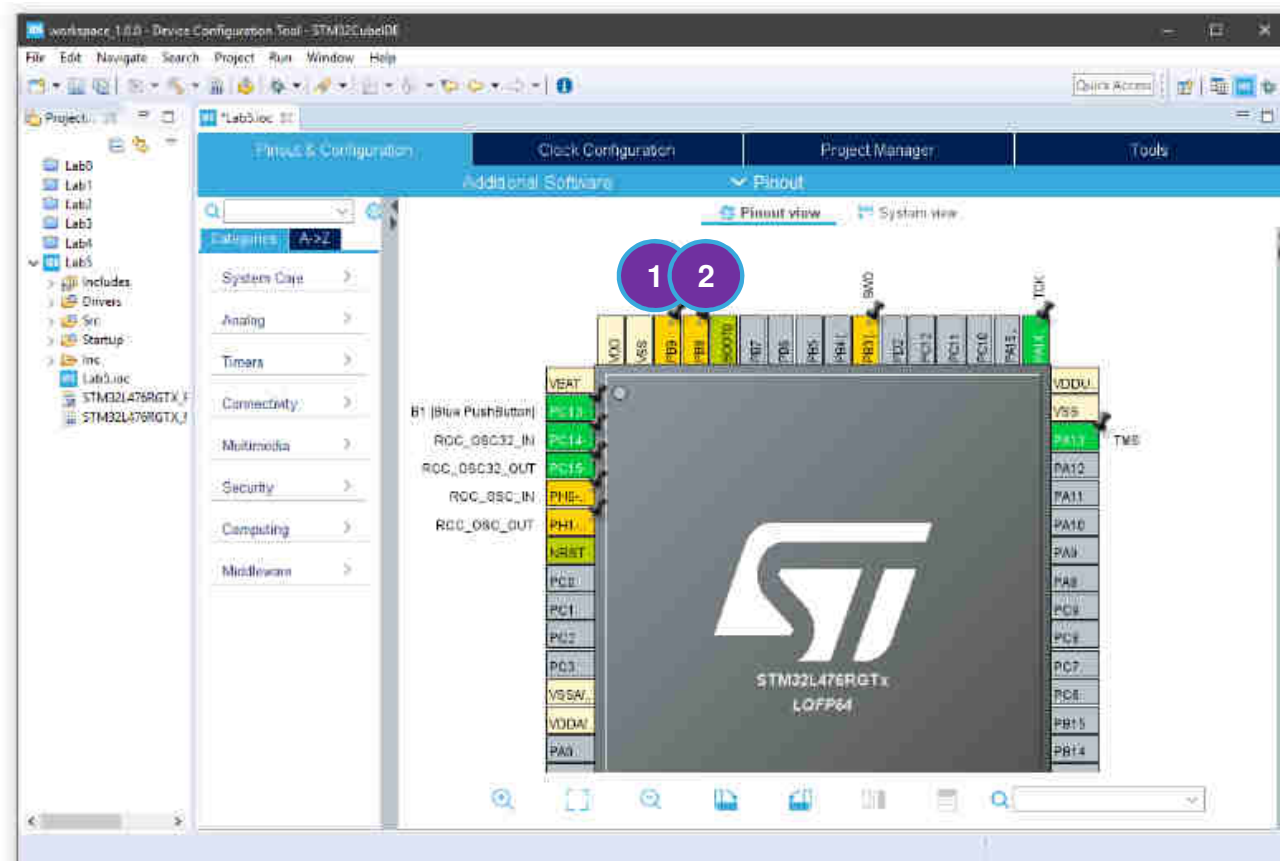
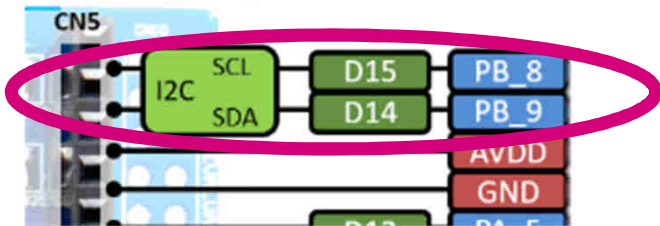
1. Click **Yes** to init peripherals in default mode



Lab5 – Configure the I2C Bus

195

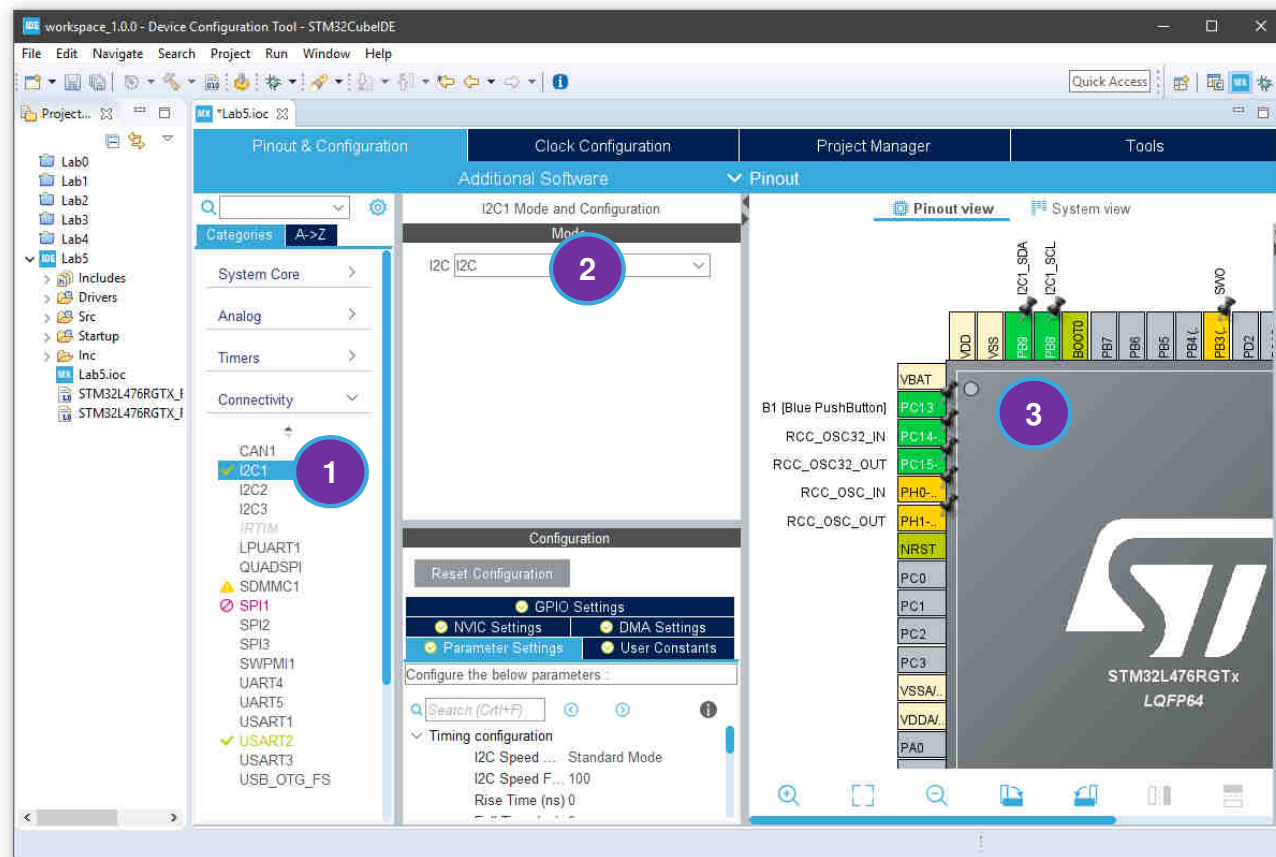
1. Left Click on **PB9** and select I2C1_SDA
2. Left Click on **PB8** and select I2C1_SCL



Lab5 – Configure the I2C Bus

196

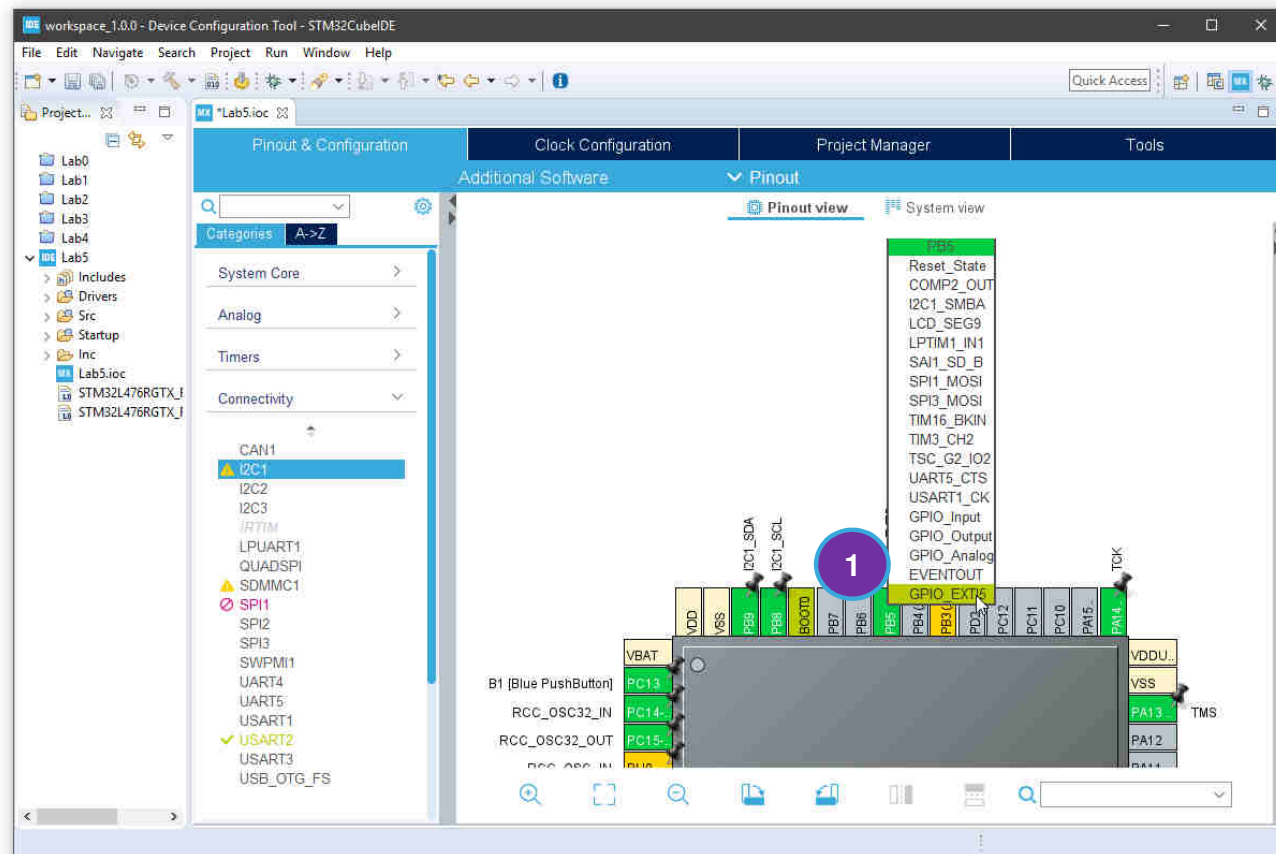
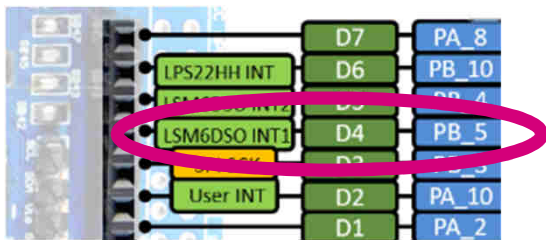
1. Expand *Connectivity* tab and check **I2C1**
2. Select **I2C** in *I2C1 Mode and Configuration*
3. PB8 and PB9 should now become green



Lab5 – Configure LSM6DSO Interrupt

197

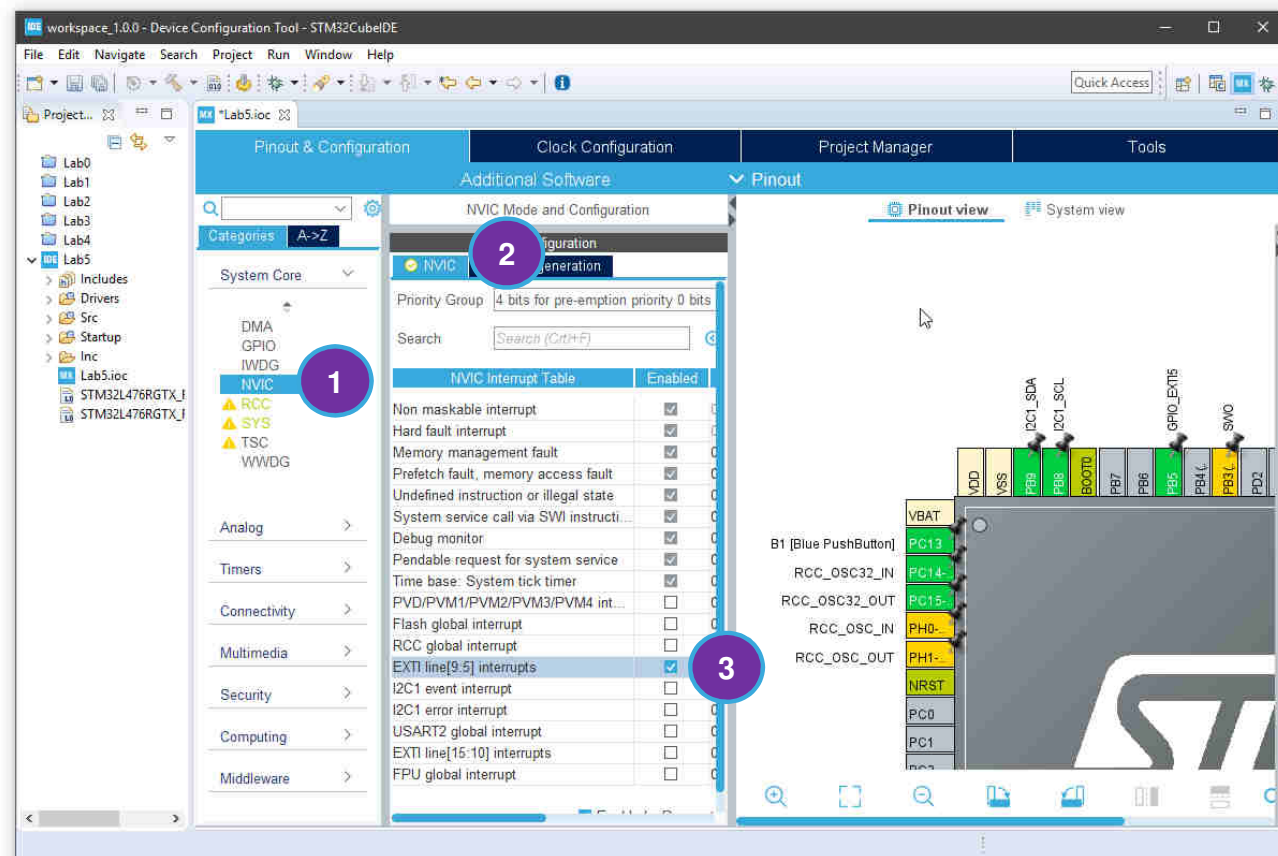
1. Left Click on **PB5** and select **GPIO_EXTI5**



Lab5 – Configure LSM6DSO Interrupt

198

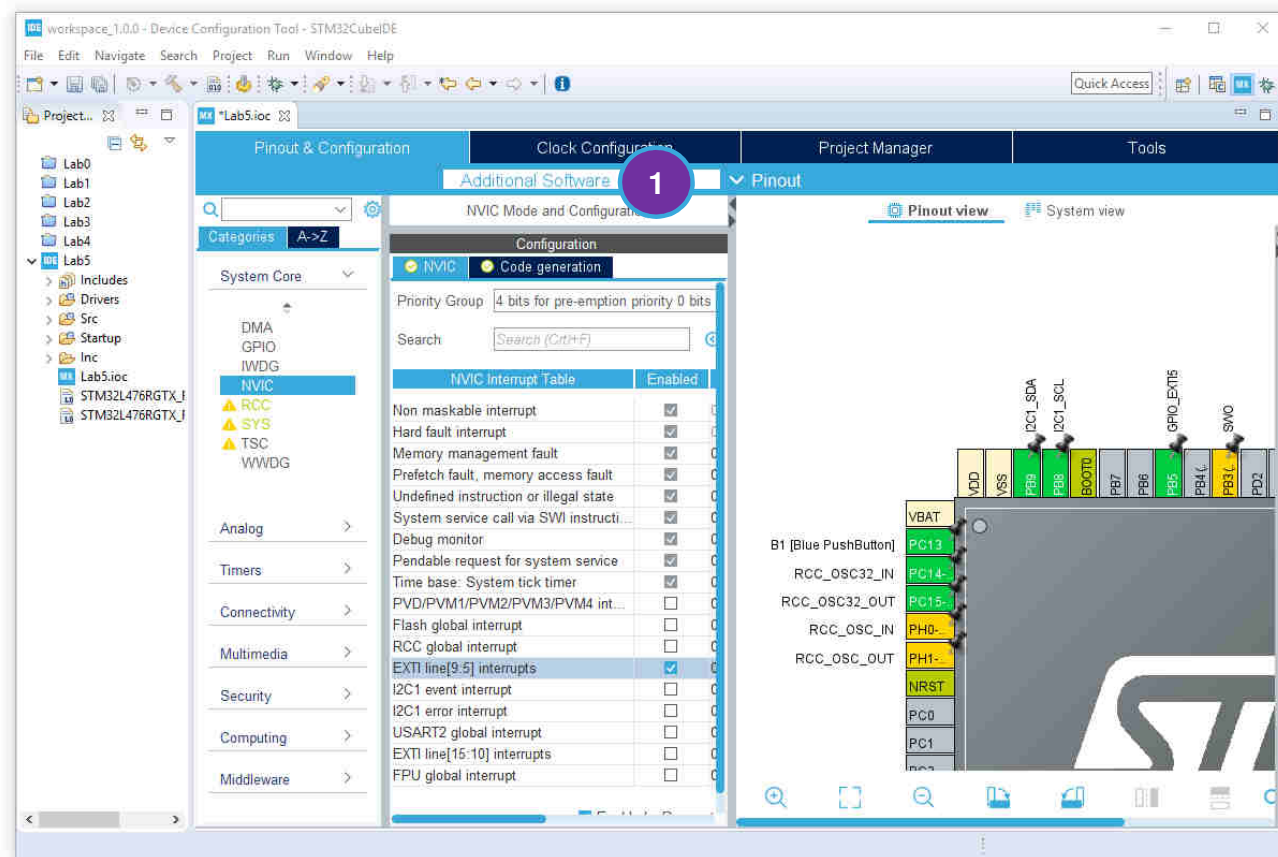
1. Check **NVIC** in tab System Core
2. Select **NVIC** in NVIC Mode and Configuration
3. Enable **EXTI line[9:5] interrupt**



Lab5 – Select the MEMS Library

199

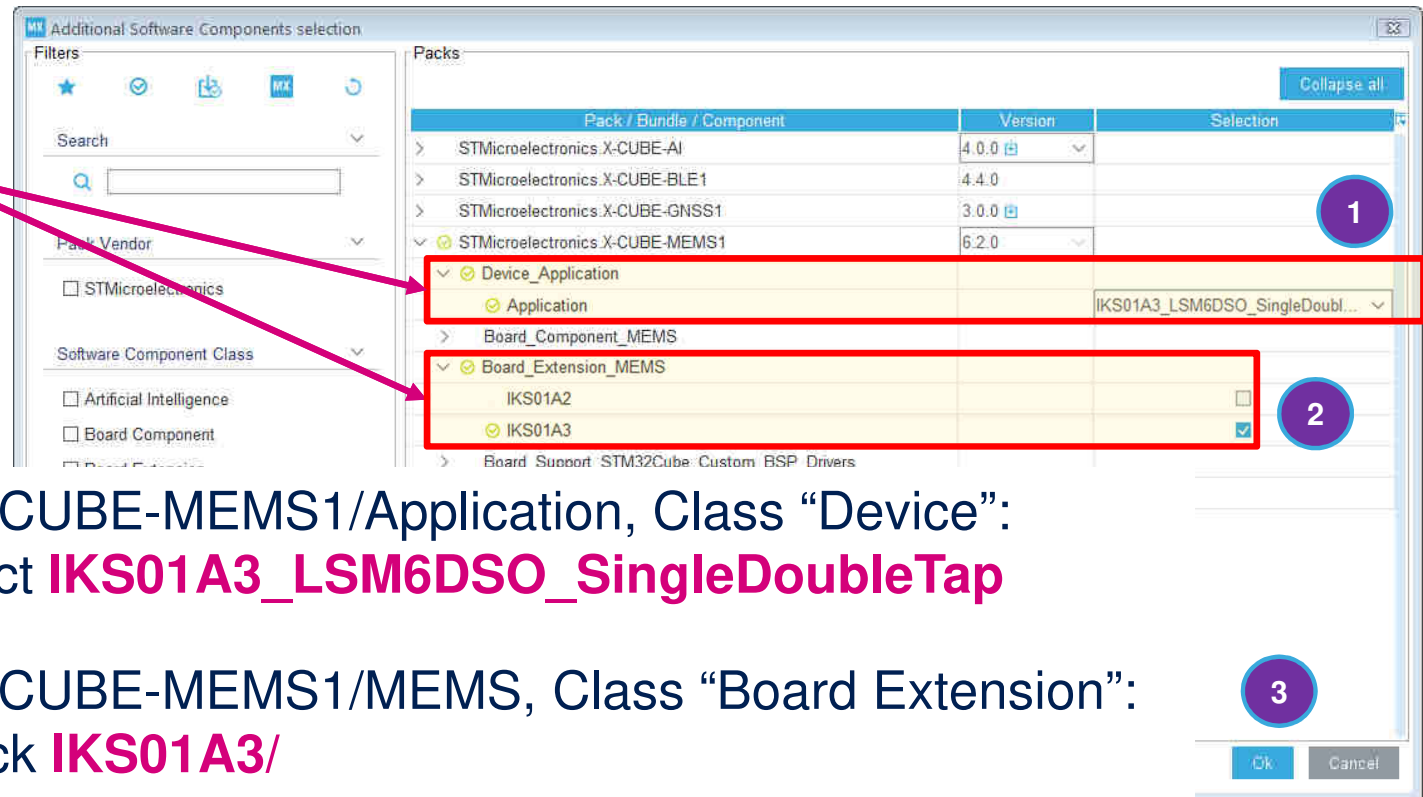
1. Click on **Additional Software**



Lab5 – Select the MEMS Library

200

Click to
expand tree

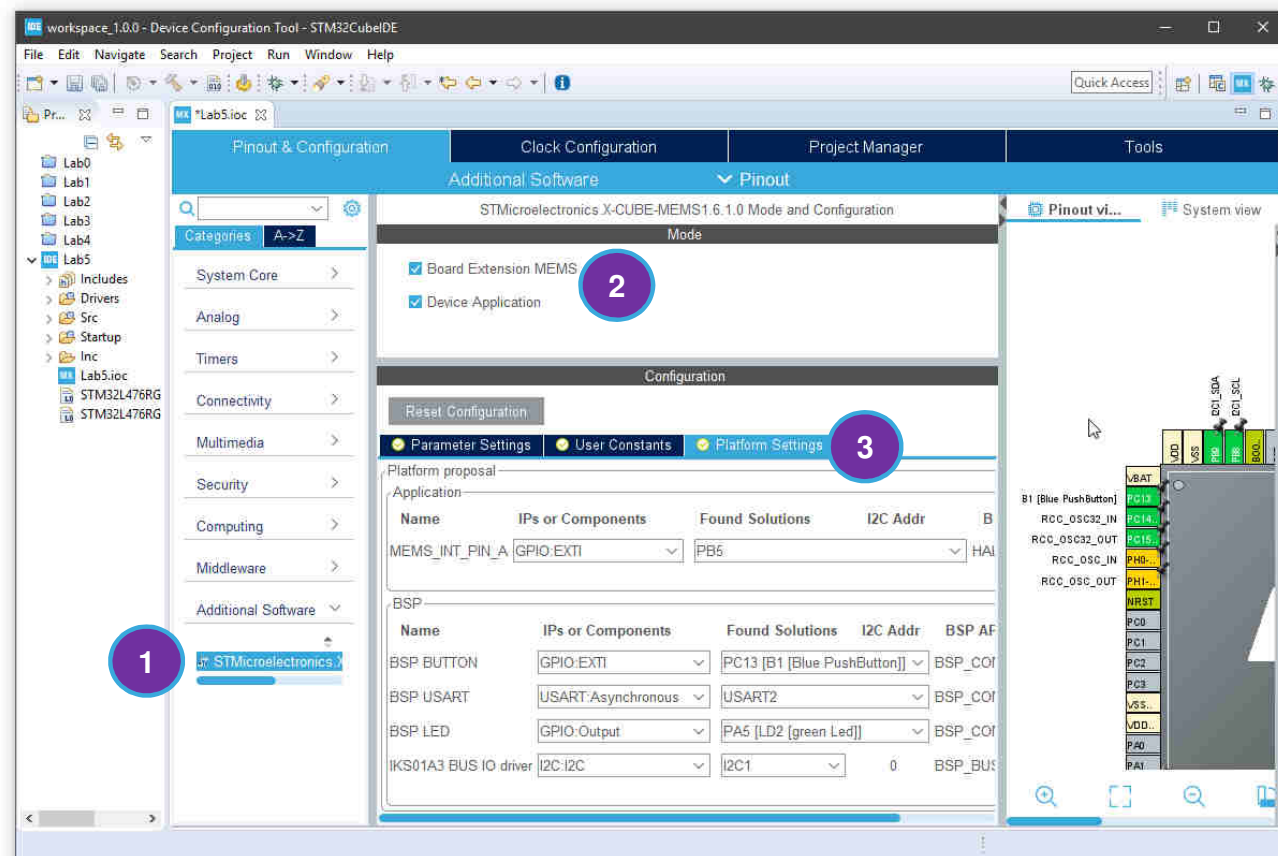


1. In X-CUBE-MEMS1/Application, Class “Device”:
Select **IKS01A3_LSM6DSO_SingleDoubleTap**
2. In X-CUBE-MEMS1/MEMS, Class “Board Extension”:
Check **IKS01A3/**
3. Click **OK**

Lab5 – Configure the MEMS Library

201

1. Expand Additional Software and select the X-CUBE-MEMS1
2. Check both:
Board Extension MEMS
Device Application
3. Configure Platform Settings as in picture



Lab5 – Configure the MEMS Library

202

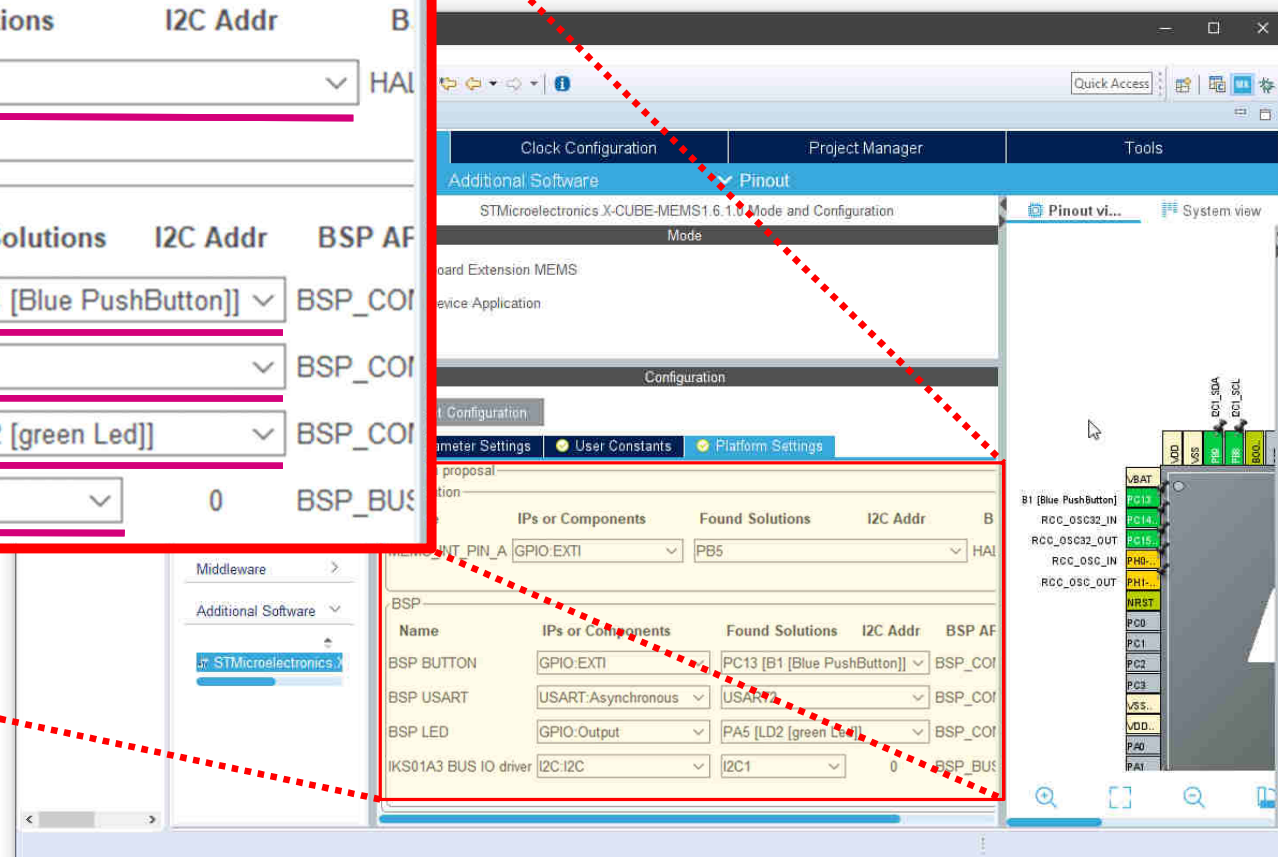
Platform proposal

Application

Name	IPs or Components	Found Solutions	I2C Addr	B
MEMS_INT_PIN_A	GPIO:EXTI	PB5		HAL

BSP

Name	IPs or Components	Found Solutions	I2C Addr	BSP AF
BSP BUTTON	GPIO:EXTI	PC13 [B1 [Blue PushButton]]		BSP_COI
BSP USART	USART:Asynchronous	USART2		BSP_COI
BSP LED	GPIO:Output	PA5 [LD2 [green Led]]		BSP_COI
IKS01A3 BUS IO driver	I2C:I2C	I2C1	0	BSP_BUS



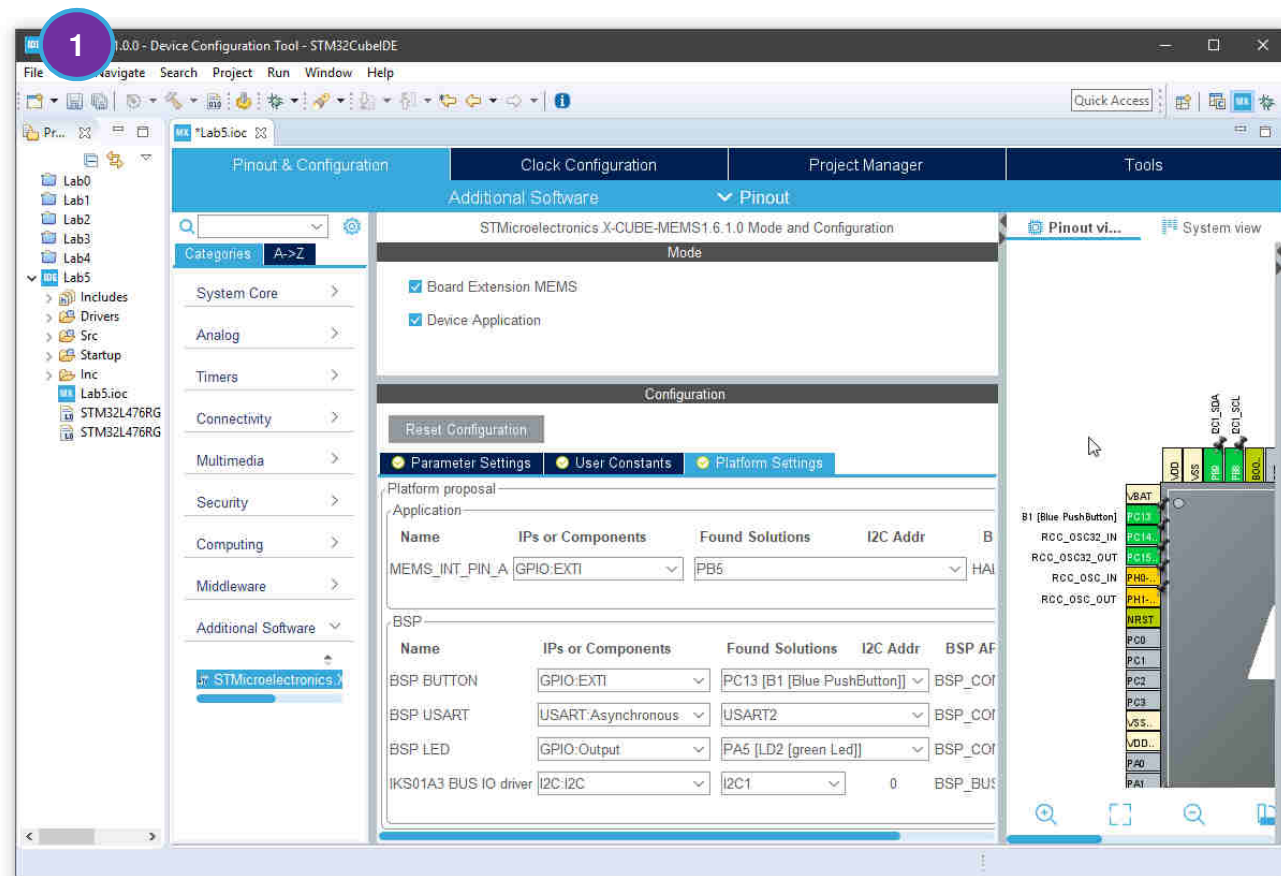
Lab5 – Save the Project

203

1. Click the save button



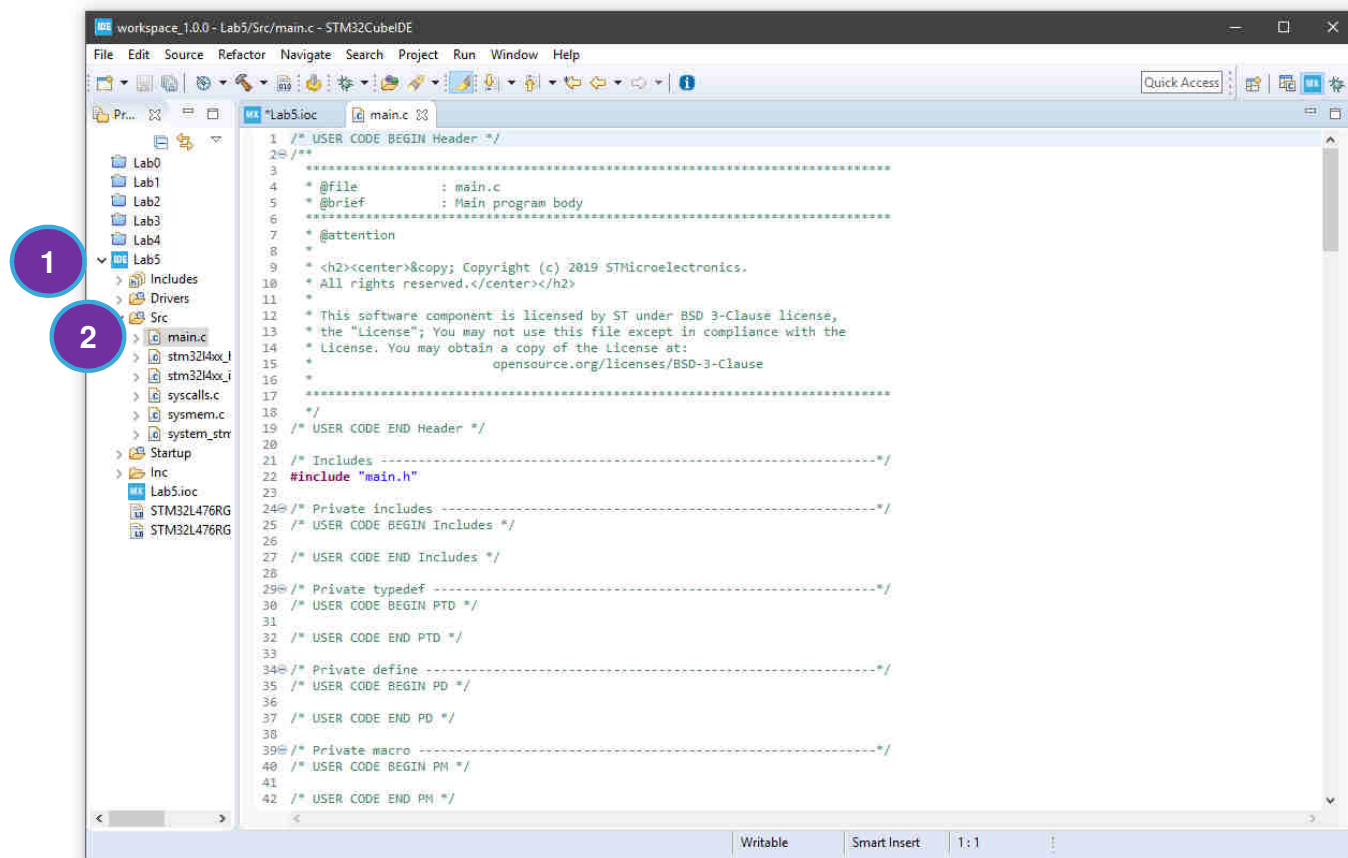
This action will generate the source code of this lab



Lab5 – Code Editing


204

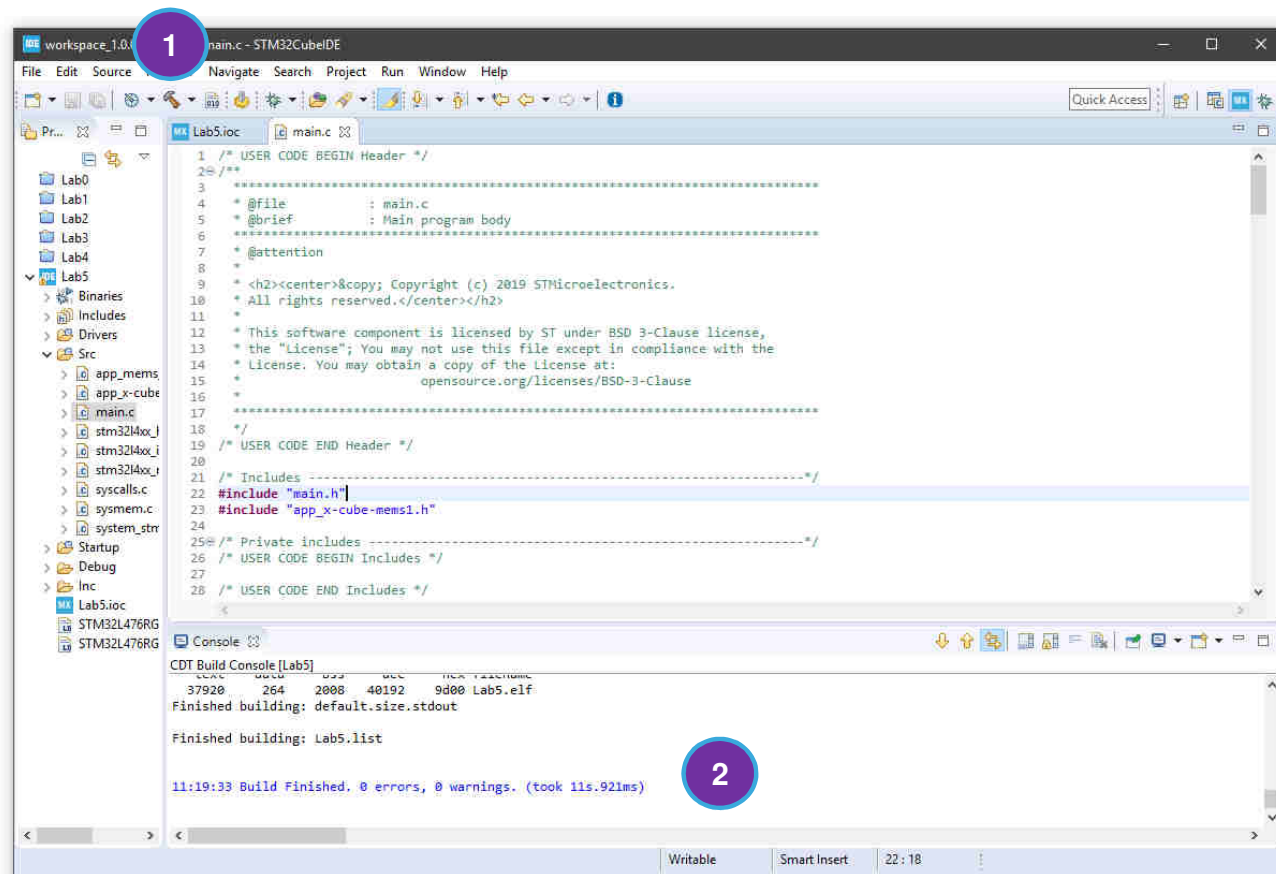
1. Expand **Src** in folder **Lab5**
2. Double click on **main.c**



Lab5 - Compiling

205

1. Click on the hammer  to begin compilation, or press **CTRL+B**
2. Compilation should terminate with 0 errors and 0 warning



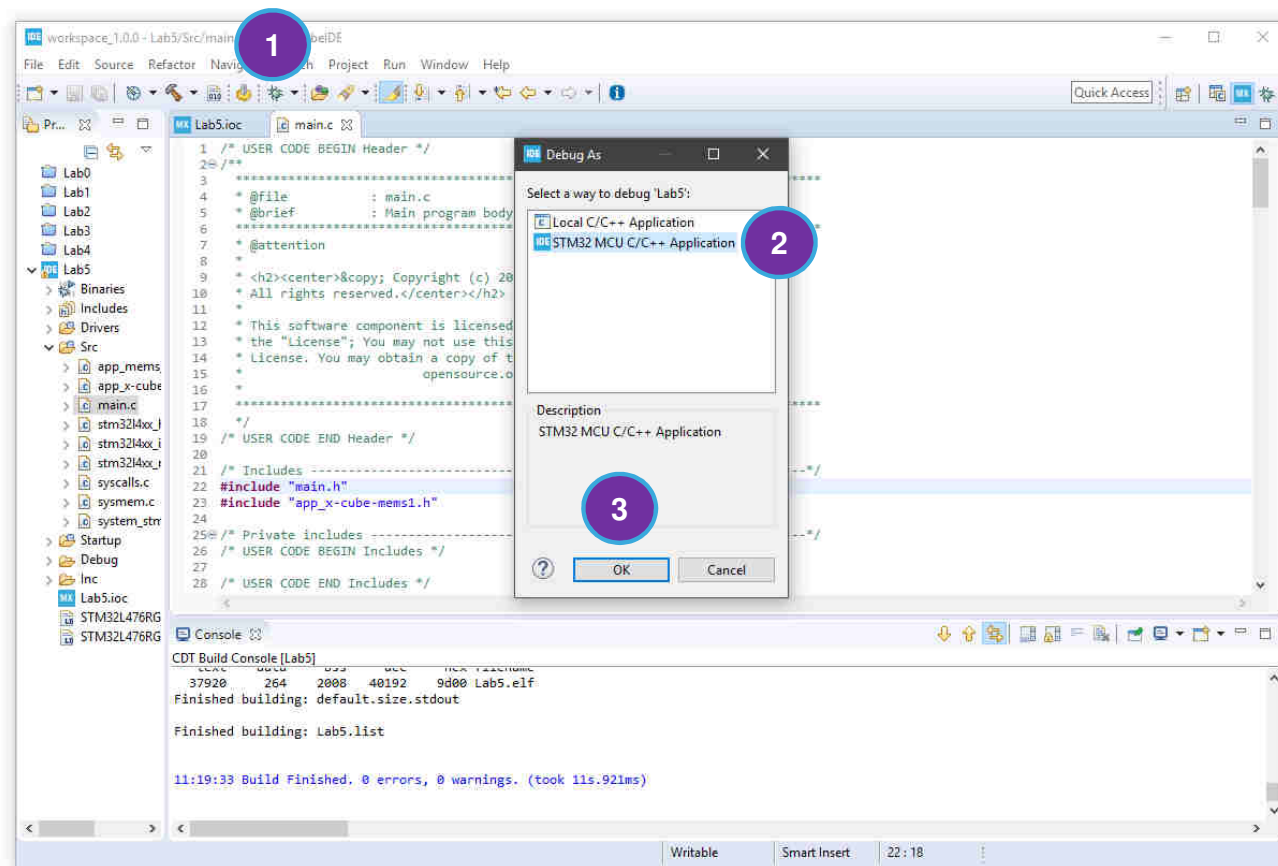
Lab5 - Debugging

206

1. Click on the bug  to begin debugging

2. Select **STM32 MCU C/C++ App**

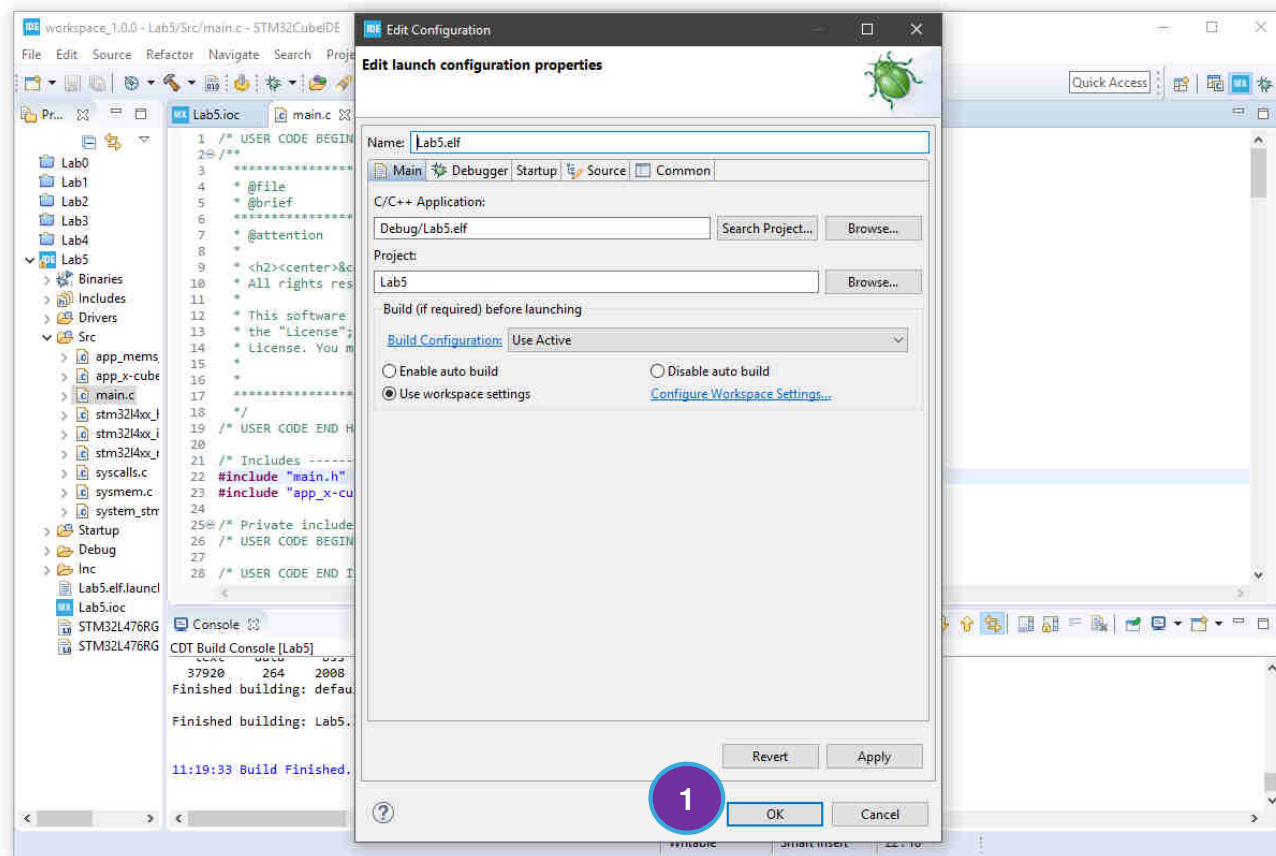
3. Click **OK**



Lab5 - Debugging

207


1. Click **OK**

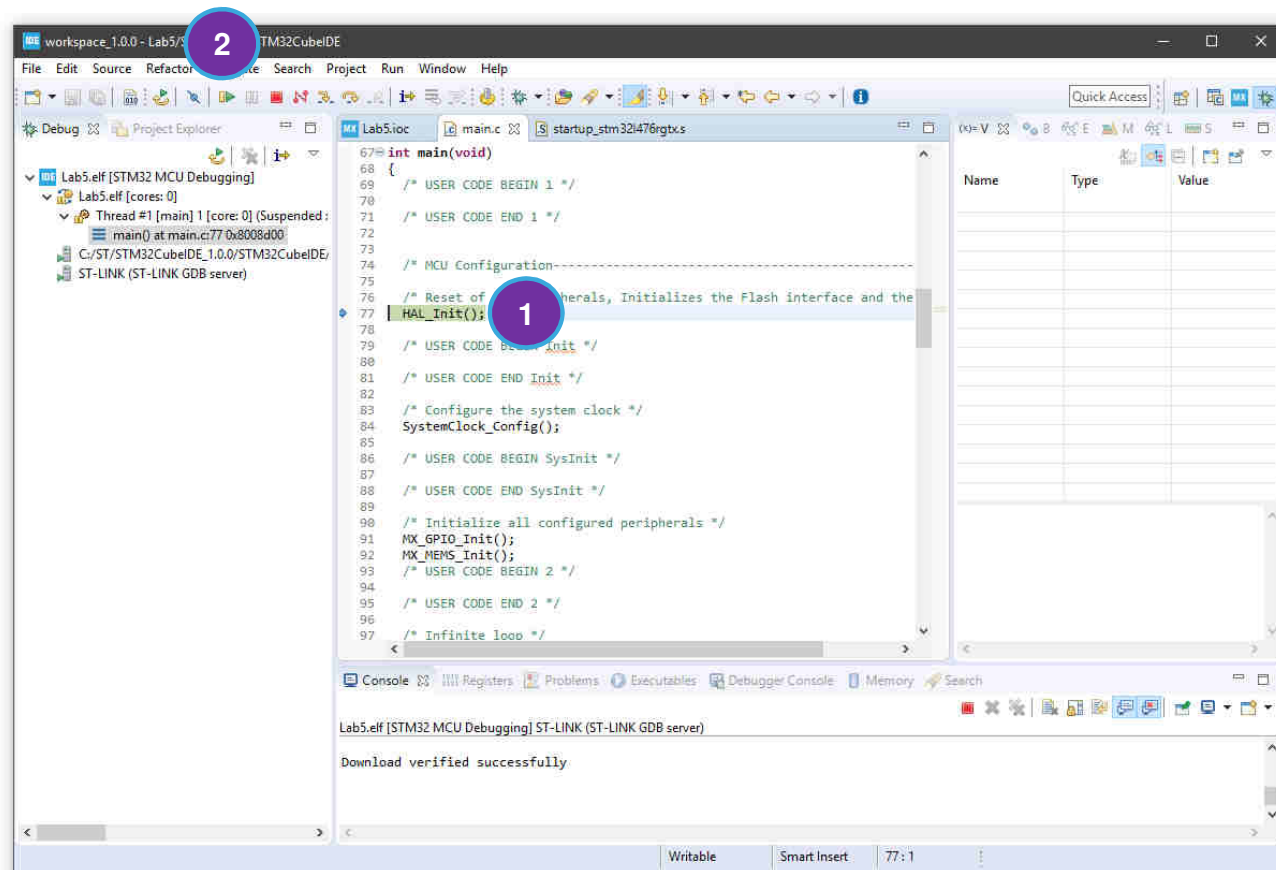


Lab5 - Debugging

208

1. Code start at the first line of the main function

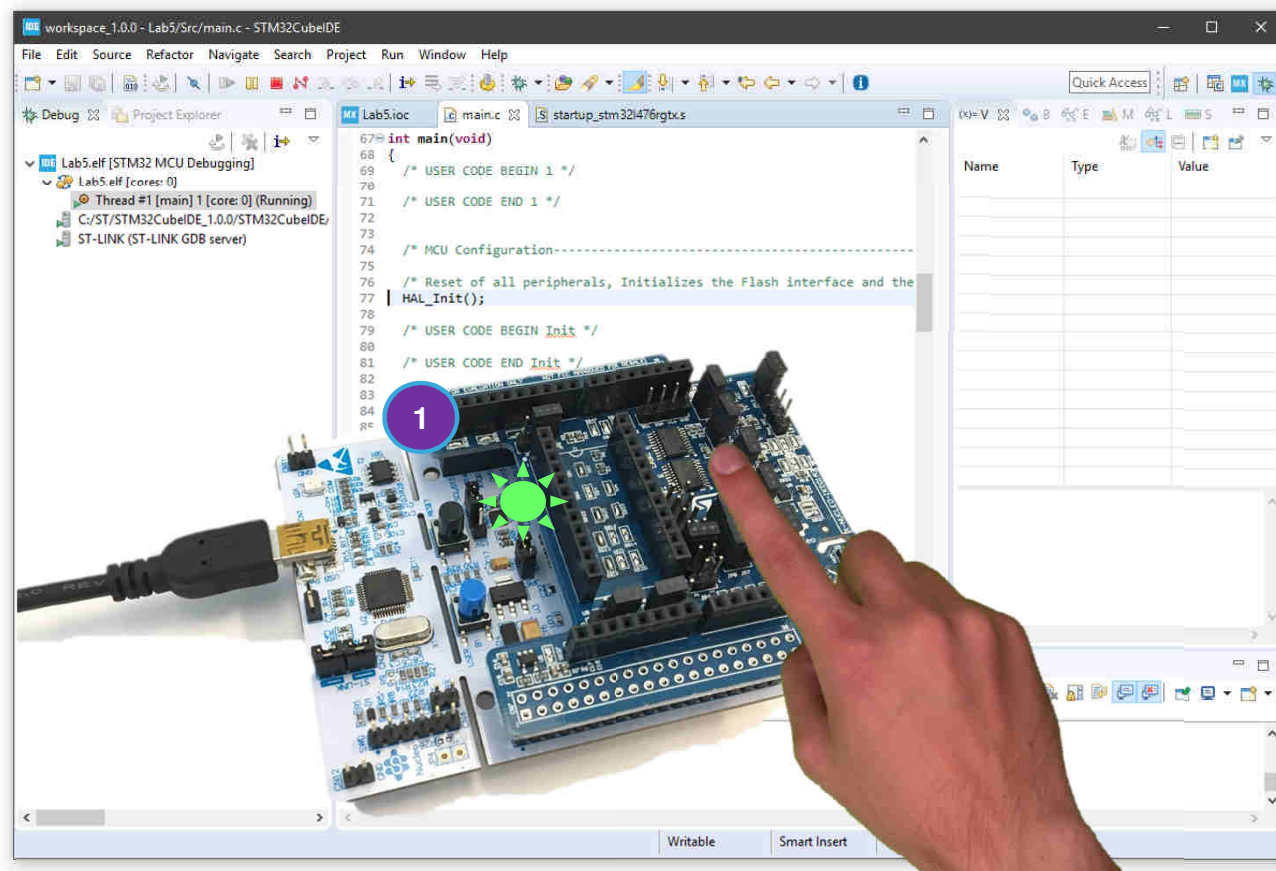
2. Click play  button to run the code



Lab5 - Testing

209

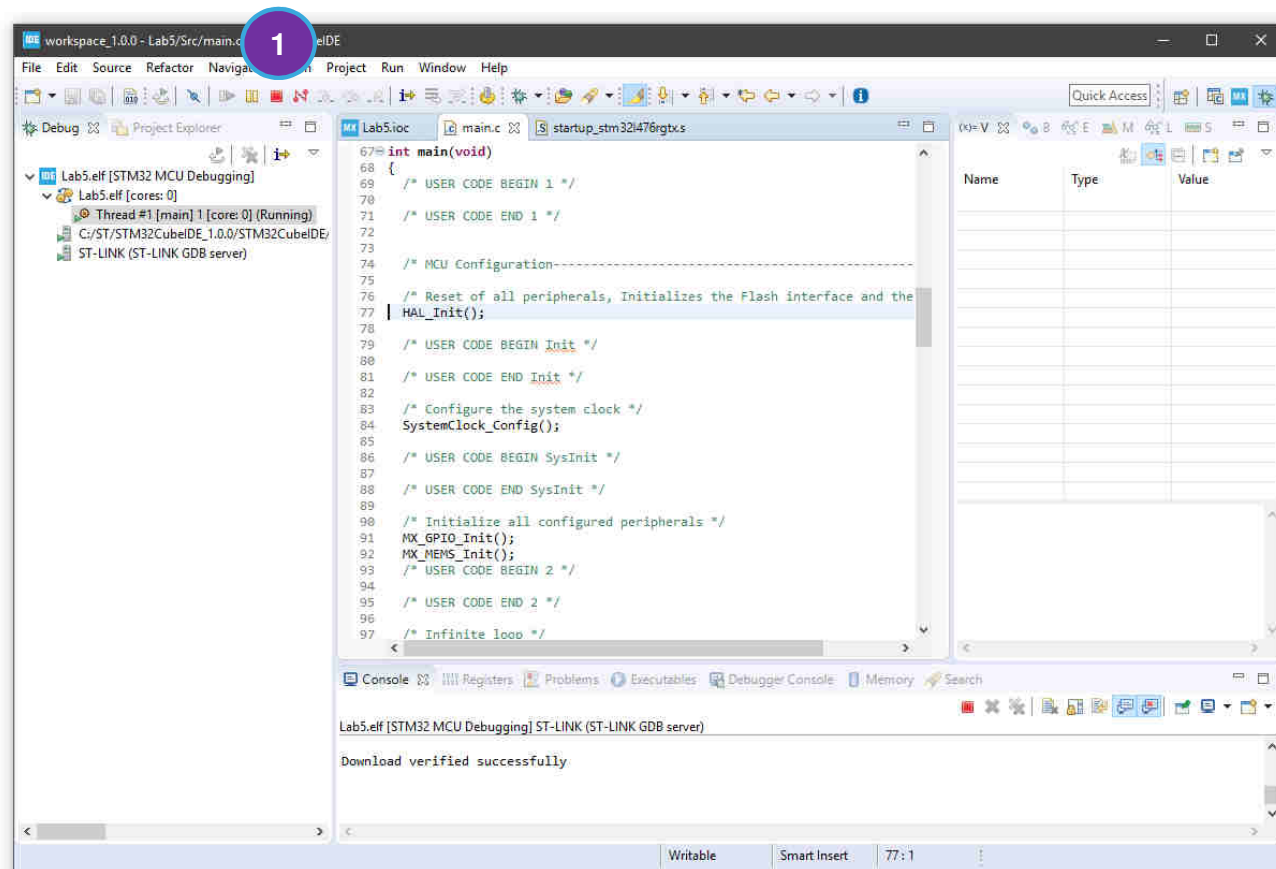
1. **TAP** or **DOUBLE TAP** the board and the GREEN led will turn ON



Lab5 - Debugging

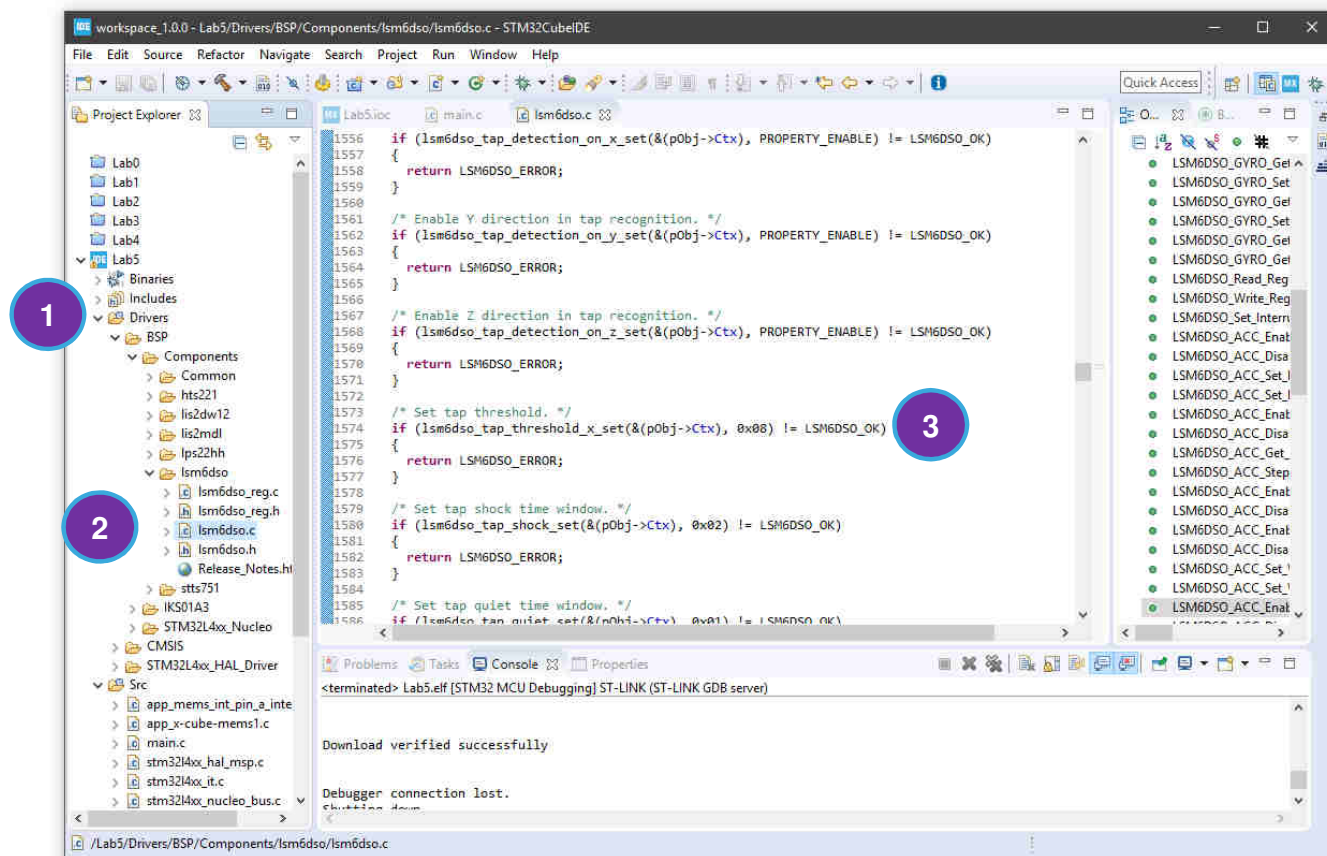
210

1. Click stop  button to interrupt the debugging



Lab5 – Code Editing 211

1. Expand folder **Drivers > BSP > Components > lsm6dso**
2. Open file **lsm6dso.c**
3. Go to **line #1574**



Lab5 – Code Editing 212

1. In **line #1574**, edit the threshold **from value 0x08 to value 0x02***

2. Save modification



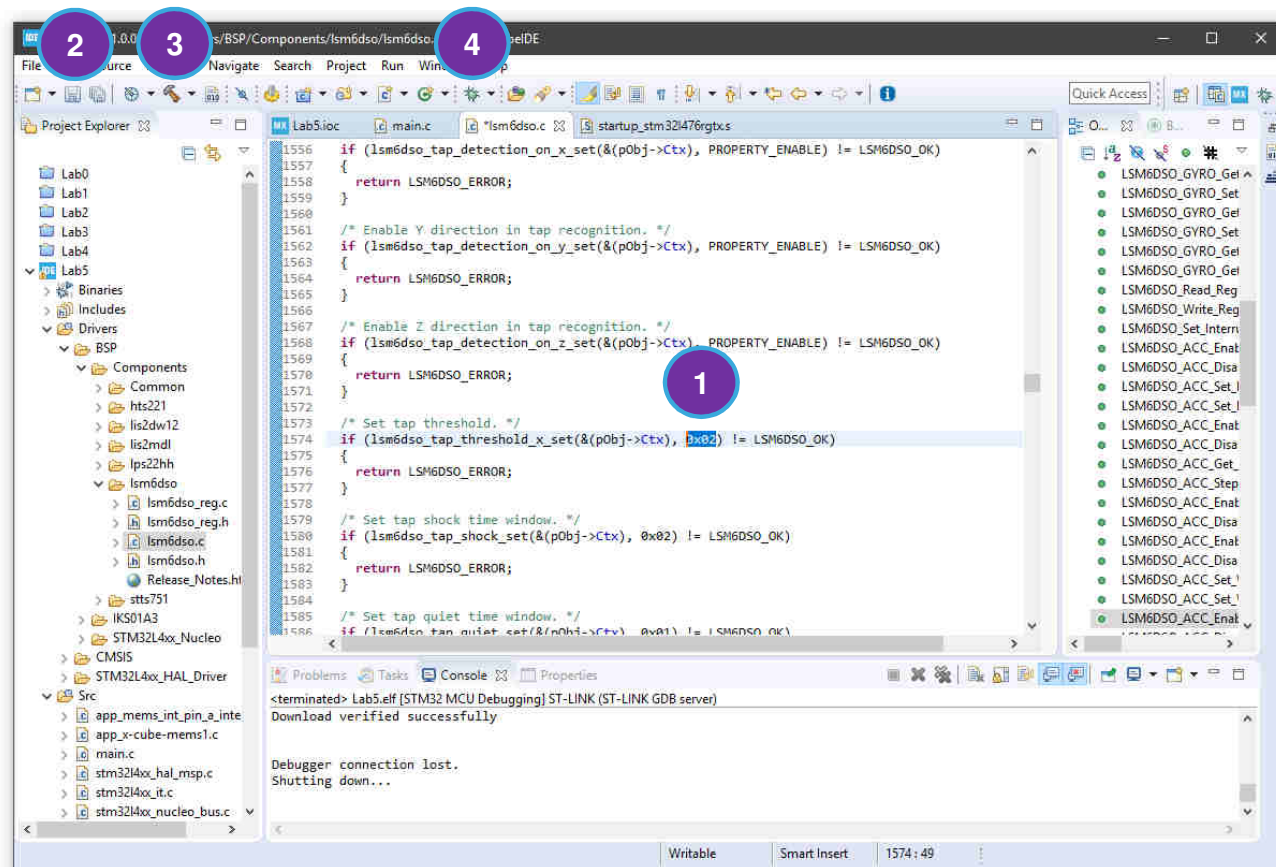
3. Recompile



4. Launch debug



* This modification will reduce the threshold of the tap detection, increasing sensitivity of the recognized tap. For further details please refer to **Application Note AN5192 Section 5.5.1**

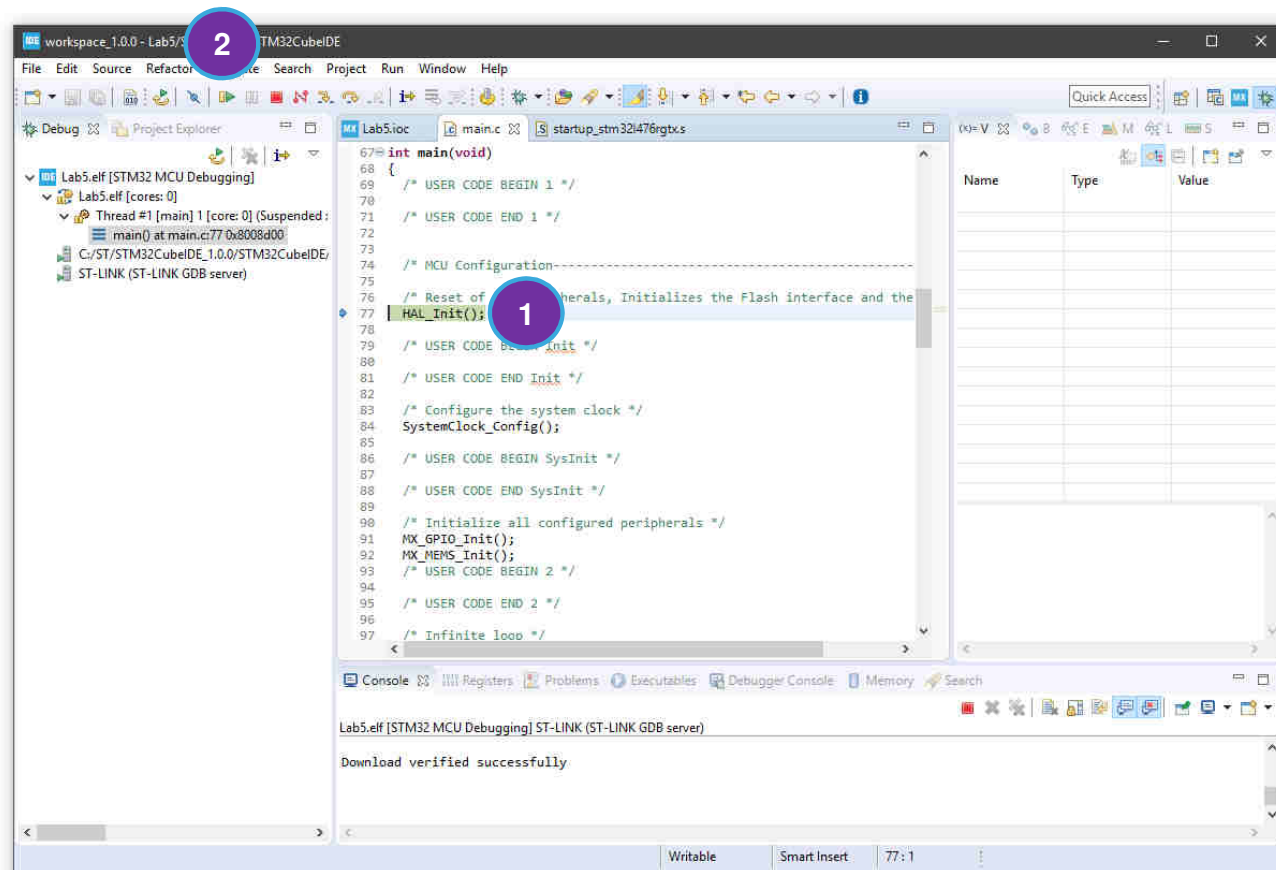


Lab5 - Debugging

213

1. Code start at the first line of the main function

2. Click play  button to run the code

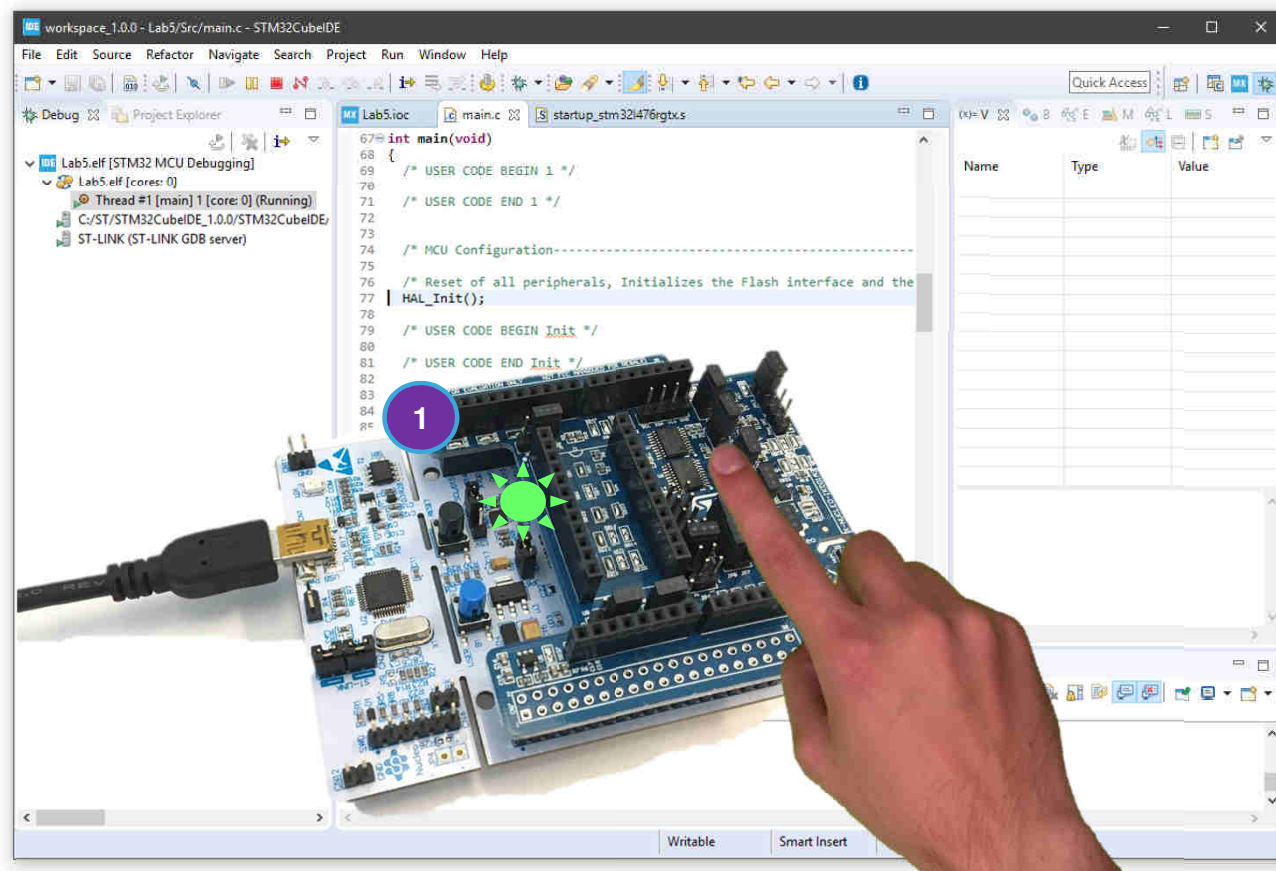


Lab5 - Testing

214

1. **TAP** or **DOUBLE TAP** the board and the GREEN led will turn ON

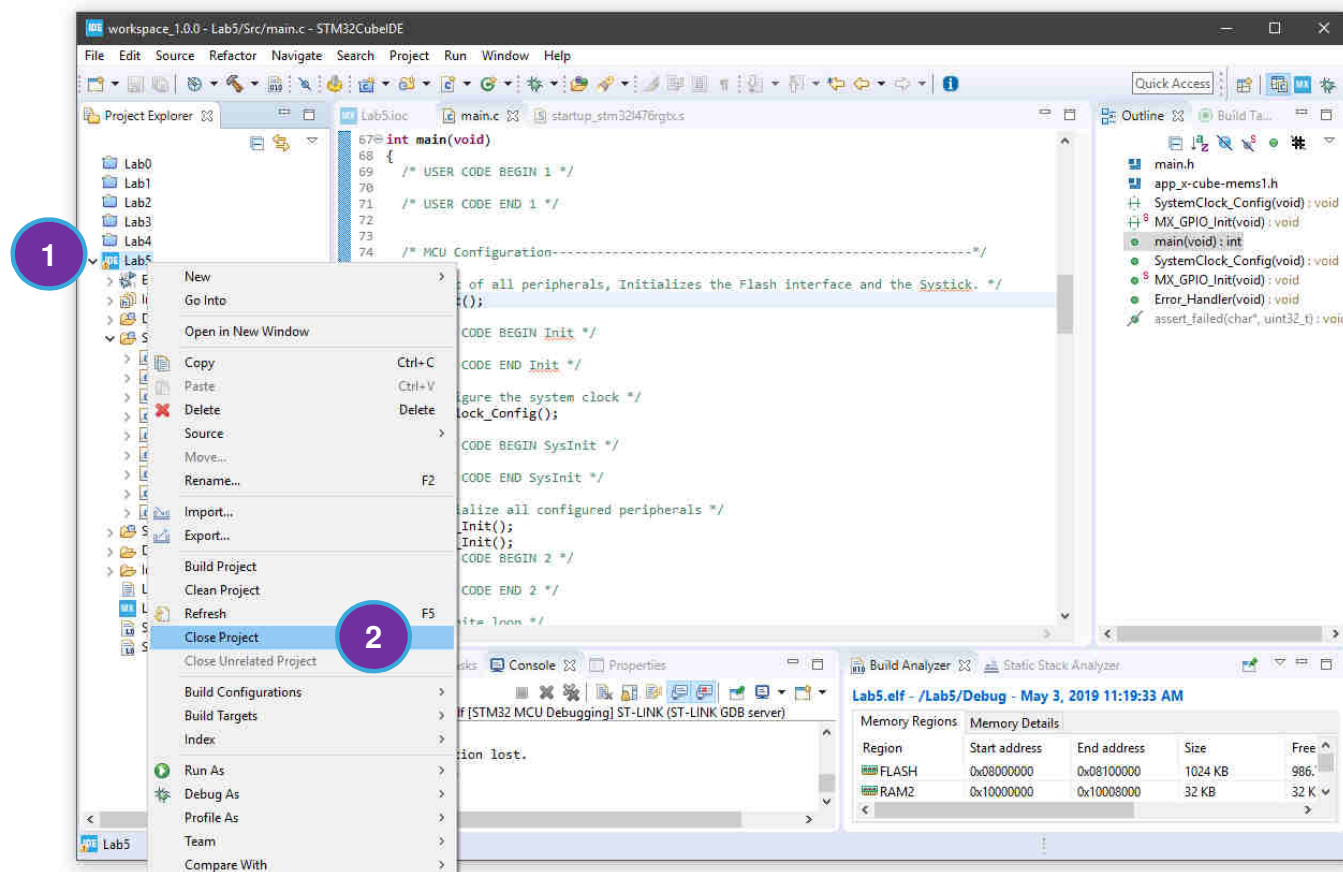
You may notice that the sensitivity of the TAP recognition has been increased




Lab5 – Closing the Project

215

1. Right-Click on **Lab5** project
2. Click on **Close Project**





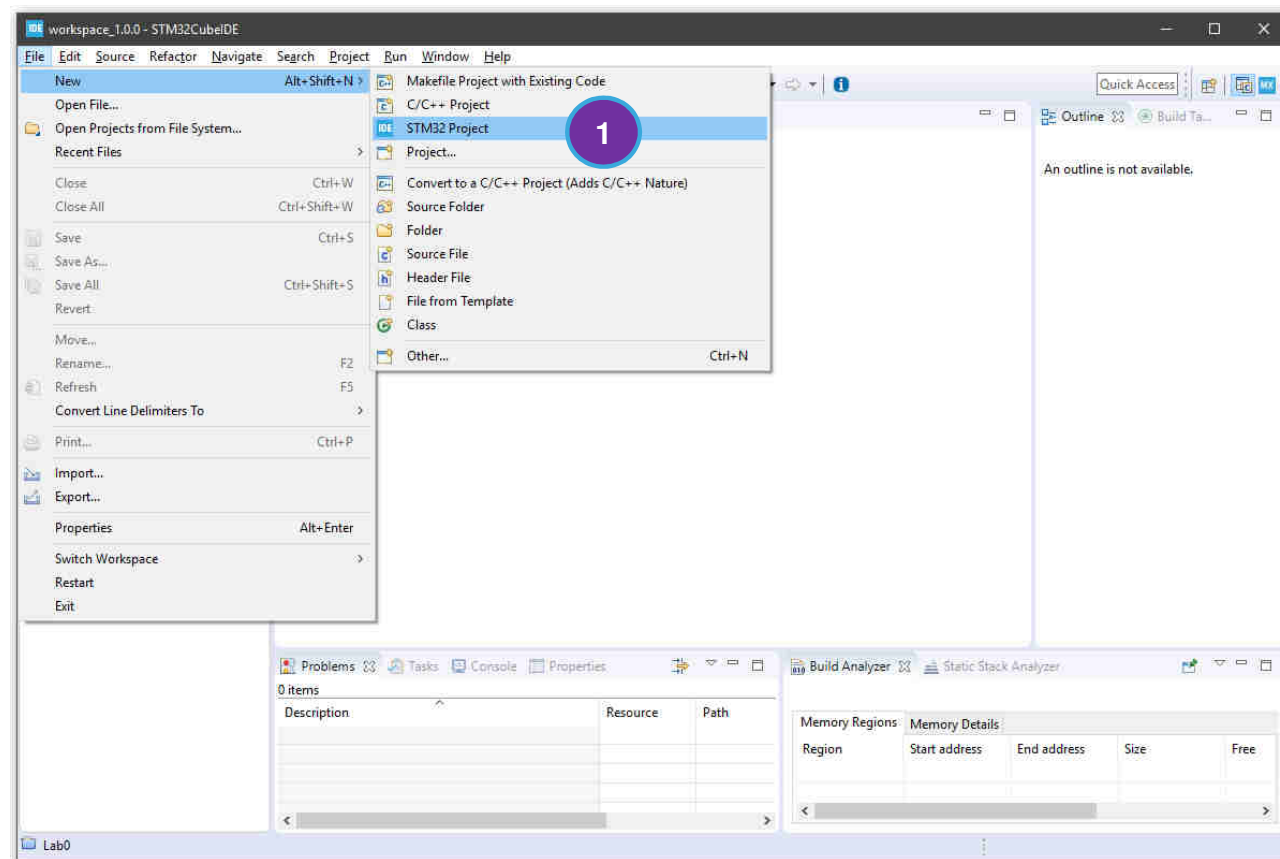
New: In this LAB the “X-NUCLEO-IKS0A3” will be used as a “Custom board”

LAB6

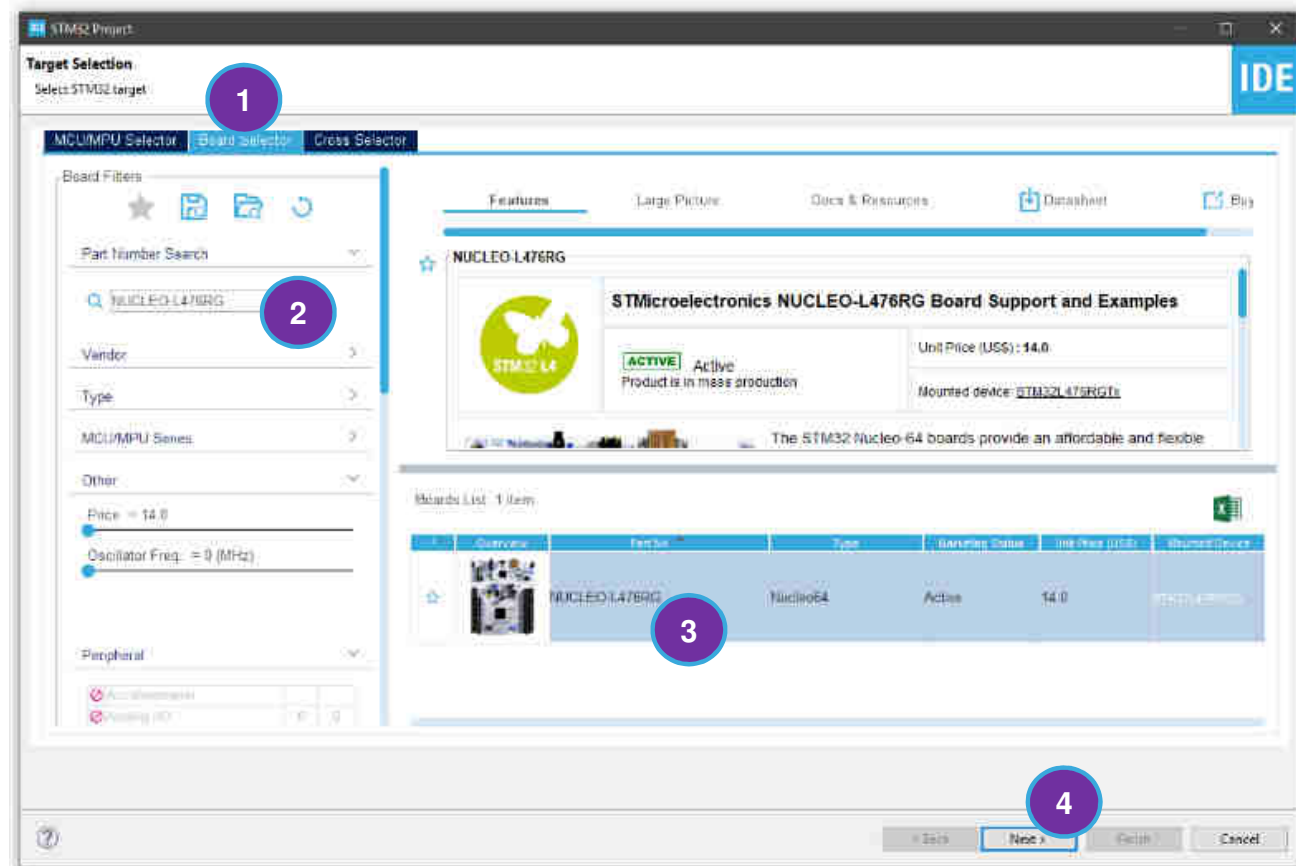
Goals:

- Configure a new project using X-CUBE-MEMS1
- Configure LSM6DSO only for USB data logging
- Change Output Data Rate to log accelerometer and gyroscope at higher acquisition speed

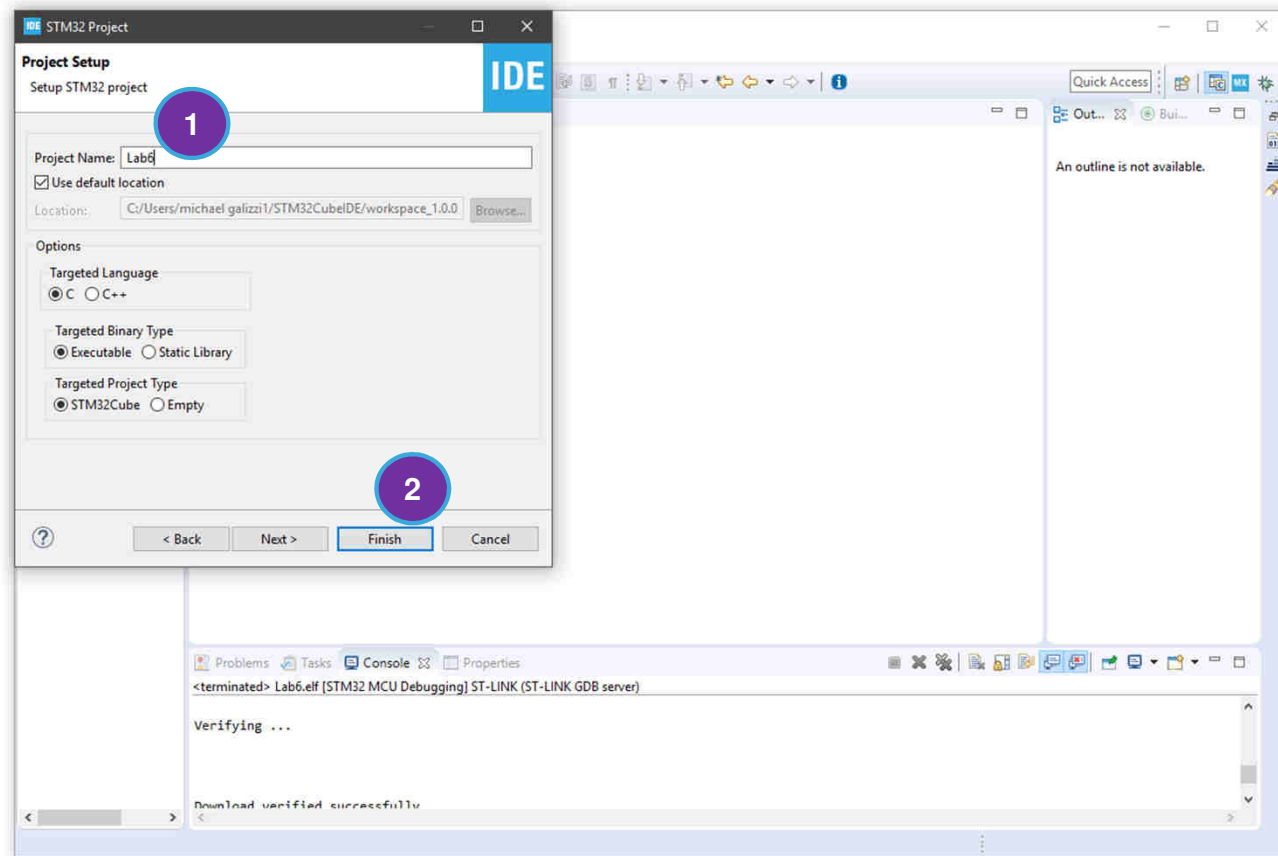
1. Click on **File > New > STM32 Project**



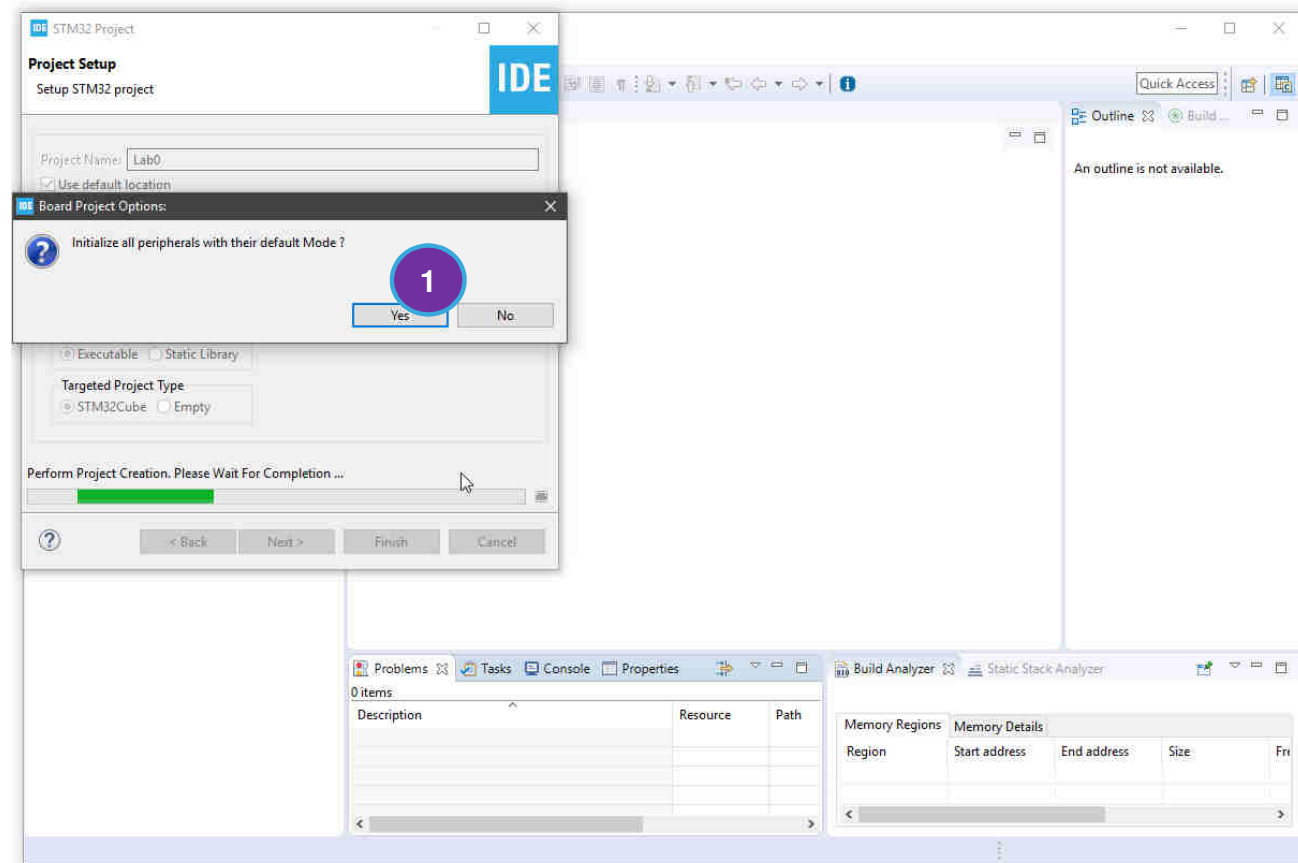
1. Click on **Board Selector**
2. Type **NUCLEO-L476RG**
3. Click on the board
4. Click **Next >**



1. Project Name **Lab6**
2. Click **Finish**



1. Click **Yes** to init peripherals in default mode



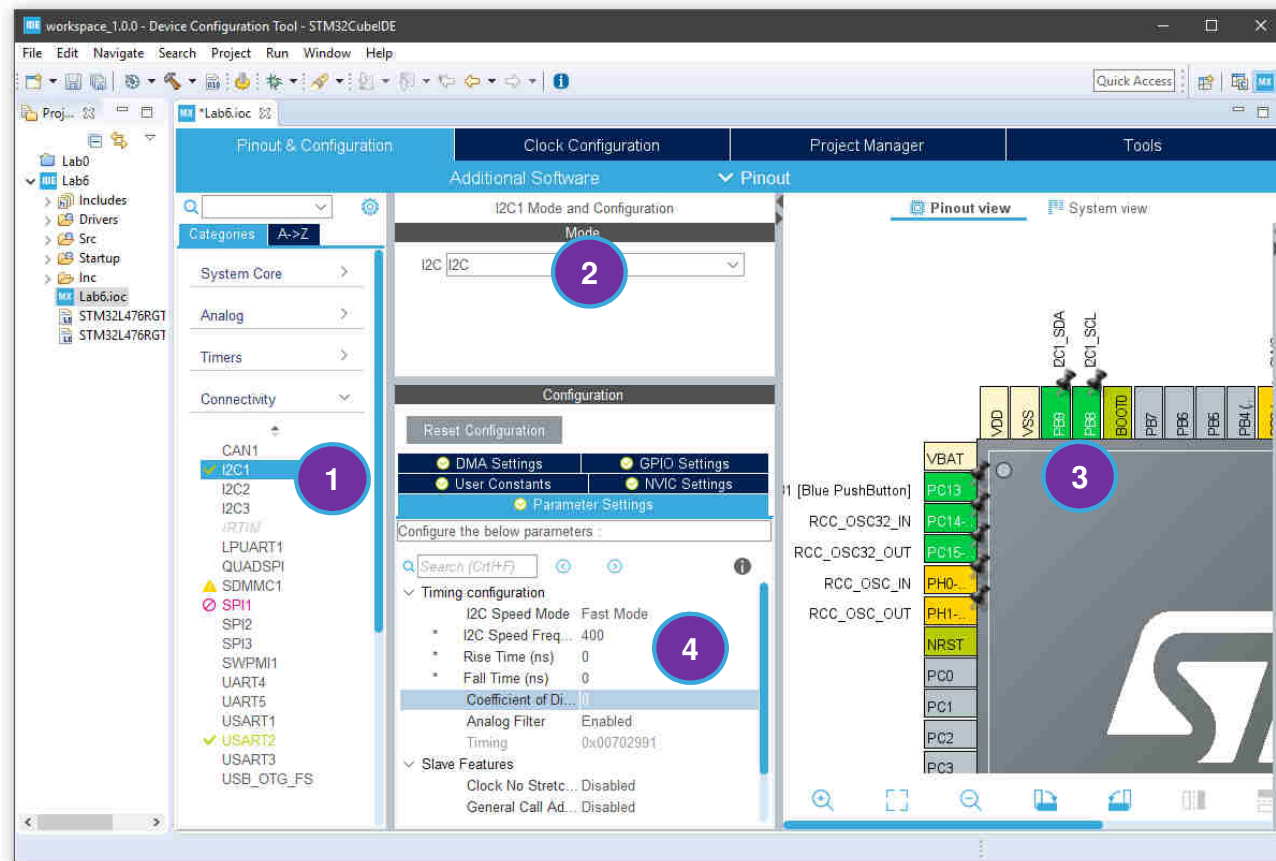
Lab6 – Configure the I2C Bus 222

1. Expand *Connectivity* tab and check **I2C1**

2. Select **I2C** in *I2C1 Mode and Configuration*

3. PB8 and PB9 should now become green

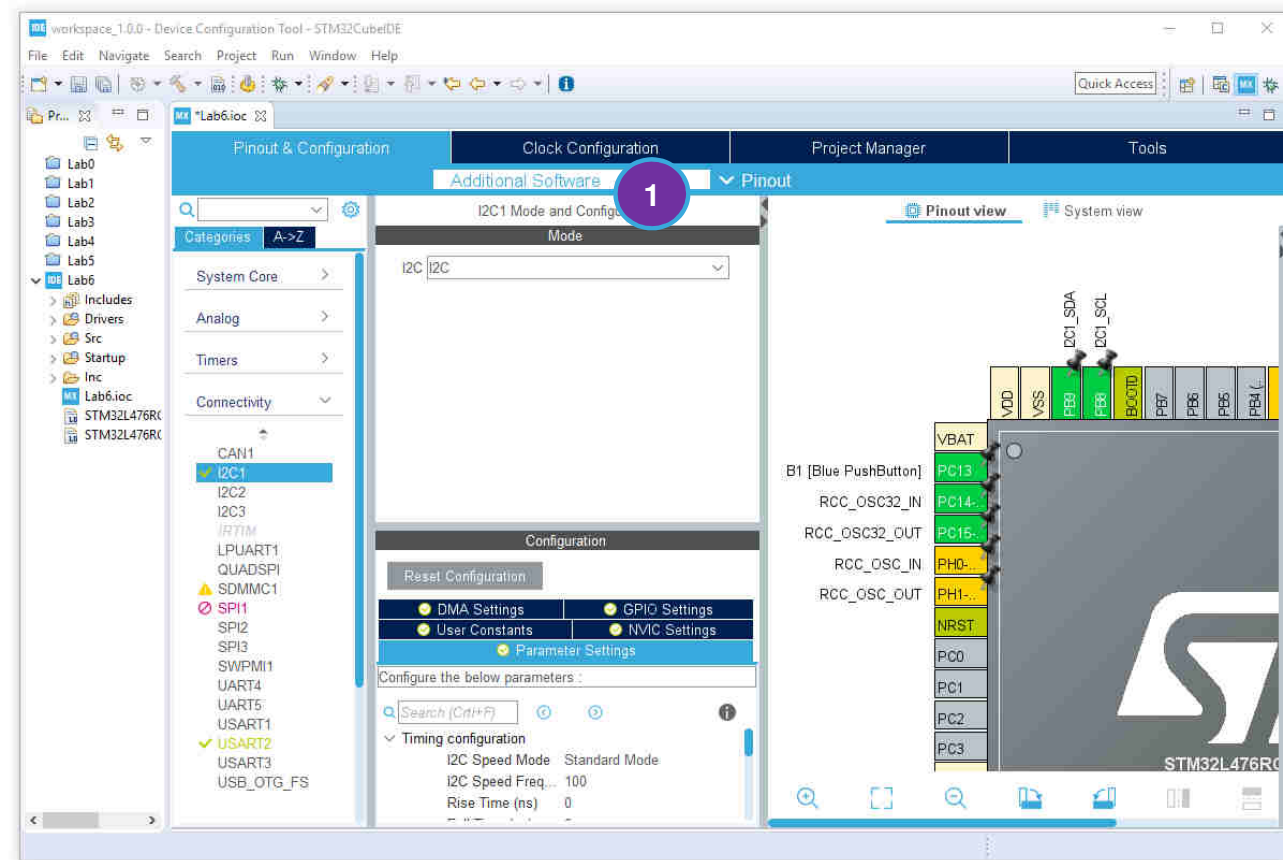
4. Setup **Fast Mode** in **Parameter Settings**



Lab6 – Select the MEMS Library

223

1. Click on **Additional Software**

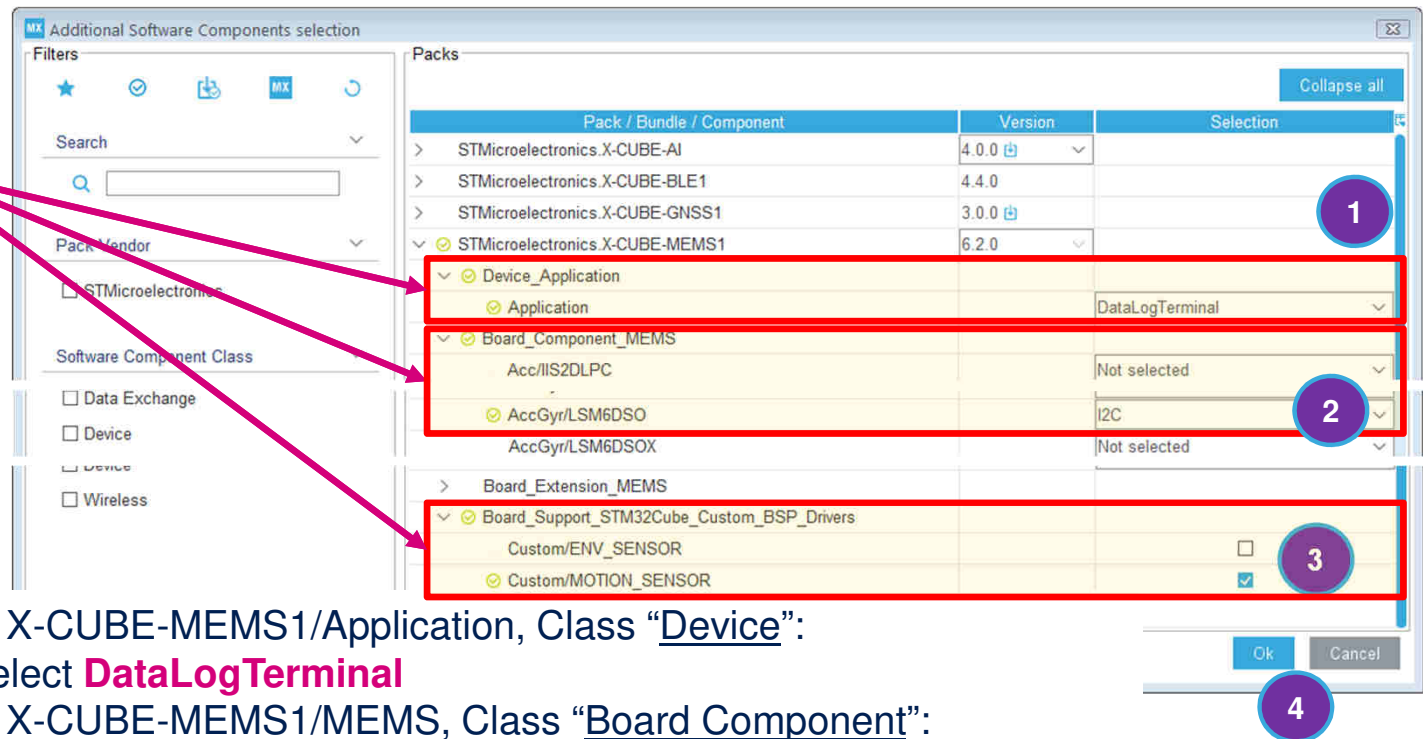


3 selections
To be done!

Lab6 – Select the MEMS Library

224

Click to
expand tree

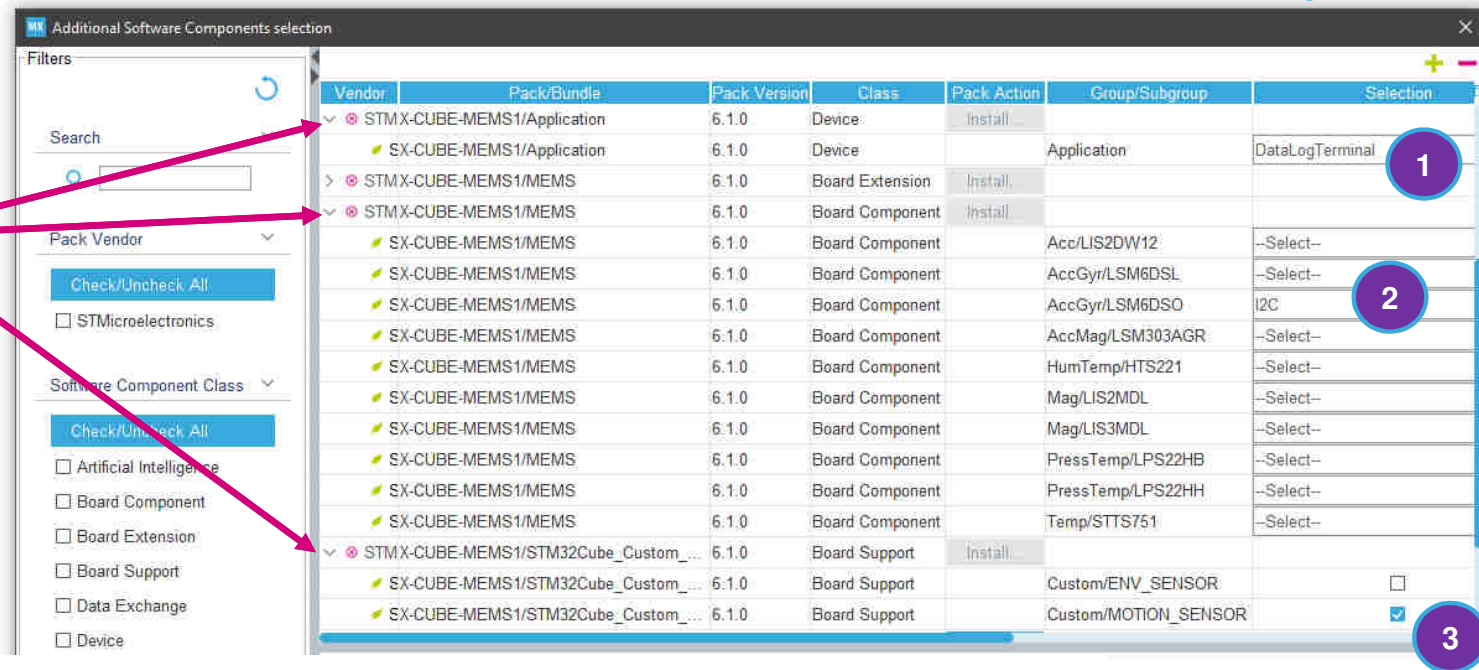


1. In X-CUBE-MEMS1/Application, Class "Device":
Select **DataLogTerminal**
2. In X-CUBE-MEMS1/MEMS, Class "Board Component":
In **AccGyr/LSM6DSO** Selection **I2C**
3. In X-CUBE-MEMS1/MEMS, Class "Board Support":
Check **Custom/MOTION_SENSOR**
4. Click **OK**

Lab6 – Select the MEMS Library

225

Click to
expand tree

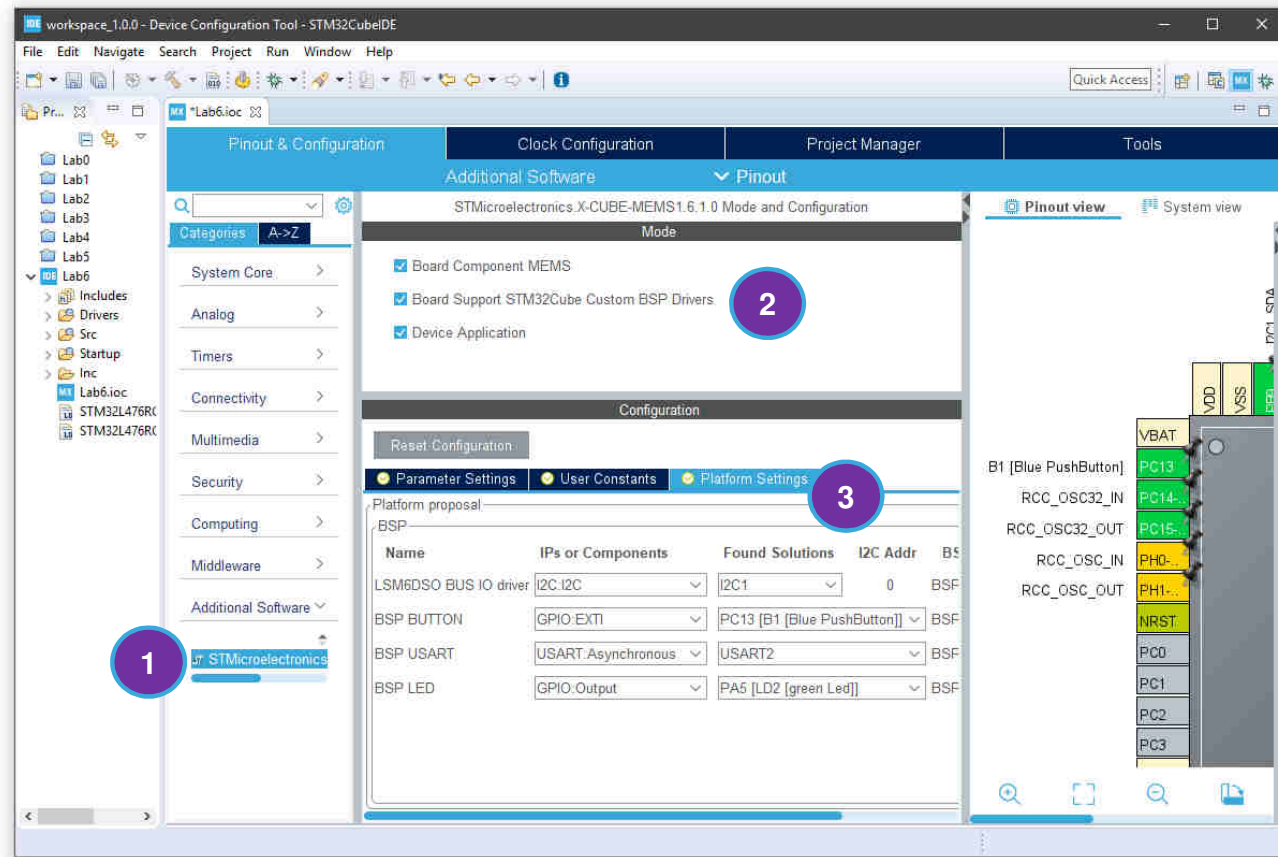


1. In X-CUBE-MEMS1/Application, Class "Device":
Select **DataLogTerminal**
2. In X-CUBE-MEMS1/MEMS, Class "Board Component":
In **AccGyr/LSM6DSO** Selection **I2C**
3. In X-CUBE-MEMS1/MEMS, Class "Board Support":
Check **Custom/MOTION_SENSOR**
4. Click **OK**

Lab6 – Configure the MEMS Library

226

1. Expand Additional Software and select the X-CUBE-MEMS1
2. Check both:
Board Component MEMS
Board Support STM32...
Device Application
3. Configure **Platform Settings** as in picture



Lab6 – Configure the MEMS Library

227

The image shows the STM32CubeIDE Platform Configuration Wizard. A red box highlights the 'Platform proposal' tab, which contains a table of BSP components. A red dotted line connects this box to a larger view of the same table in the 'Platform Settings' tab. Another red dotted line connects the 'Platform Settings' tab to the 'Pinout view' on the right, which shows the physical pin connections for the selected components.

Name	IPs or Components	Found Solutions	I2C Addr	BSP
LSM6DSO BUS IO driver	I2C:I2C	I2C1	0	BSP
BSP BUTTON	GPIO:EXTI	PC13 [B1 [Blue PushButton]]		BSP
BSP USART	USART:Asynchronous	USART2		BSP
BSP LED	GPIO:Output	PA5 [LD2 [green Led]]		BSP

The Pinout view on the right shows the physical pin connections for the selected components:

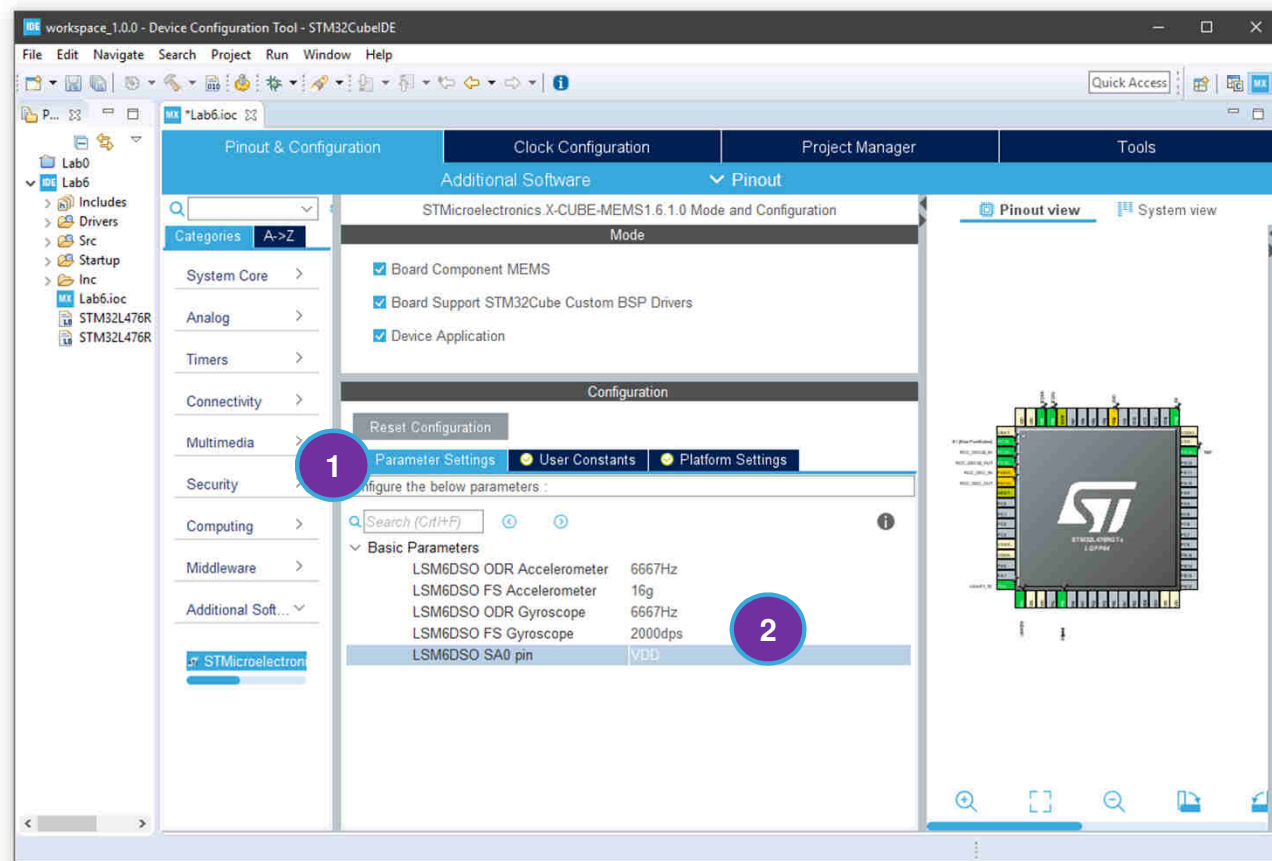
- B1 [Blue PushButton] connected to PC13
- RCC_OSC32_IN connected to PC14
- RCC_OSC32_OUT connected to PC15
- RCC_OSC_IN connected to PH0
- RCC_OSC_OUT connected to PH1
- NRST connected to PC0
- PC0 connected to PC1
- PC1 connected to PC2
- PC2 connected to PC3

Lab6 – Configure the MEMS Library

228

1. Configure **Parameter Settings** as in picture

2. ODR_Accelerometer: 6667Hz
FS_Accelerometer: 16g
ODR_Gyroscope: 6667Hz
FS_Gyroscope: 2000dps



Lab6 – Configure the MEMS Library

229

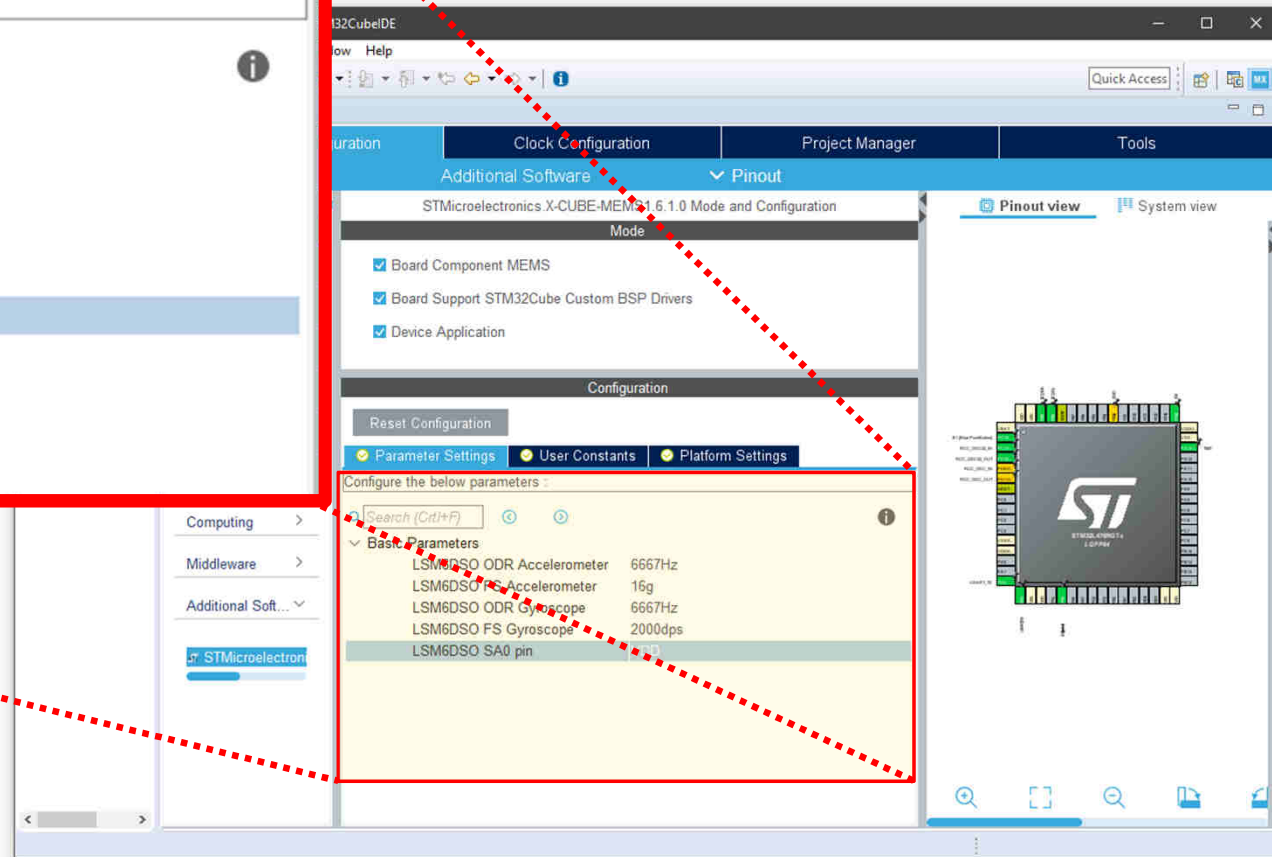
✓ Parameter Settings ✓ User Constants ✓ Platform Settings

Configure the below parameters :

Search (Ctrl+F)

Basic Parameters

LSM6DSO ODR Accelerometer	6667Hz
LSM6DSO FS Accelerometer	16g
LSM6DSO ODR Gyroscope	6667Hz
LSM6DSO FS Gyroscope	2000dps
LSM6DSO SA0 pin	VDD



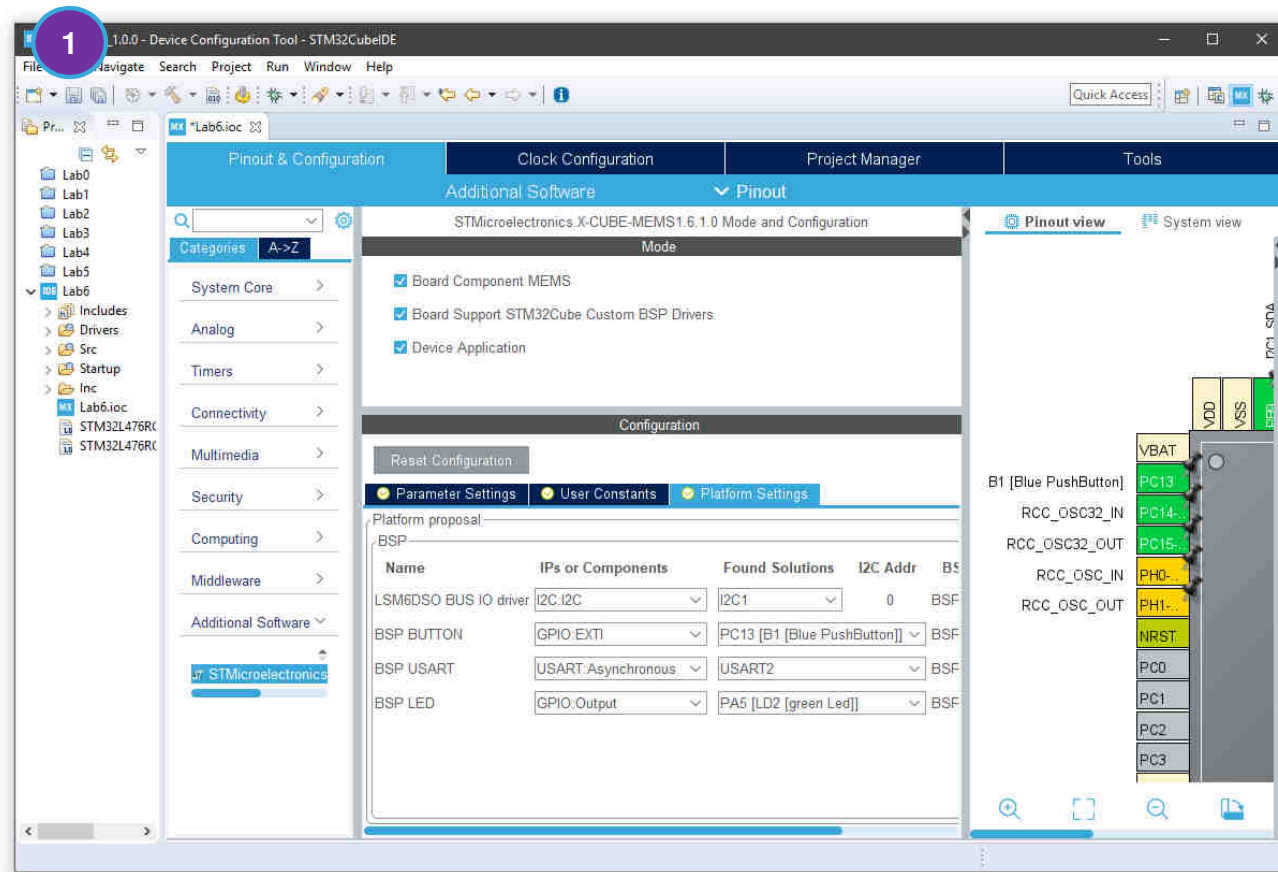
Lab6 – Save the Project

230

1. Click the save button



This action will generate the source code of this lab

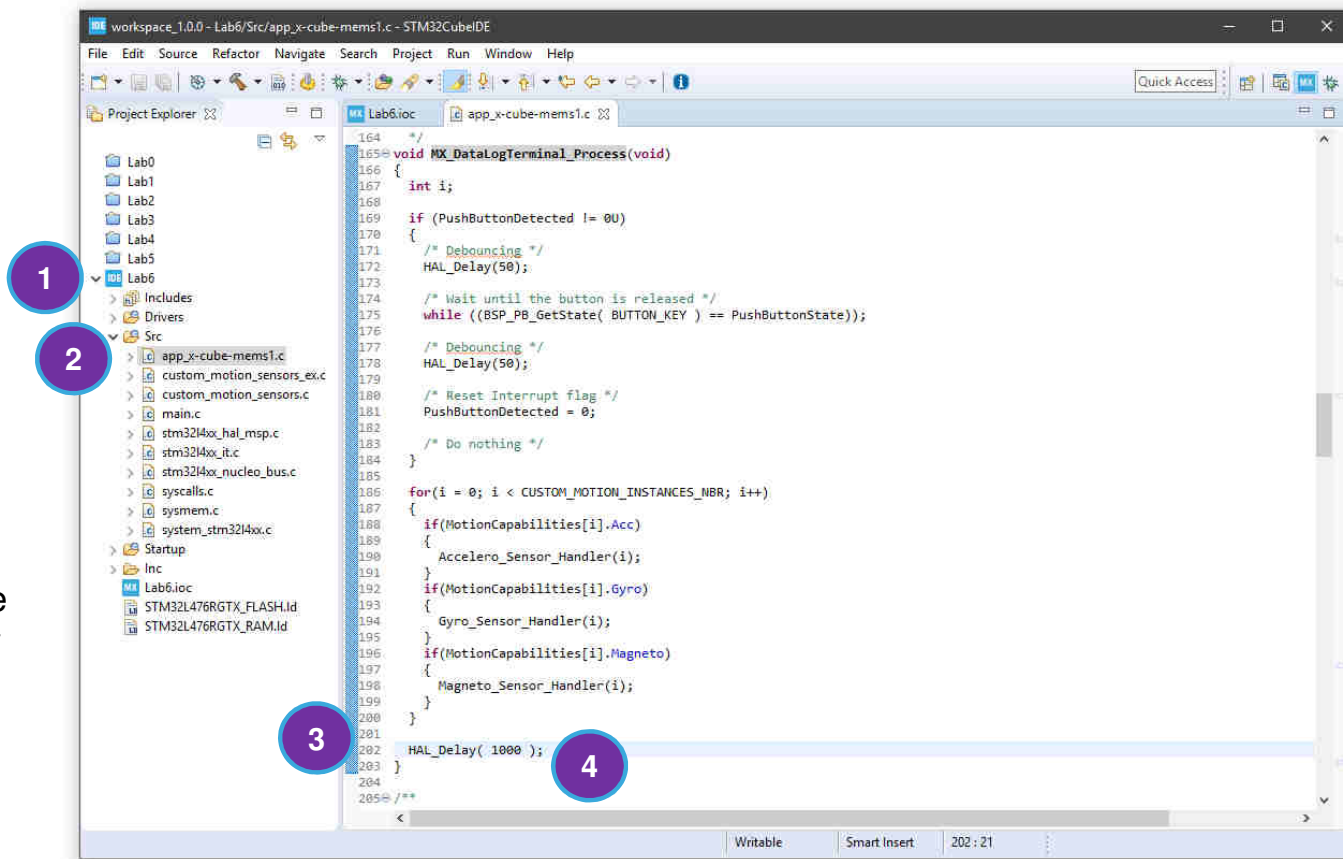


Lab6 – Code Editing 1/2

231

1. Expand **Src** in folder **Lab6**
2. Double click on **app_x-cube-mems1.c**
3. Go to line **#202**
4. Change it from **HAL_Delay(1000);** to **HAL_Delay(50);**

Note: Sensor ODR is 6667 Hz, meanwhile output on serial terminal is updated every 50 ms (20 Hz)



Lab6 – Code Editing 2/2

232

1. Go to line **#50** of file **app_x-cube-mems1.c**
2. Change it from
static uint8_t verbose = 1;
to
static uint8_t verbose = 0;

This modification will reduce the serial terminal output info to only RAW accelerometer and gyroscope data



```
workspace_1.0.0 - Lab6/Src/app_x-cube-mems1.c - STM32CubeIDE
File Edit Source Refactor Navigate Search Project Run Window Help
Lab6.ioc app_x-cube-mems1.c
/*
 * Limitations under the license.
 */
#ifdef __cplusplus
extern "C" {
#endif

/* Includes -----*/
#include "app_x-cube-mems1.h"
#include "main.h"
#include <stdio.h>

#include "custom_motion_sensors.h"
#include "lsm6dso_settings.h"
#include "stm32l4xx_nucleo.h"
#include "math.h"

/* Private typedef -----*/
typedef struct displayFloatToInt_s {
    int8_t sign; /* 0 means positive, 1 means negative*/
    uint32_t out_int;
    uint32_t out_dec;
} displayFloatToInt_t;

/* Private define -----*/
#define MAX_BUF_SIZE 256

/* Private variables -----*/
static volatile uint8_t PushButtonState = 0;
static uint8_t verbose = 0; /* 0: no output to UART terminal ON/OFF. */
static CUSTOM_MOTION_SENSOR_Capabilities_t MotionCapabilities[CUSTOM_MOTION_INSTANCES_NBR];
static char dataOut[MAX_BUF_SIZE];
static int32_t PushButtonState = GPIO_PIN_RESET;

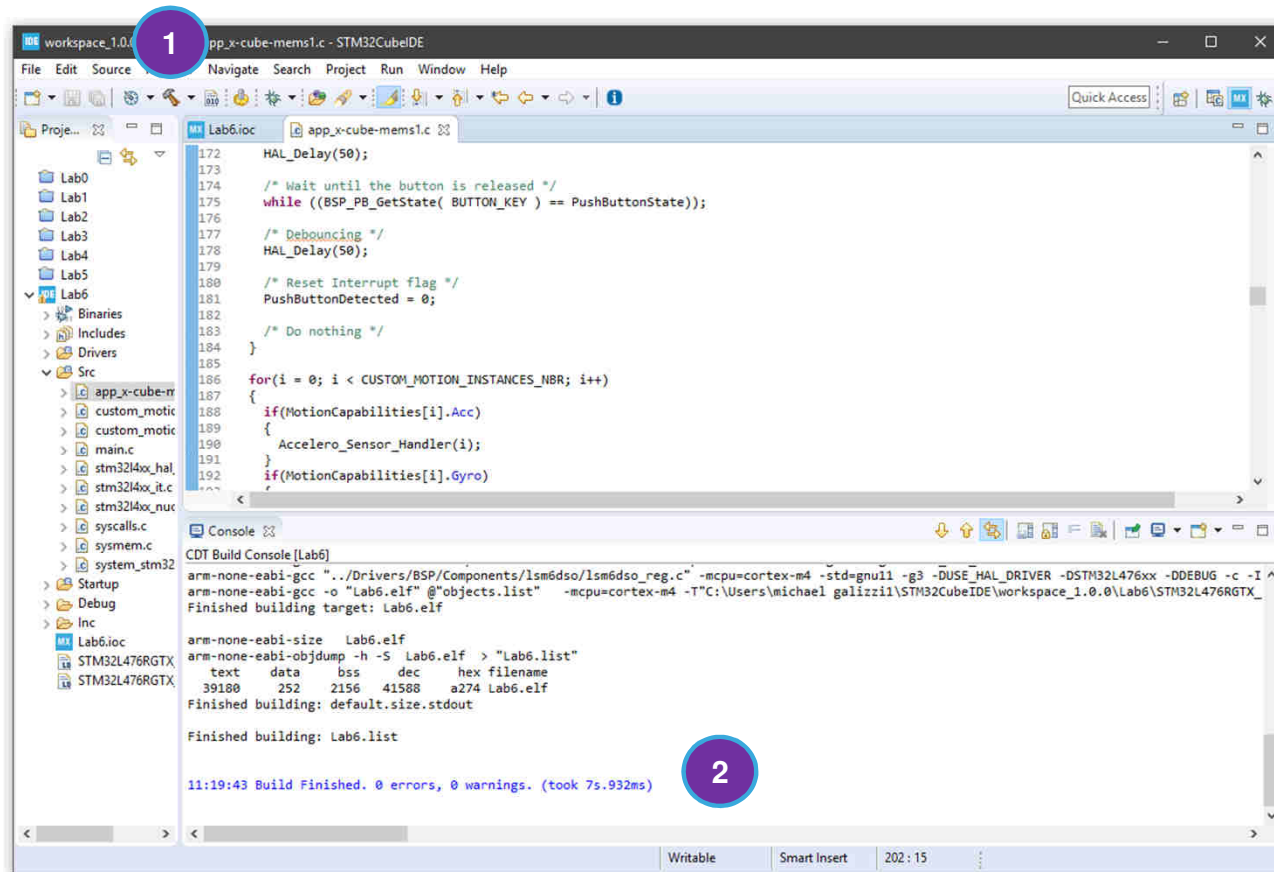
/* Private function prototypes -----*/
static void floatToInt(float in, displayFloatToInt_t *out_value, int32_t dec_prec);
static void Accelero_Sensor_Handler(uint32_t Instance);
static void Gyro_Sensor_Handler(uint32_t Instance);
static void Magneto_Sensor_Handler(uint32_t Instance);
static void MX_DataLogTerminal_Init(void);
static void MX_DataLogTerminal_Process(void);
```

Lab6 - Compiling

233

1. Click on the hammer  to begin compilation, or press **CTRL+B**

2. Compilation should terminate with 0 errors and 0 warning



```
workspace_1.0.0 - STM32CubeIDE
File Edit Source Navigate Search Project Run Window Help
Lab6.ioc app_x-cube-mems1.c
172 HAL_Delay(50);
173
174 /* Wait until the button is released */
175 while ((BSP_PB_GetState( BUTTON_KEY ) == PushButtonState));
176
177 /* Debouncing */
178 HAL_Delay(50);
179
180 /* Reset Interrupt flag */
181 PushButtonDetected = 0;
182
183 /* Do nothing */
184 }
185
186 for(i = 0; i < CUSTOM_MOTION_INSTANCES_NBR; i++)
187 {
188     if(MotionCapabilities[i].Acc)
189     {
190         Accelerometer_Handler(i);
191     }
192     if(MotionCapabilities[i].Gyro)
193     {
194         Gyro_Handler(i);
195     }
196 }
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198 }
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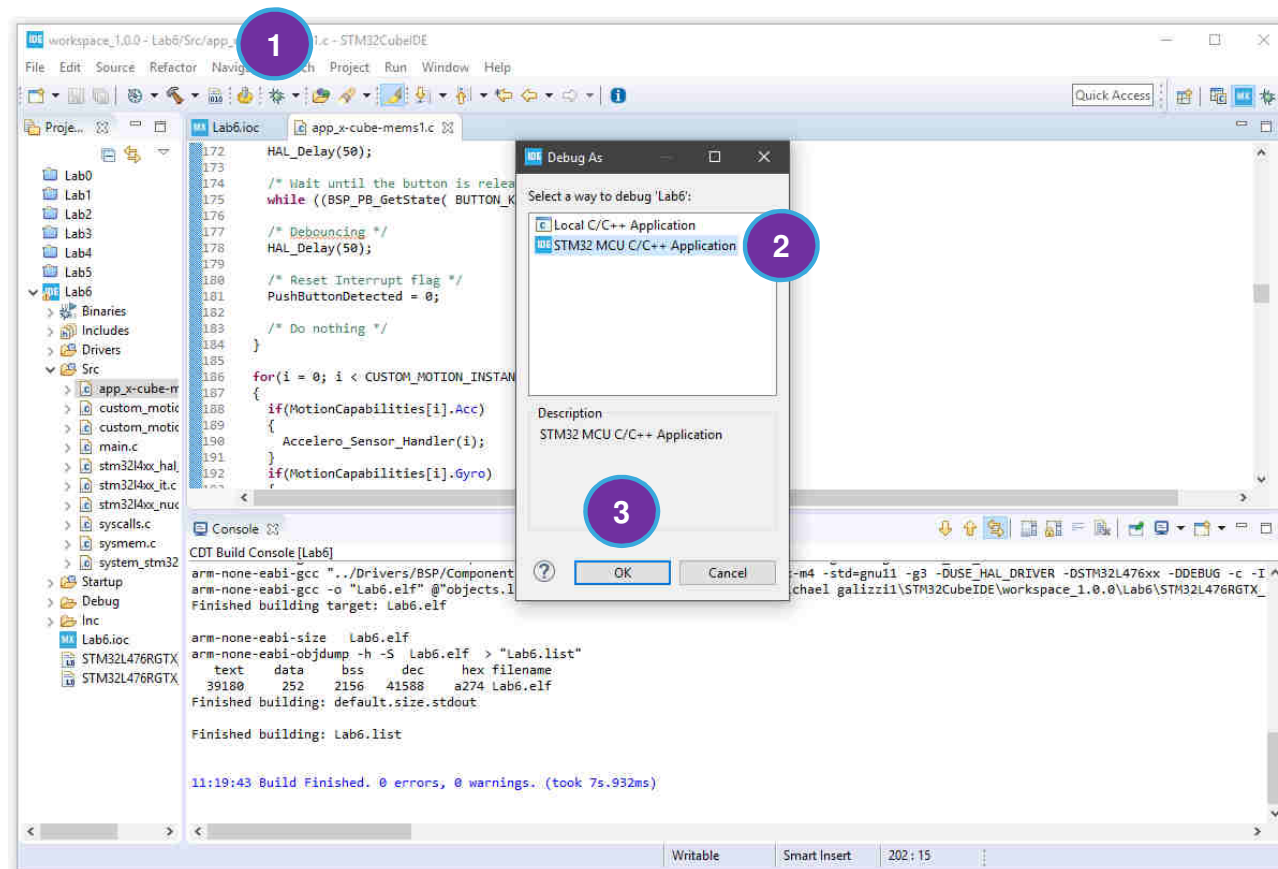
Lab6 - Debugging

234

1. Click on the bug  to begin debugging

2. Select **STM32 MCU C/C++ App**

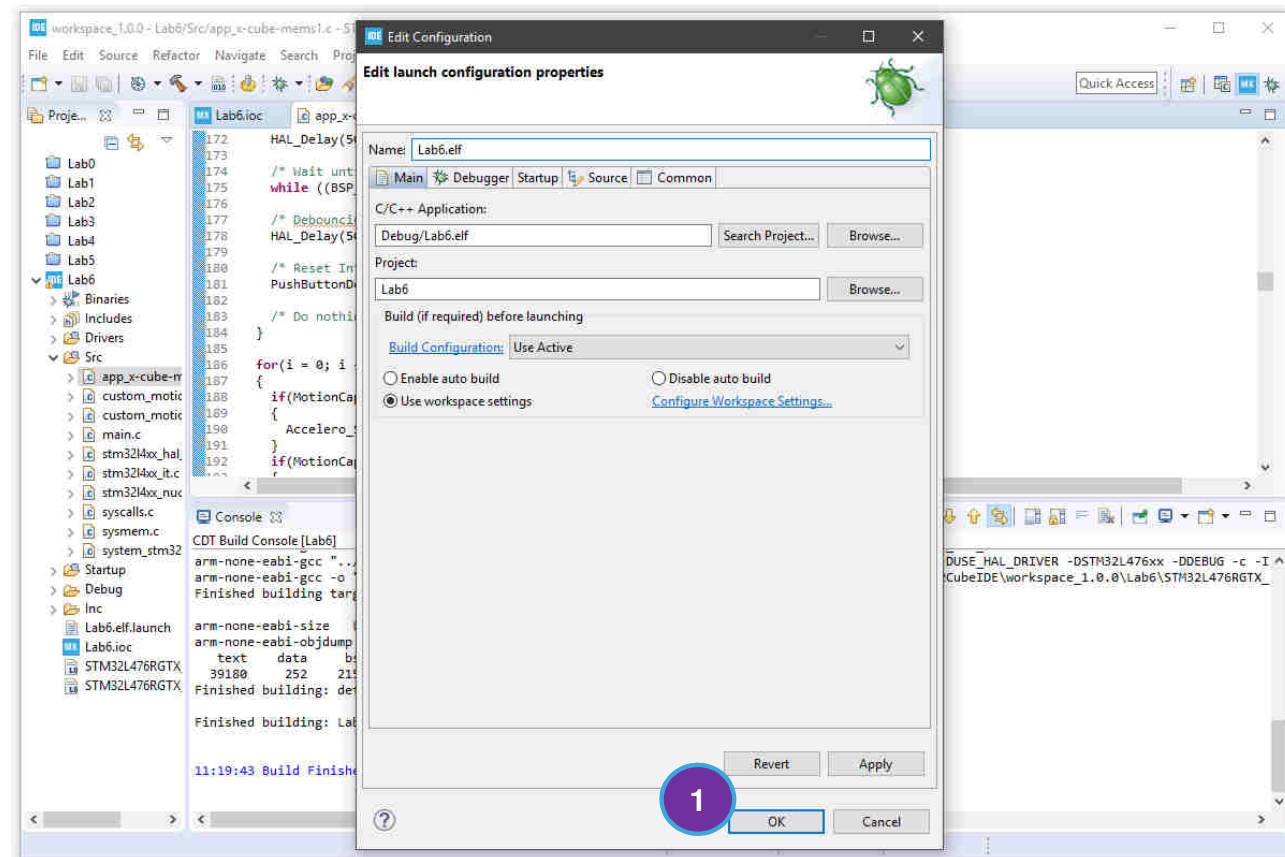
3. Click **OK**



Lab6 - Debugging

235

1. Click **OK**

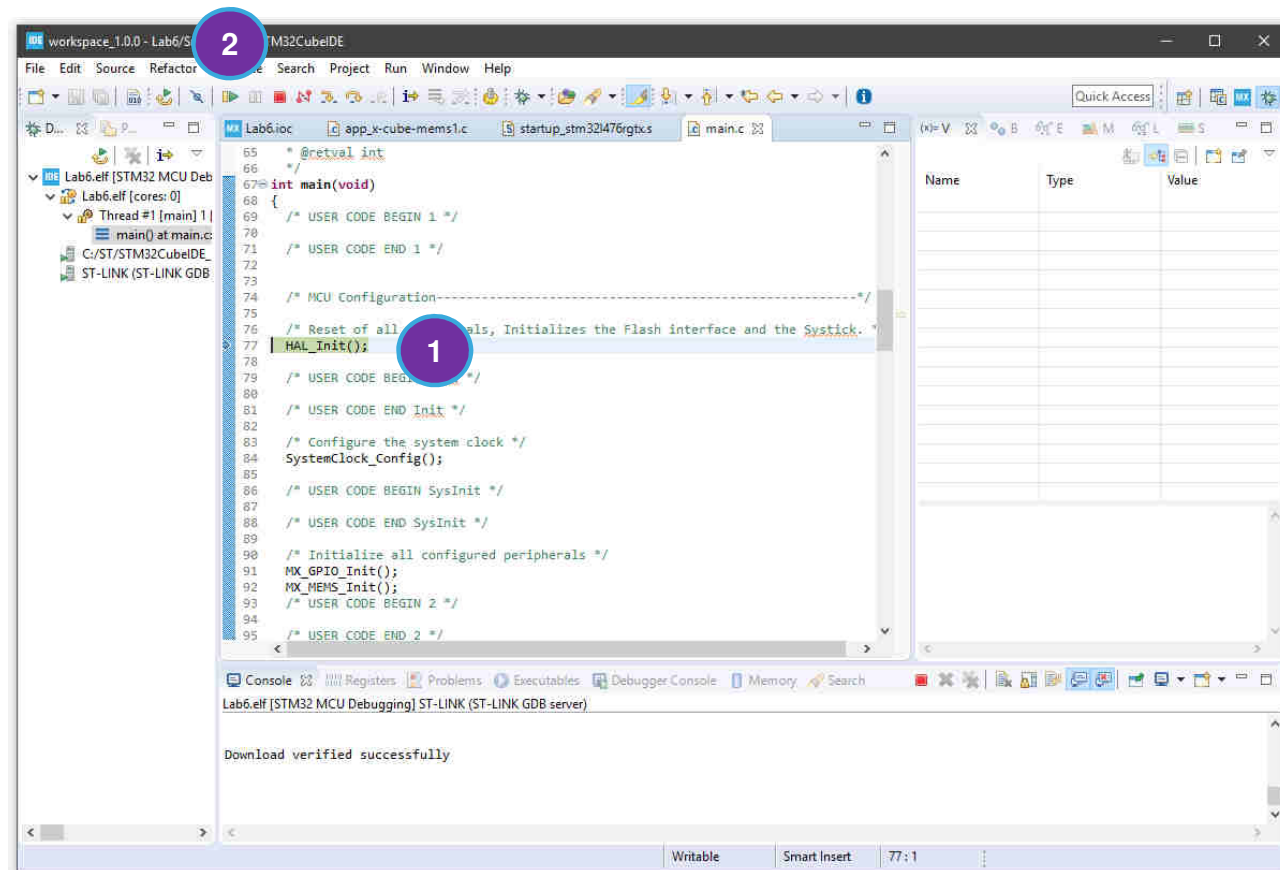


Lab6 - Debugging

236

1. Code start at the first line of the main function

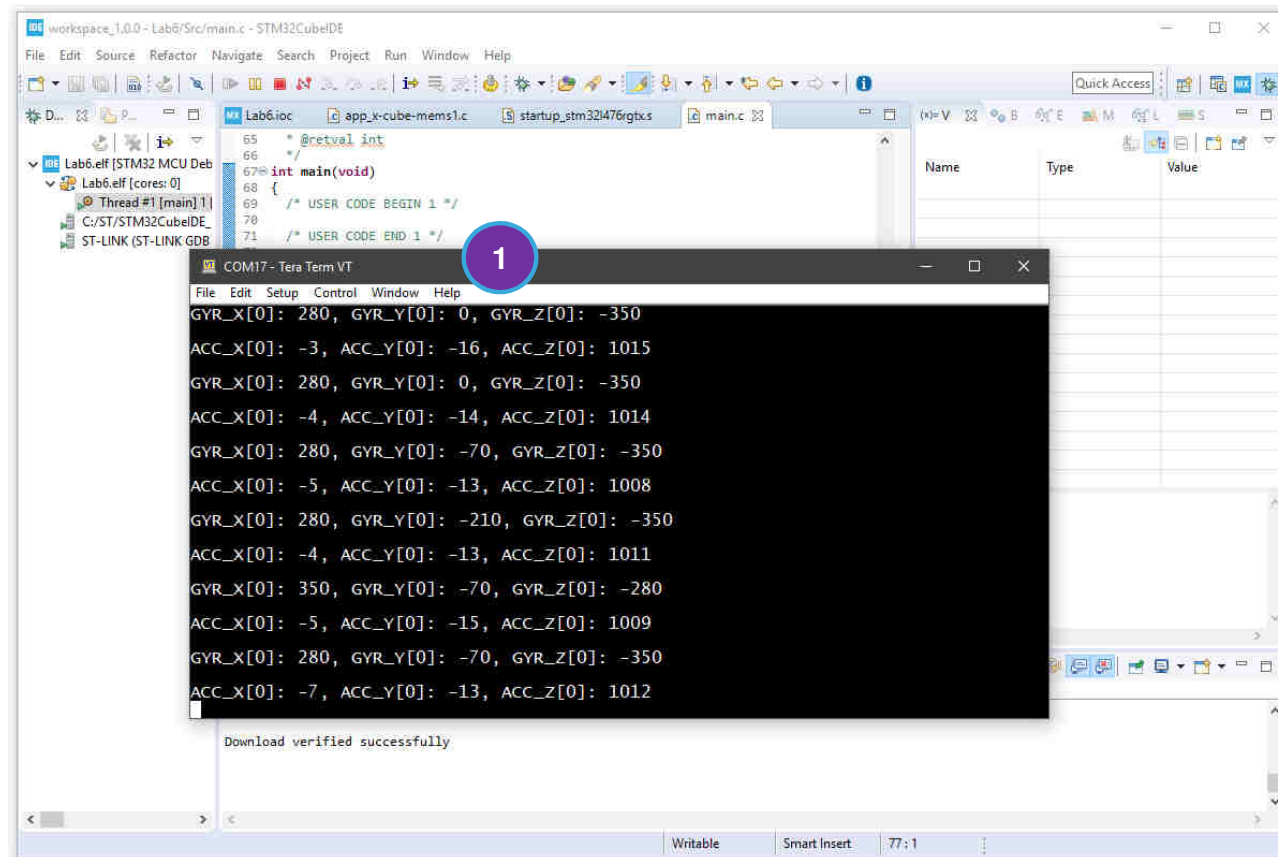
2. Click play  button to run the code



Lab6 - Debugging

237

1. Open Tera Term to view the output



The screenshot shows an IDE window with a C program and its output in Tera Term. The program is a simple test of sensor data. The output in Tera Term shows the values of GYR_X[0], GYR_Y[0], GYR_Z[0], ACC_X[0], ACC_Y[0], and ACC_Z[0] for 10 iterations. A red circle with the number 1 is placed over the Tera Term window title bar.

```
workspace_1.0.0 - Lab6/Src/main.c - STM32CubeIDE
File Edit Source Refactor Navigate Search Project Run Window Help
D:\... Lab6.ioc app_x-cube-mems1.c startup_stm32l476gtx.s main.c
Lab6.elf [STM32 MCU Deb]
  Lab6.elf [cores: 0]
    Thread #1 [main] 1
      C:/ST/STM32CubeIDE_
      ST-LINK (ST-LINK GDB)

65 * @retval int
66 *
67 int main(void)
68 {
69     /* USER CODE BEGIN 1 */
70
71     /* USER CODE END 1 */
```

COM17 - Tera Term VT

```
File Edit Setup Control Window Help
GYR_X[0]: 280, GYR_Y[0]: 0, GYR_Z[0]: -350
ACC_X[0]: -3, ACC_Y[0]: -16, ACC_Z[0]: 1015
GYR_X[0]: 280, GYR_Y[0]: 0, GYR_Z[0]: -350
ACC_X[0]: -4, ACC_Y[0]: -14, ACC_Z[0]: 1014
GYR_X[0]: 280, GYR_Y[0]: -70, GYR_Z[0]: -350
ACC_X[0]: -5, ACC_Y[0]: -13, ACC_Z[0]: 1008
GYR_X[0]: 280, GYR_Y[0]: -210, GYR_Z[0]: -350
ACC_X[0]: -4, ACC_Y[0]: -13, ACC_Z[0]: 1011
GYR_X[0]: 350, GYR_Y[0]: -70, GYR_Z[0]: -280
ACC_X[0]: -5, ACC_Y[0]: -15, ACC_Z[0]: 1009
GYR_X[0]: 280, GYR_Y[0]: -70, GYR_Z[0]: -350
ACC_X[0]: -7, ACC_Y[0]: -13, ACC_Z[0]: 1012

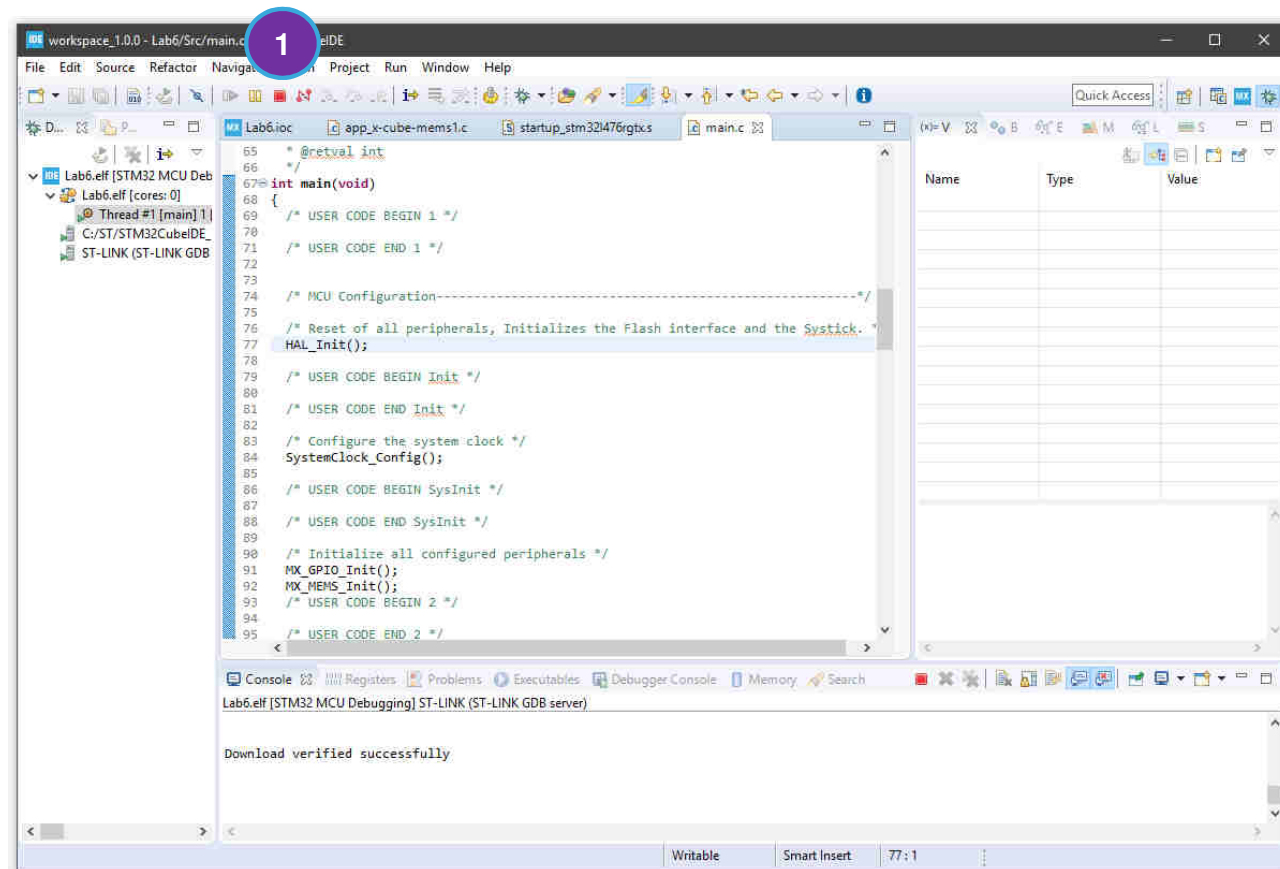
Download verified successfully
```

Writable Smart Insert 77:1

Lab6 - Debugging

238

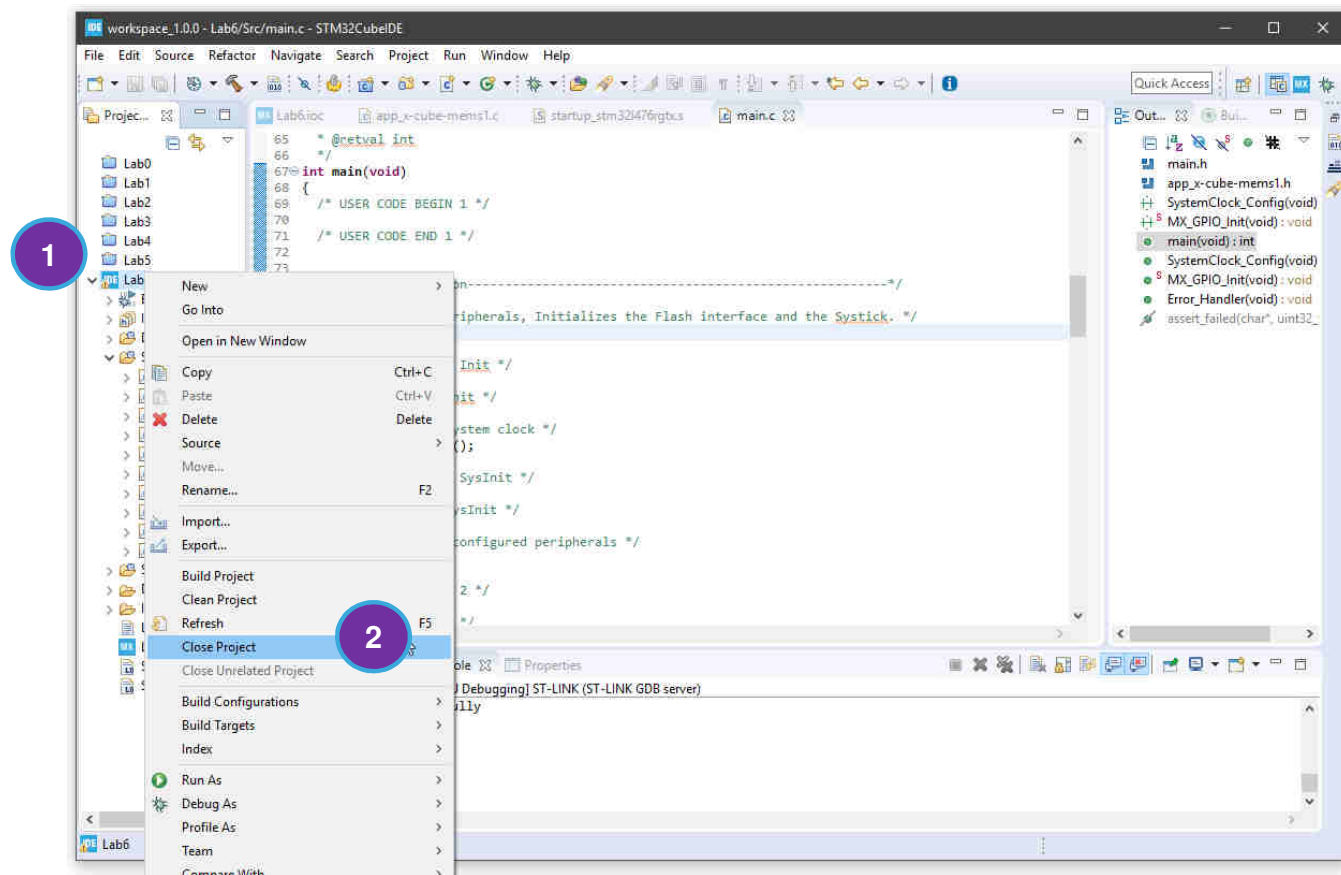
1. Click stop  button to interrupt the debugging



Lab6 – Closing the Project

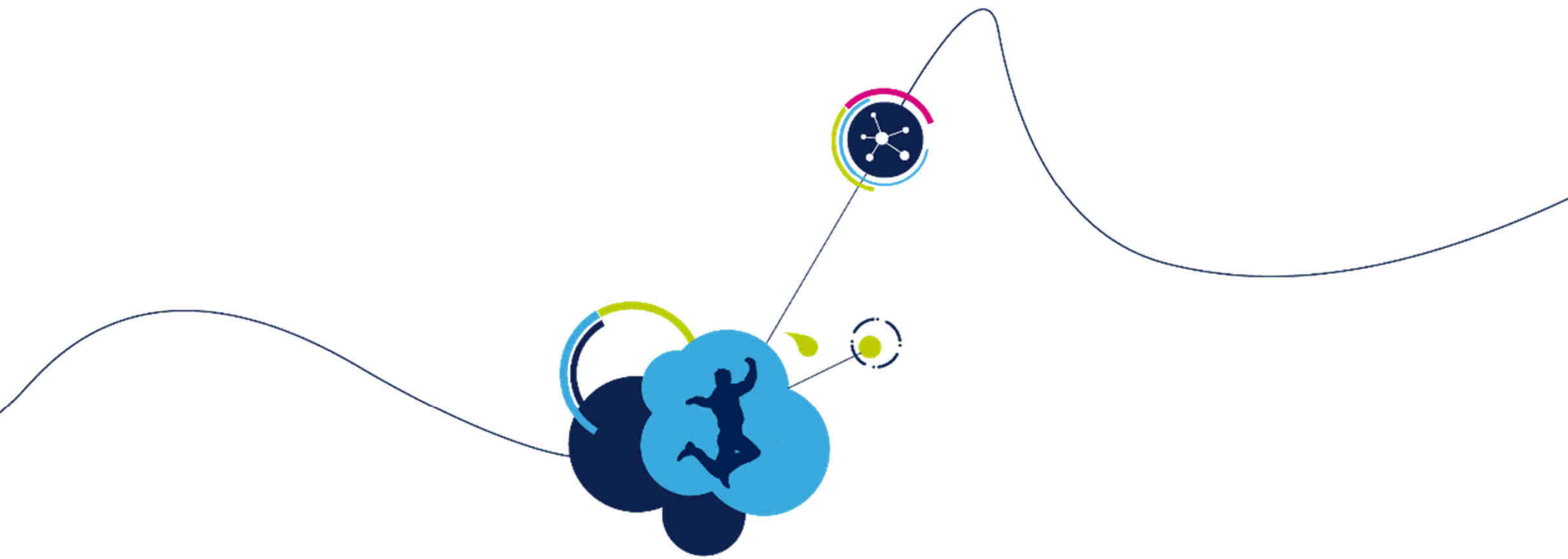
239

1. Right-Click on **Lab6** project
2. Click on **Close Project**



Thank You!

life.augmented

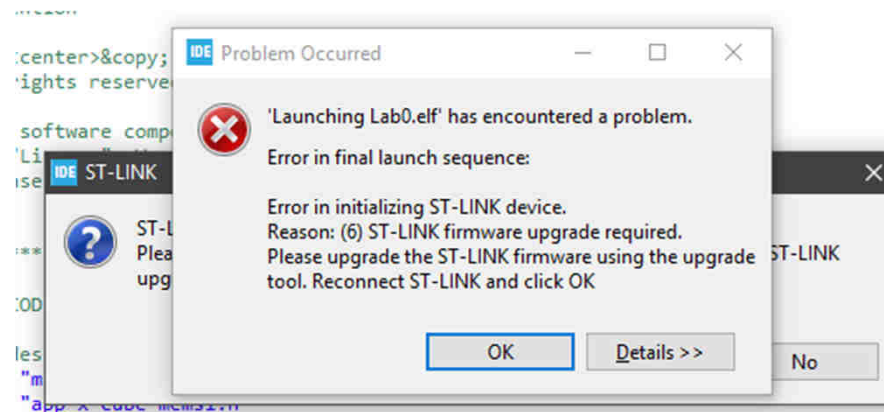


Troubleshooting

Common Issue #1

242

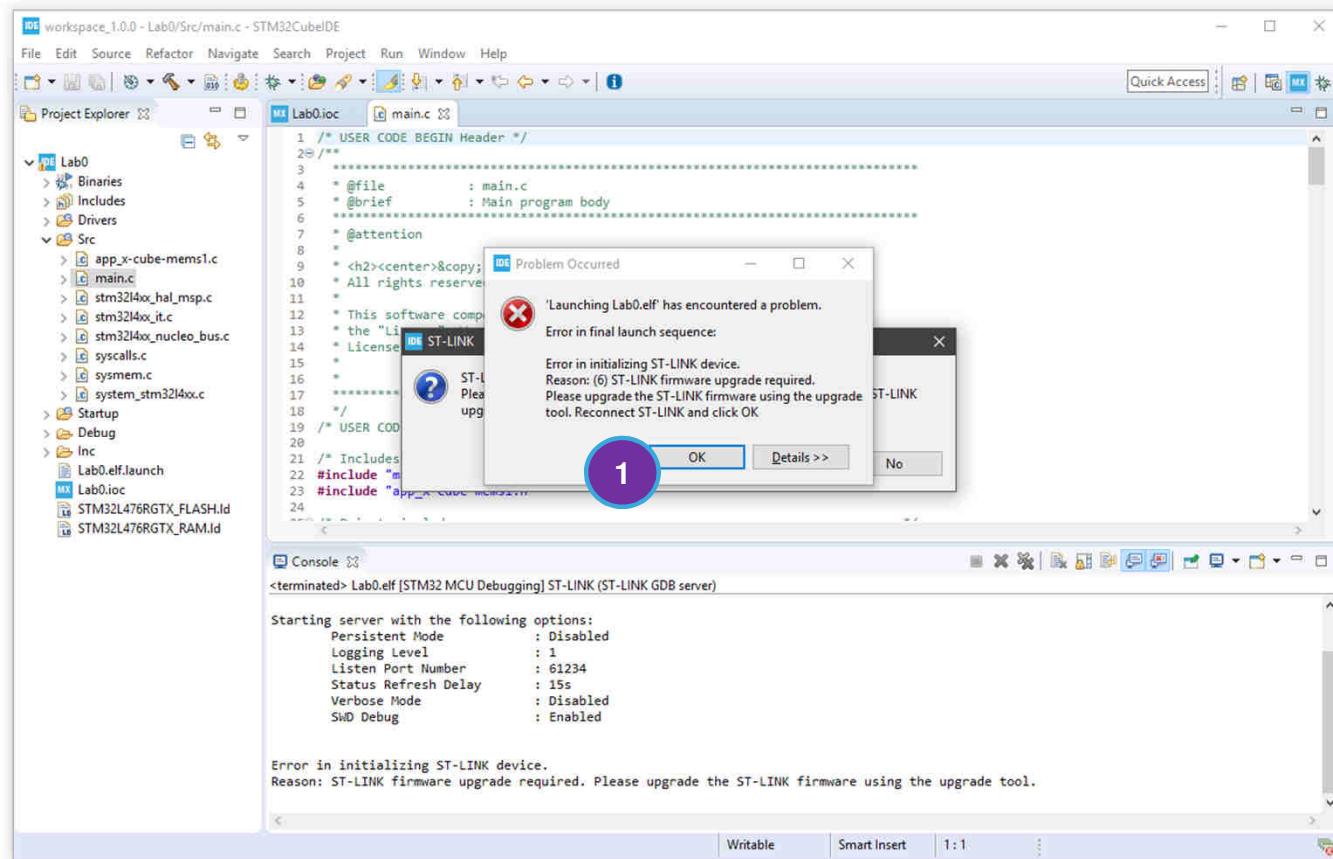
- *Description:* when debugging is launched by pressing , a **Problem Occurred** because ST-LINK need to be updated



Common Issue #1: Solution

243

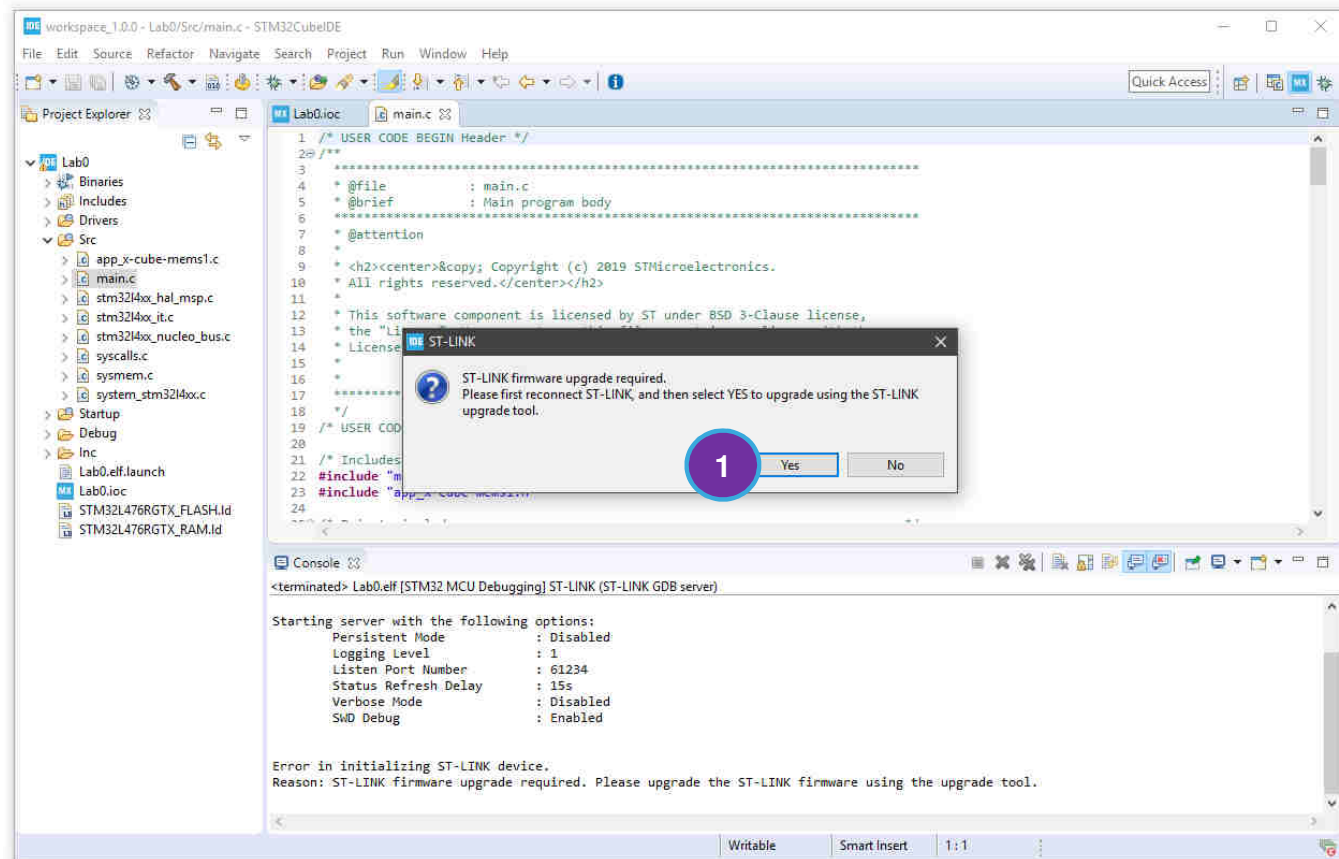
1. Click **OK** to run upgrade to latest firmware



Common Issue #1: Solution

244

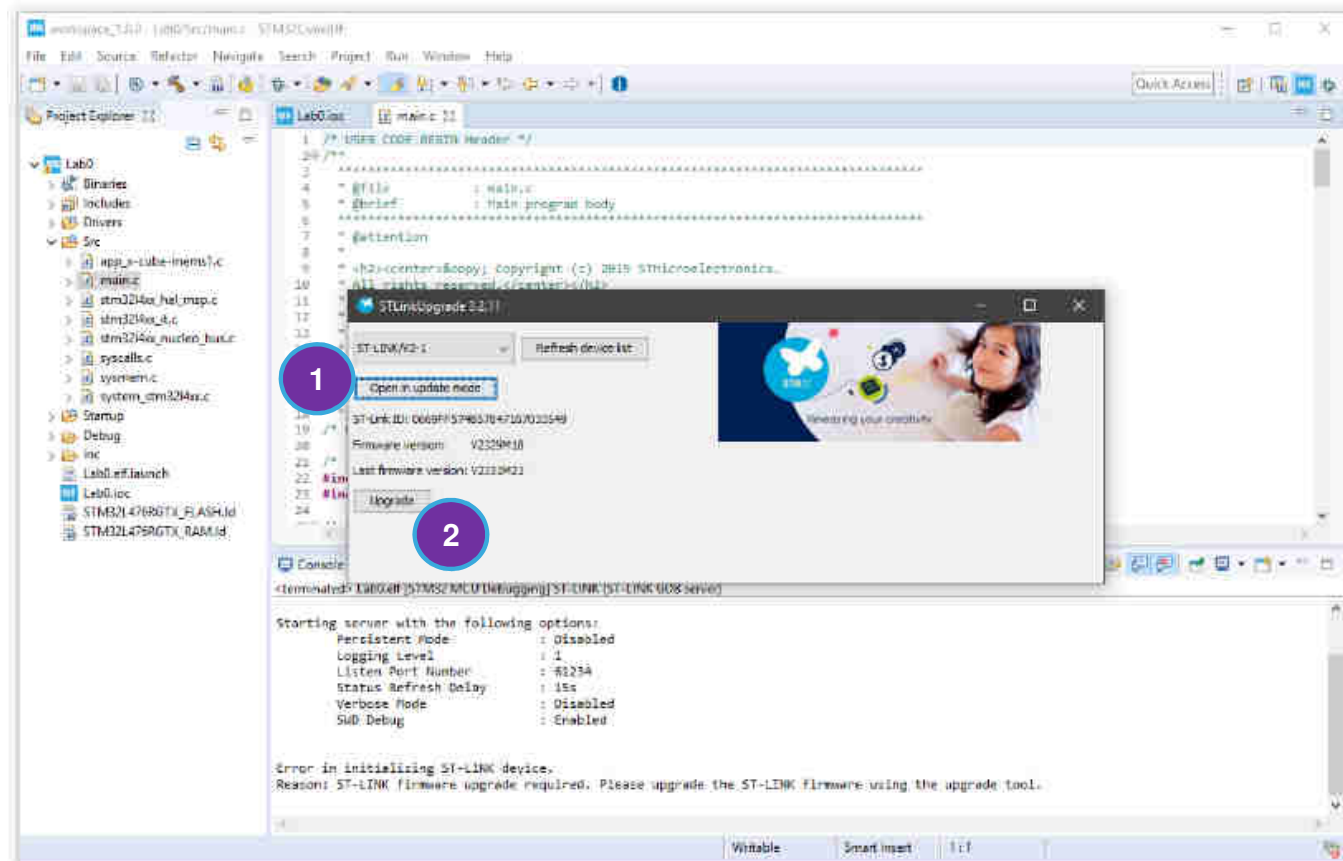
1. Click **Yes** when is asked to upgrade the ST-LINK



Common Issue #1: Solution

245

1. Click **Open in update mode** to force ST-LINK
2. Click on **Upgrade**

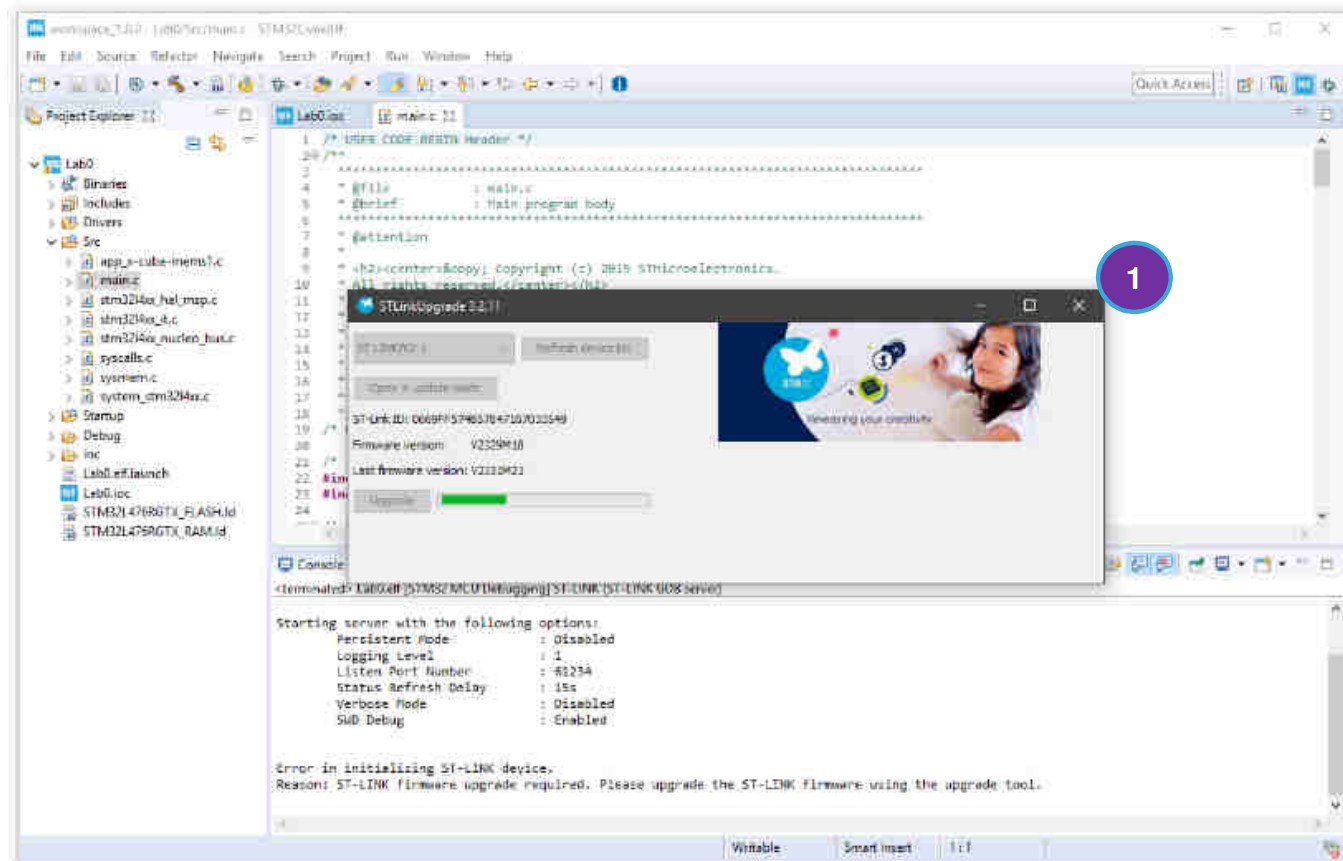


Common Issue #1: Solution

246


Wait until update is finished and then close the window.

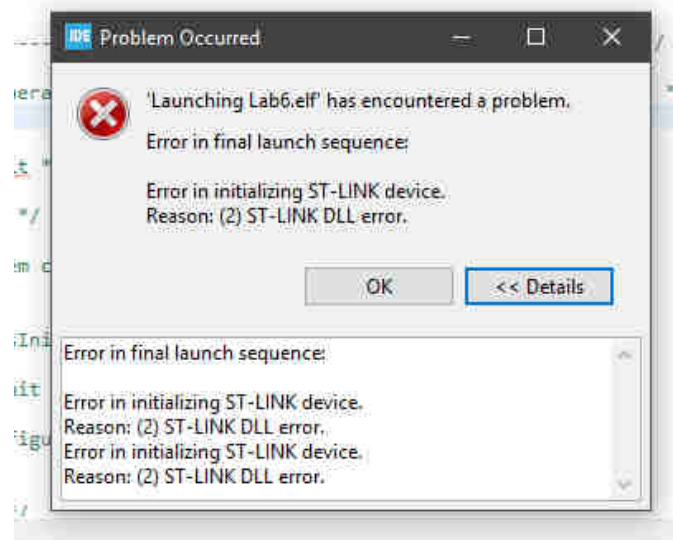
1. Click on **X** when finished



Common Issue #2

247

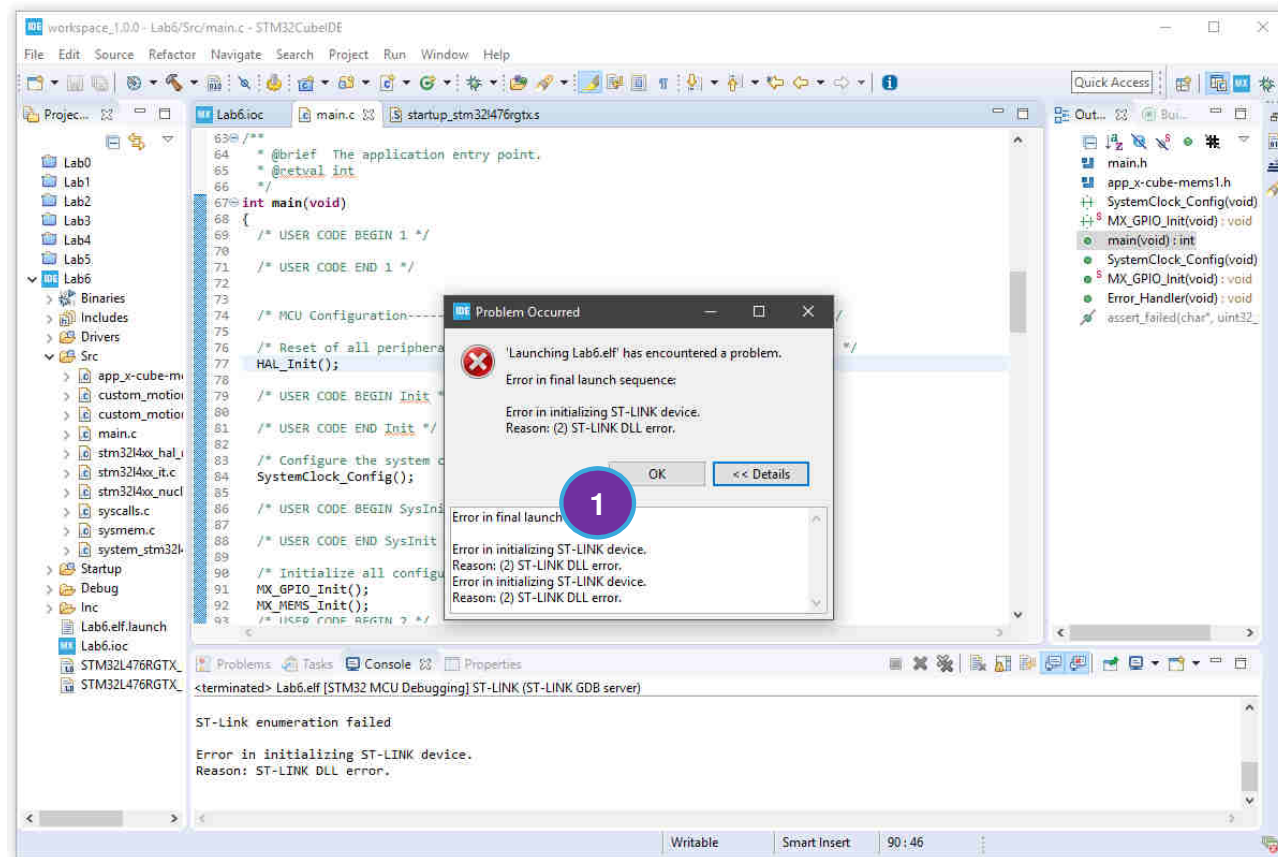
- *Description:* when debugging is launched by pressing , a **Problem Occurred** because ST-LINK is not detected even if it is plugged correctly to the PC



Common Issue #2: Solution

248

1. Click **OK** and proceed to install ST-LINK driver



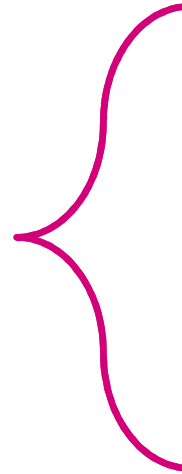
Common Issue #2: Solution

249

1. Extract the archive **en.stsw-link009.zip** located in **C:\X-CUBE-MEMS1_HandsOn\Drivers**
2. Run installer for your PC architecture (32bit or 64bit)



en.stsw-link009.zip



amd64
x86
dpinst_amd64.exe
dpinst_x86.exe
readme.txt
stlink_bridge_winusb.inf
stlink_dbg_winusb.inf
stlink_VCP.inf
stlink_winusb_install.bat
stlinkbridgewinusb_x64.cat
stlinkbridgewinusb_x86.cat
stlinkdbgwinusb_x64.cat
stlinkdbgwinusb_x86.cat
stlinkvcp_x64.cat
stlinkvcp_x86.cat

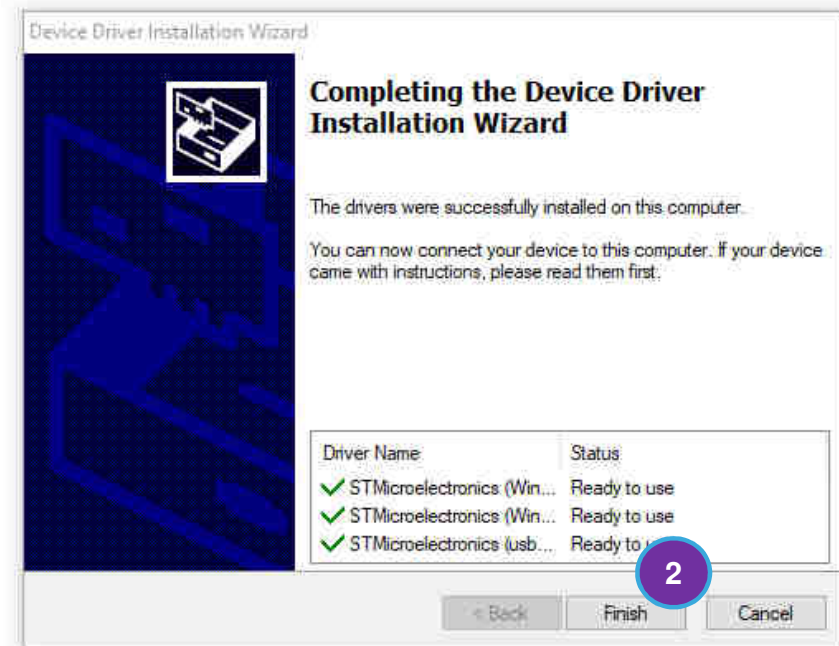
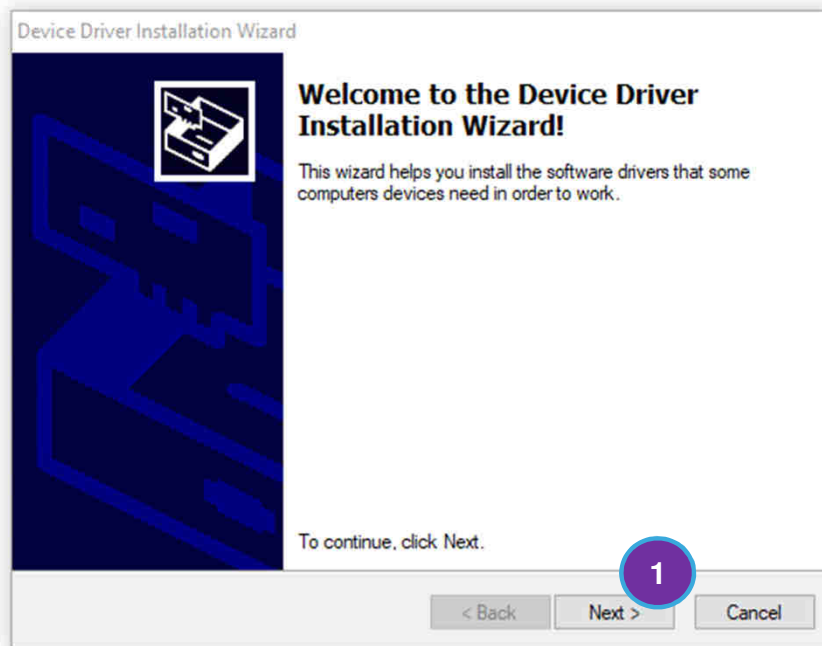
2



Common Issue #2: Solution


250

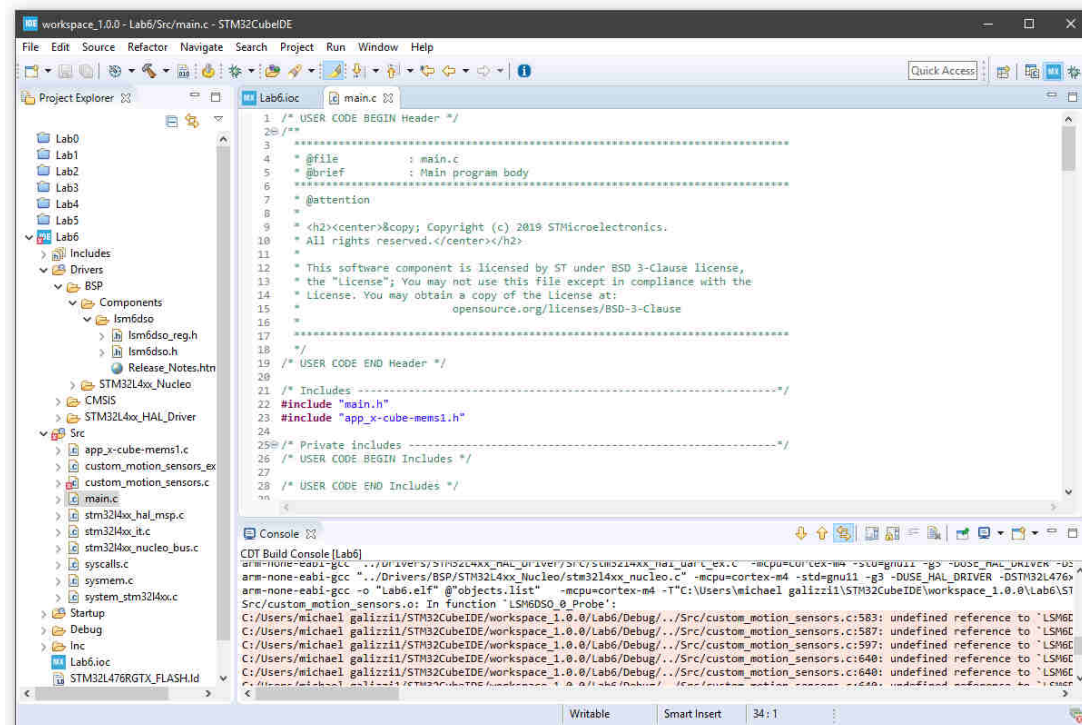
1. Click **Next >**
2. Click **Finish**



Common Issue #3

251

- *Description:* regenerating the code by saving the project  after modify the .ioc file may lead to some missed source file inclusion and compilation will fails.



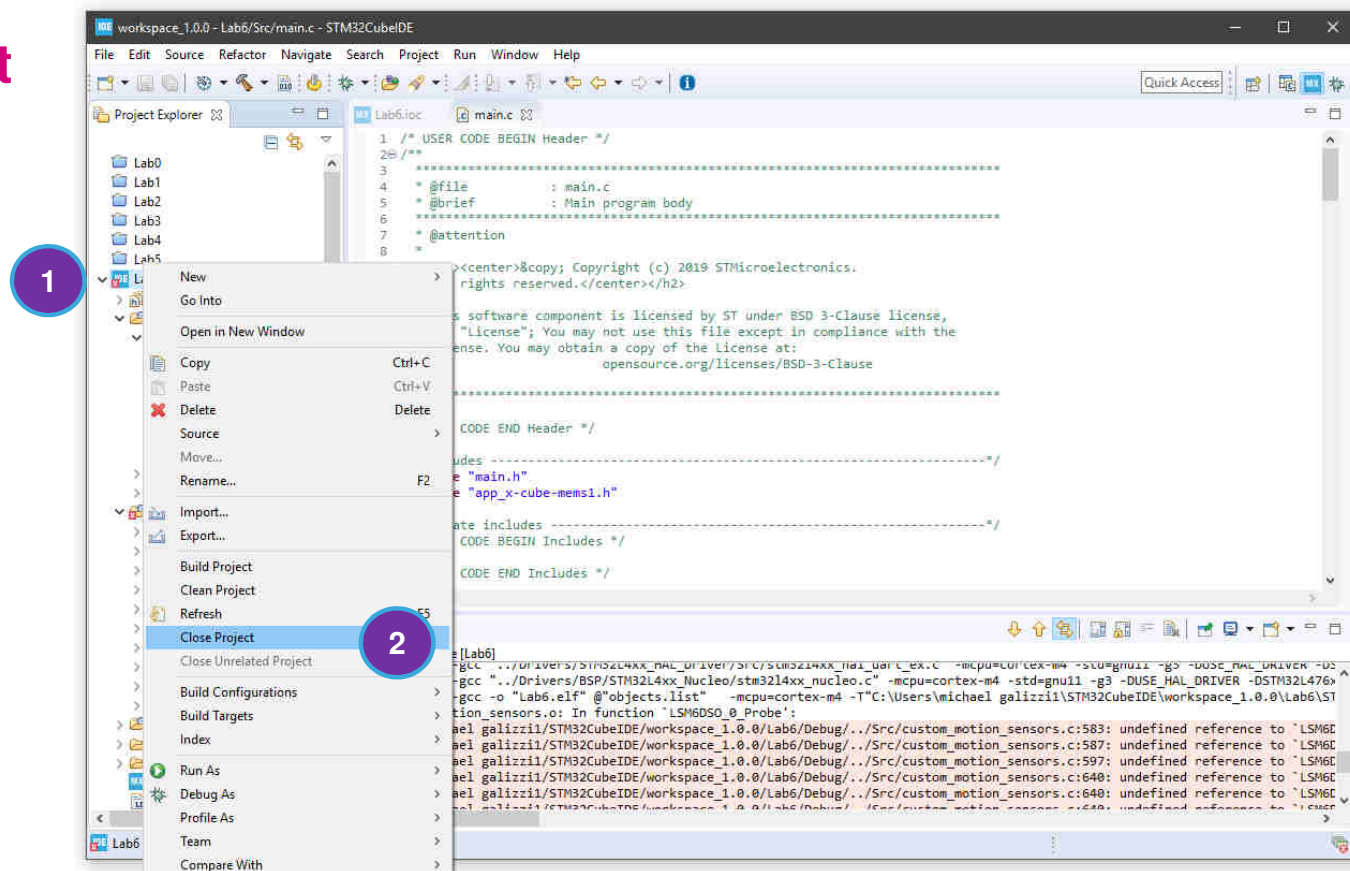
```
1 /* USER CODE BEGIN Header */
2 /**
3  * @file
4  * @brief : Main program body
5  * @attention
6  *
7  * <h2><center>&copy; Copyright (c) 2019 STMicroelectronics.
8  * All rights reserved.</center></h2>
9  *
10  * This software component is licensed by ST under BSD 3-Clause license,
11  * the "License"; You may not use this file except in compliance with the
12  * License. You may obtain a copy of the license at:
13  * opensource.org/licenses/BSD-3-Clause
14  */
15 /* USER CODE END Header */
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Common Issue #3: Solution

252

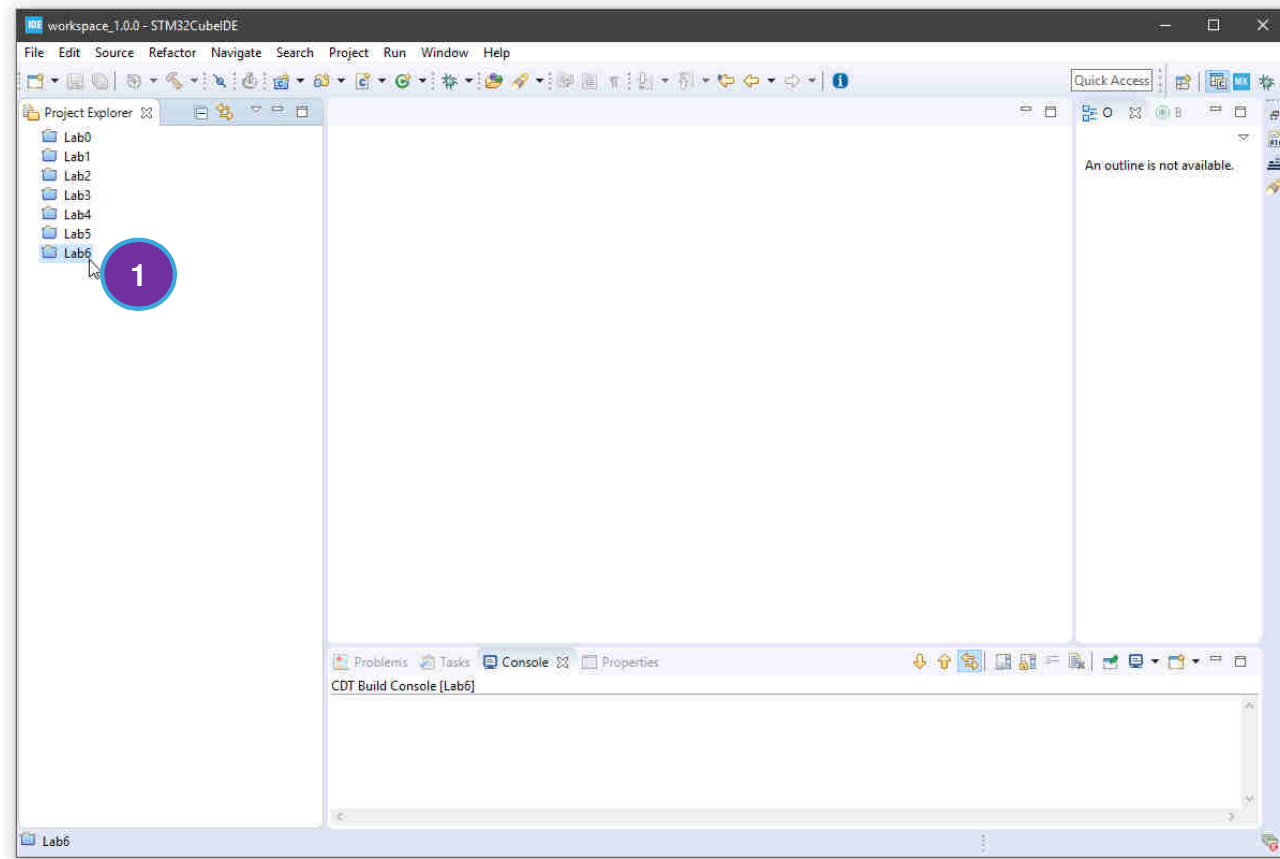
1. Right click on the project
2. Click on **Close Project**



Common Issue #3: Solution

253

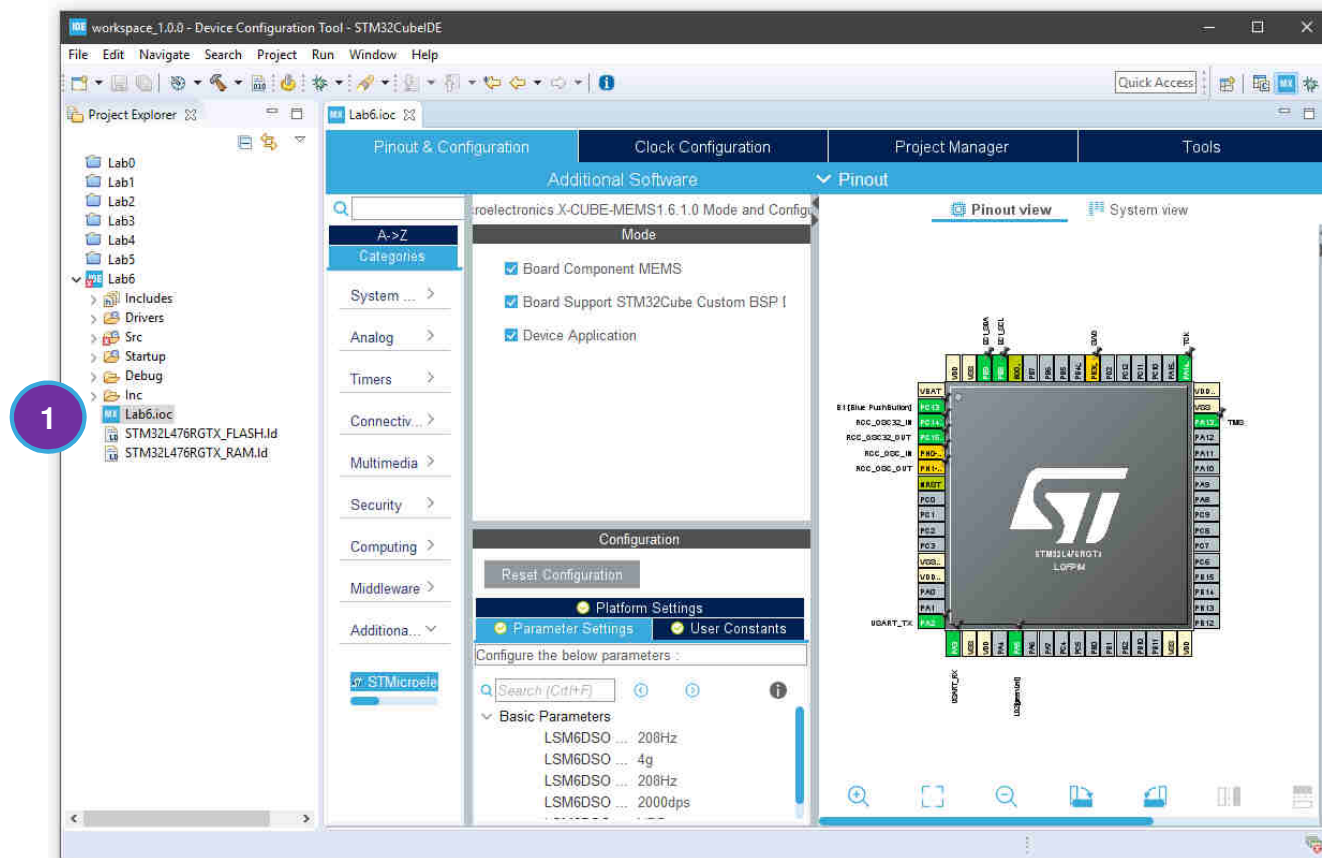
1. Double click the project to open it back



Common Issue #3: Solution


254

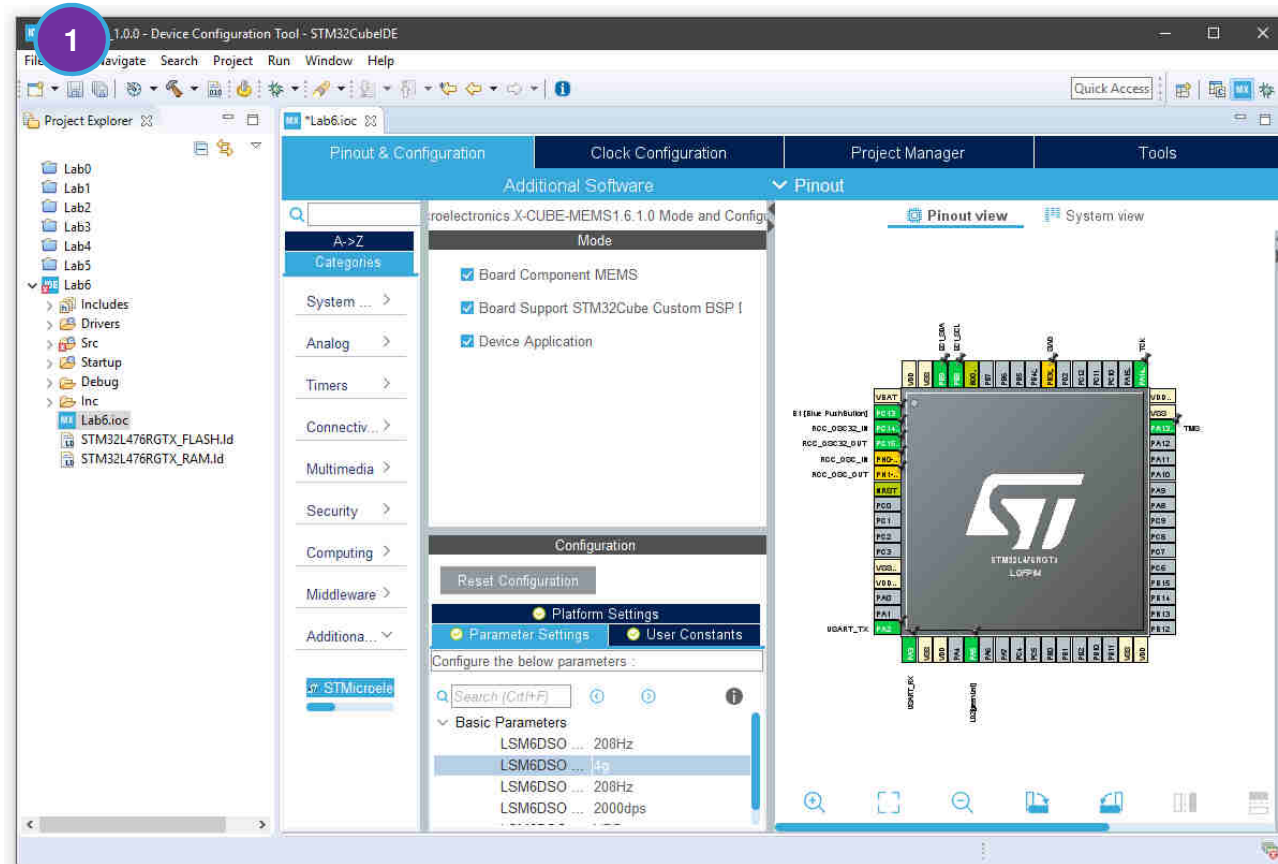
1. **Open the .ioc** file and modify something in the project in order that is possible to save it again



Common Issue #3: Solution

255

1. Save the project by clicking on  At this point included files will be restored correctly

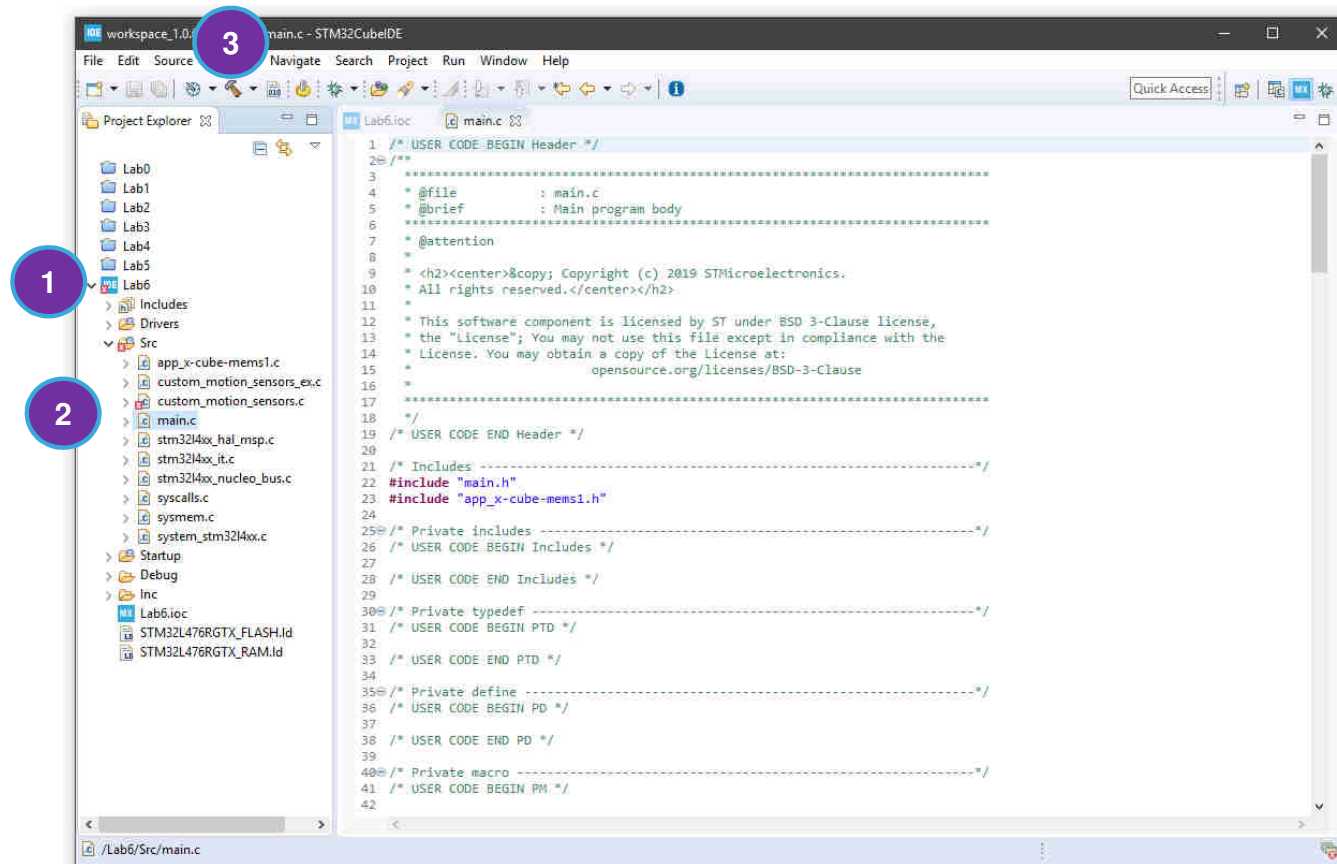


Common Issue #3: Solution

256

1. Expand **Src** folder and open **main.c**

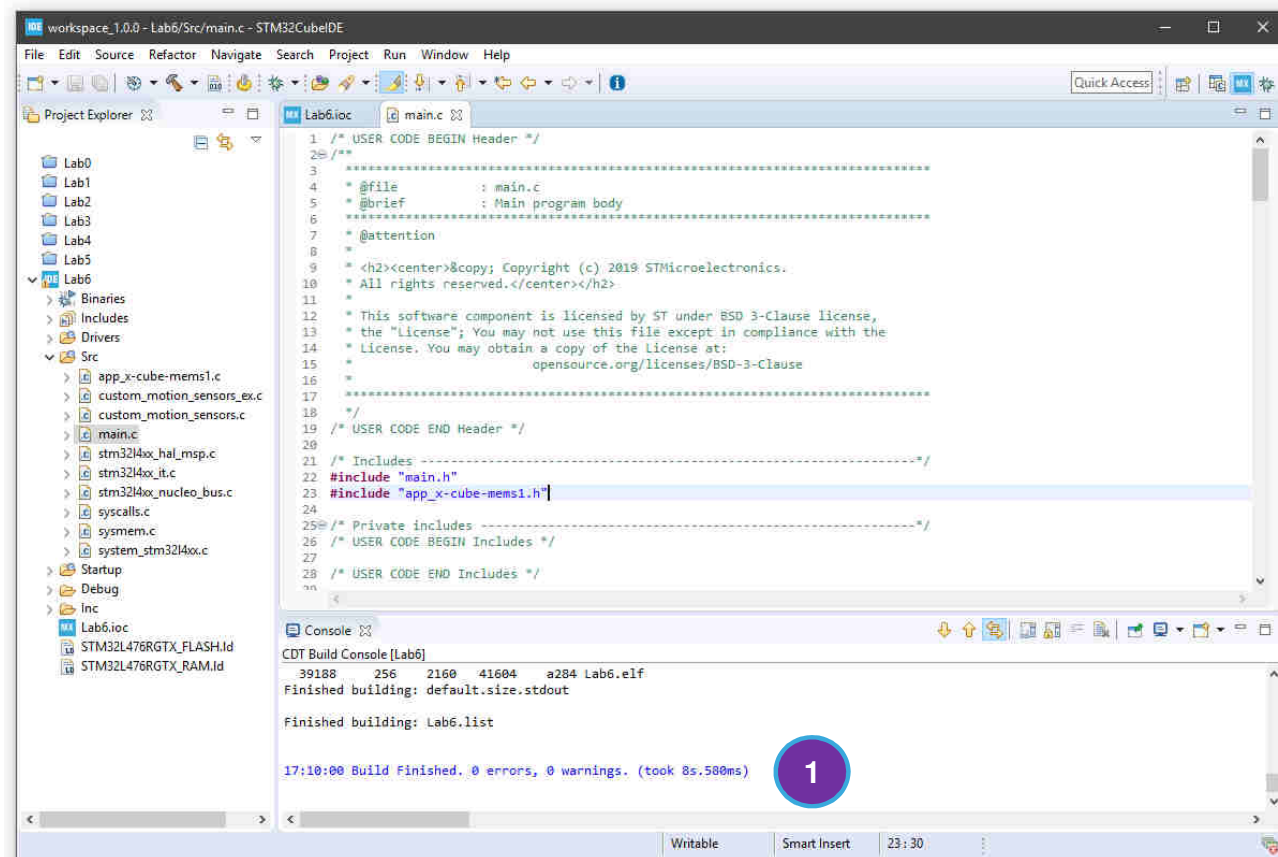
2. Compile by clicking on



Common Issue #3: Solution

257

1. Compilation should now terminate without warnings/errors



A1

258



Backup: How to Download and Install sw

Tools from the Web

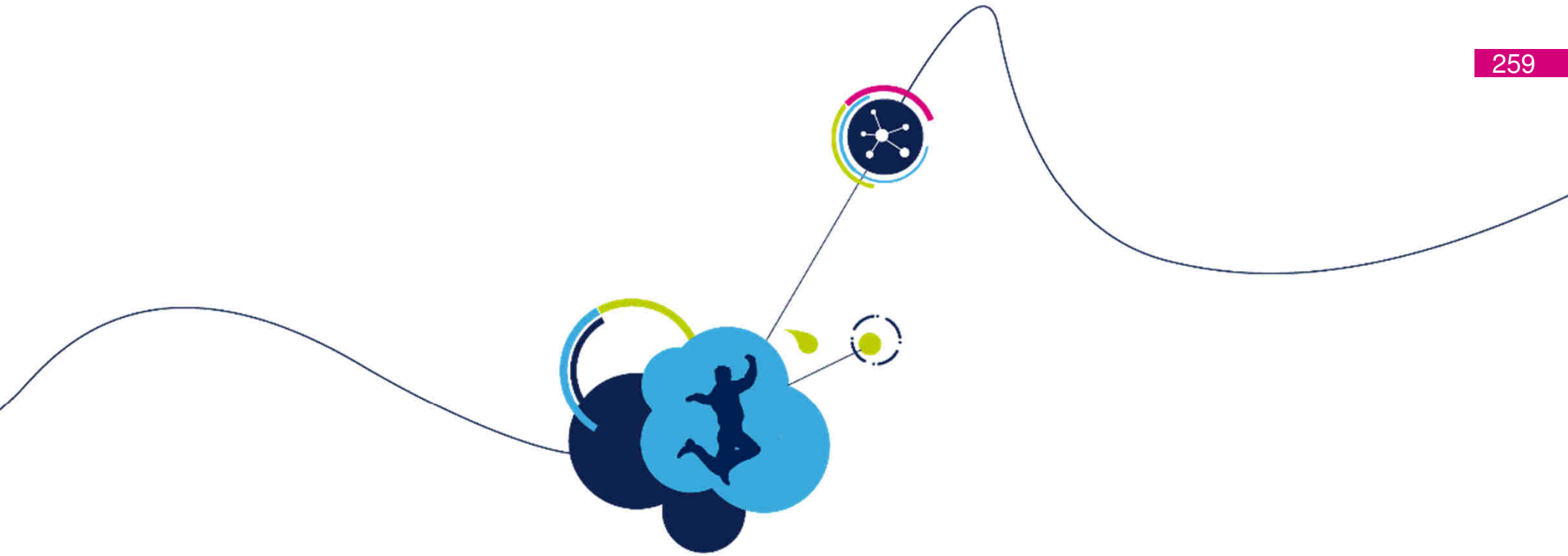
A1

Title Length issue:

1- Shorten title or use 2 lines

2- Call the macro: B_TOOL_FixTitle_slide()

Author, 8/27/2019

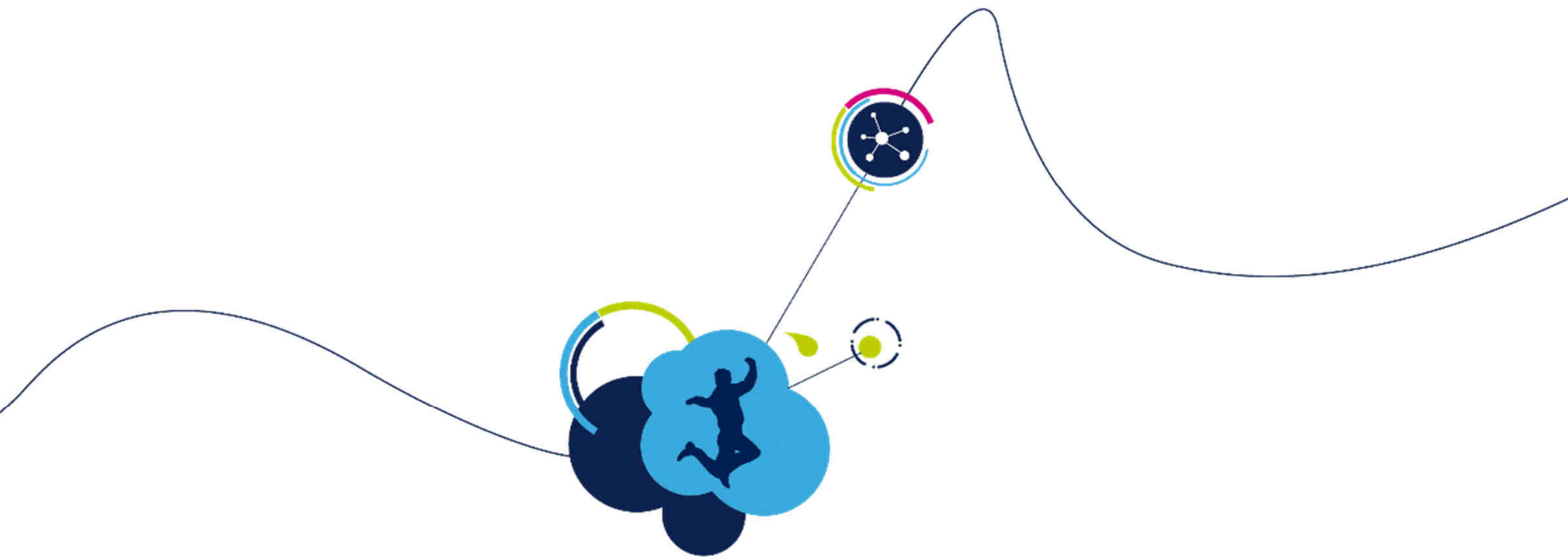


Required HW & SW

Required HW & SW

260

- **Laptop with USB type A**
- **64 bit OS** Win (7, 10), MacOS, Linux (Generic, Debian, RPM)
 - Virtual Machine is also OK (example: Parallel, VM Fusion...)
 - **Administration rights** are required for SW tools installation
- **Terminal emulator**
 - **TeraTerm** under Windows is OK, download from <https://ttssh2.osdn.jp/index.html.en>
 - **Serial COM port settings: 115200 bps, 8N1, no flow control**
- **SW tools from STMicroelectronics installed**
 - **STM32CubeIDE** 1.0.2 integrated development environment, download from www.st.com
You will need to create a **my.st.com** account.
 - **X-Cube-MEMS1** 6.2.0 software package extension for MEMS sensors, download from STM32CubeIDE after installation (see next slides)

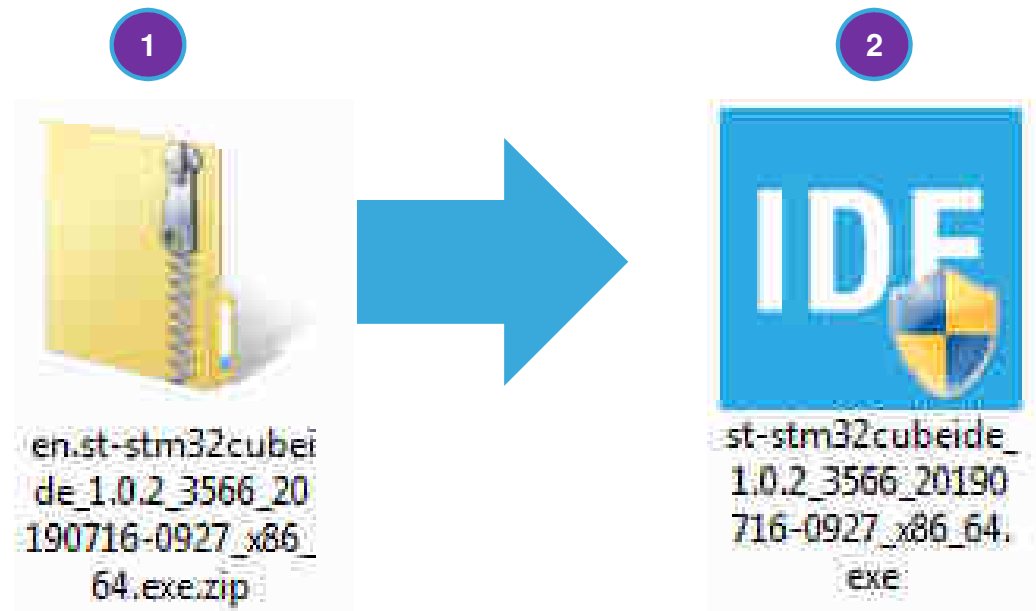


STM32CubeIDE Installation

STM32CubeIDE Installation

262

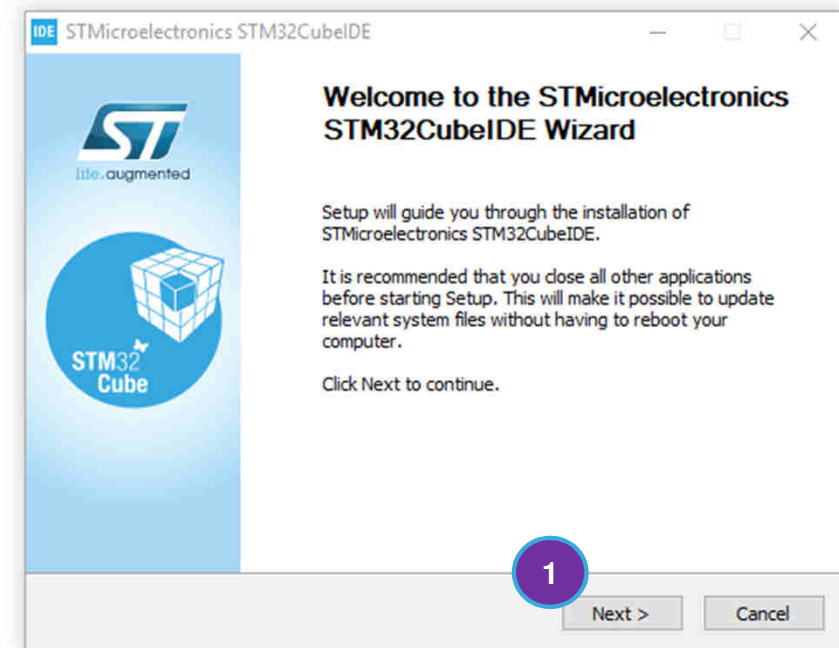
1. Go to www.st.com and download the zip package **STM32CubeIDE**
2. Unzip and run the installer



STM32CubeIDE Installation

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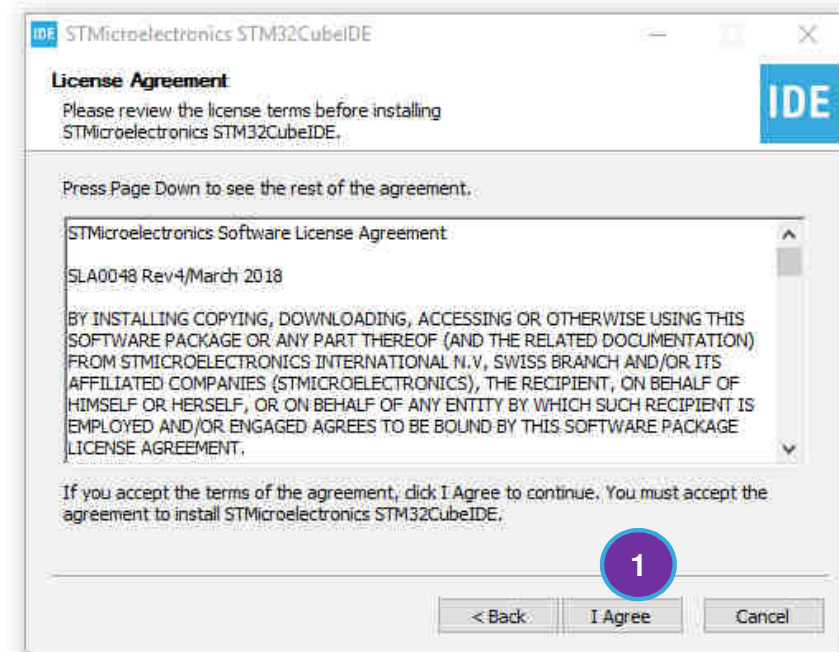
1. Click **Next >**



STM32CubeIDE Installation

264

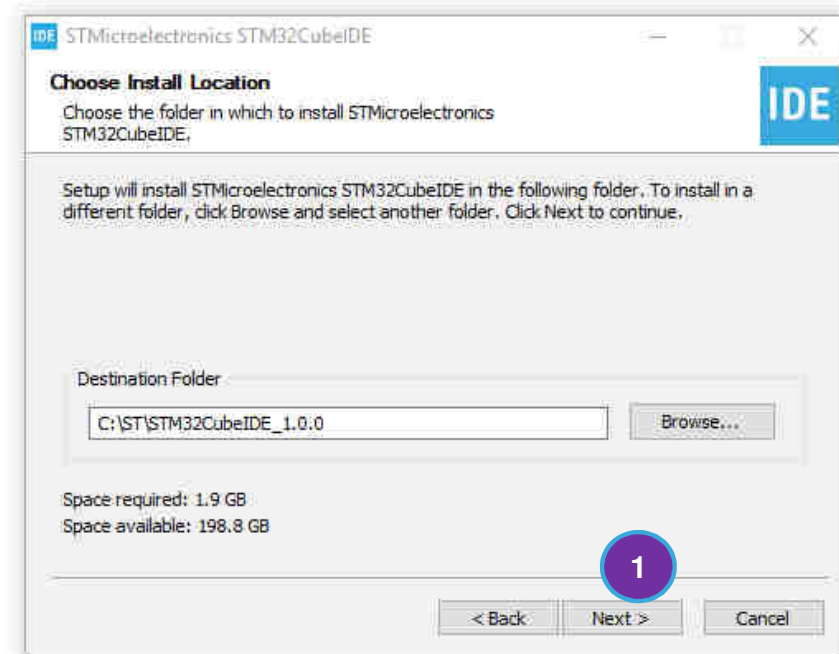
1. Click **I Agree**



STM32CubeIDE Installation

265

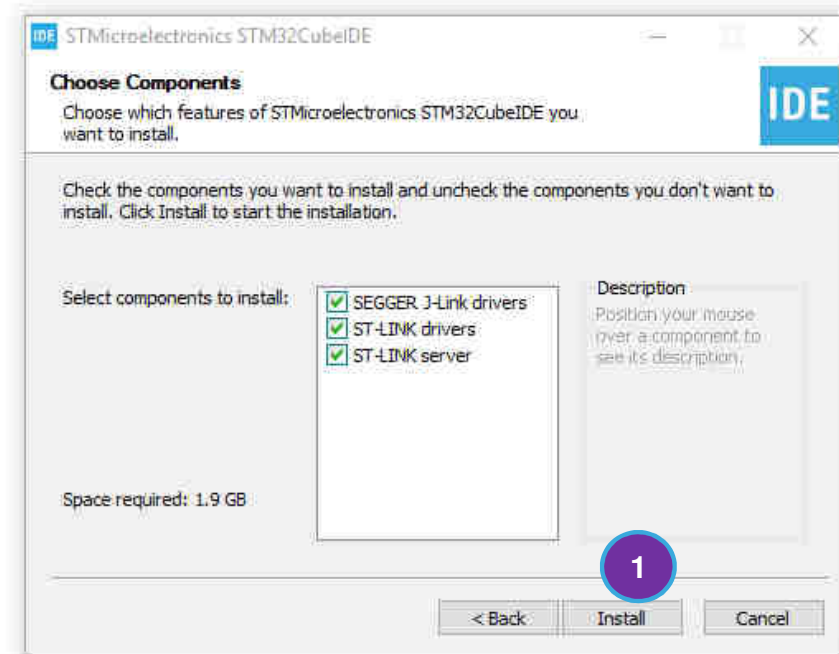
1. Click **Next >**



STM32CubeIDE Installation

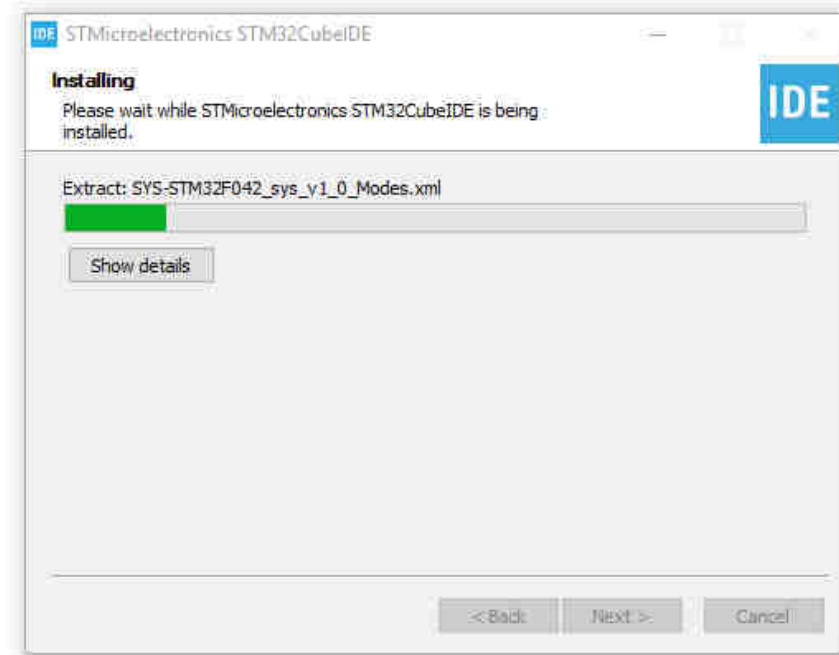
266

1. Click **Install**



STM32CubeIDE Installation... 267

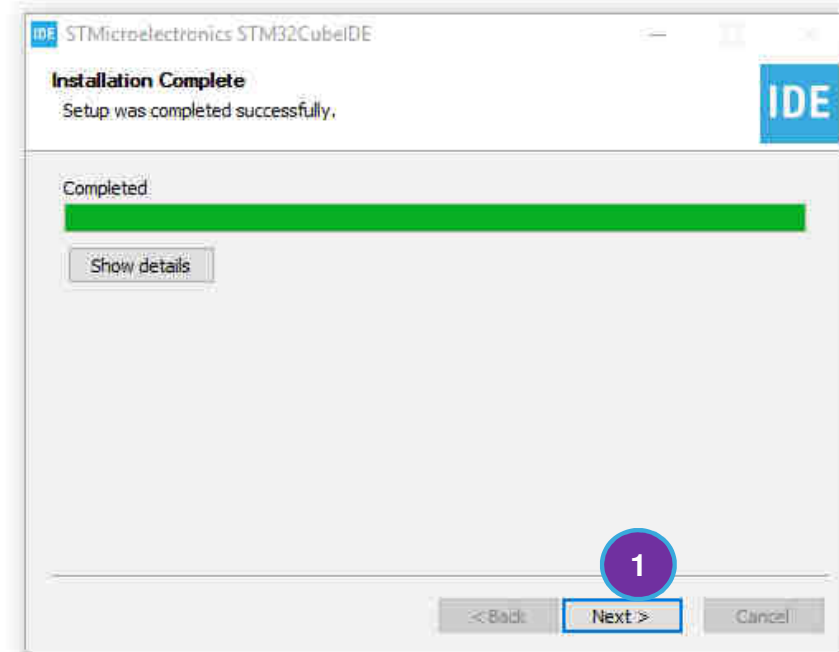
1. Wait until installation is completed



...STM32CubeIDE Installation

268

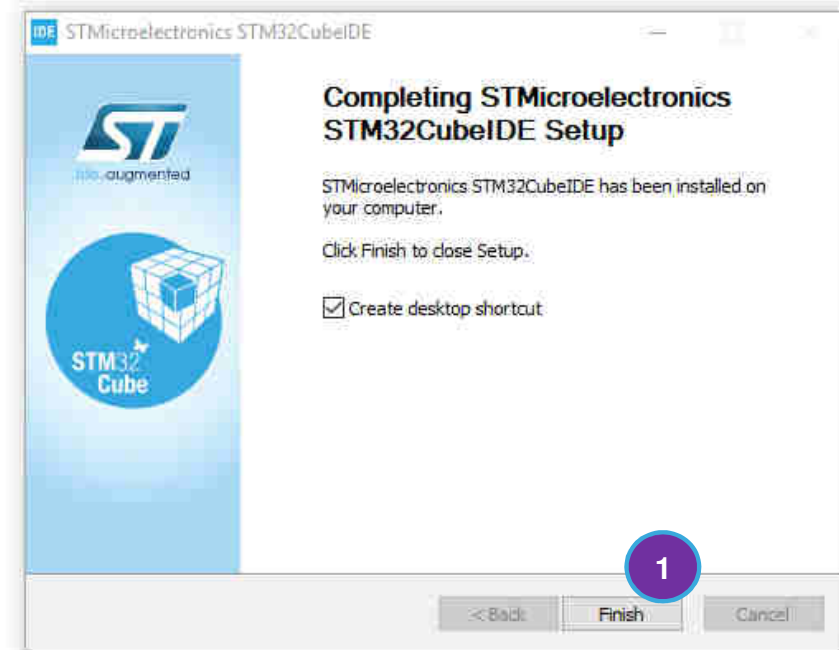
1. Click **Next >**



STM32CubeIDE Installation

269

1. Click **Finish**



STM32CubeIDE Configuration

270

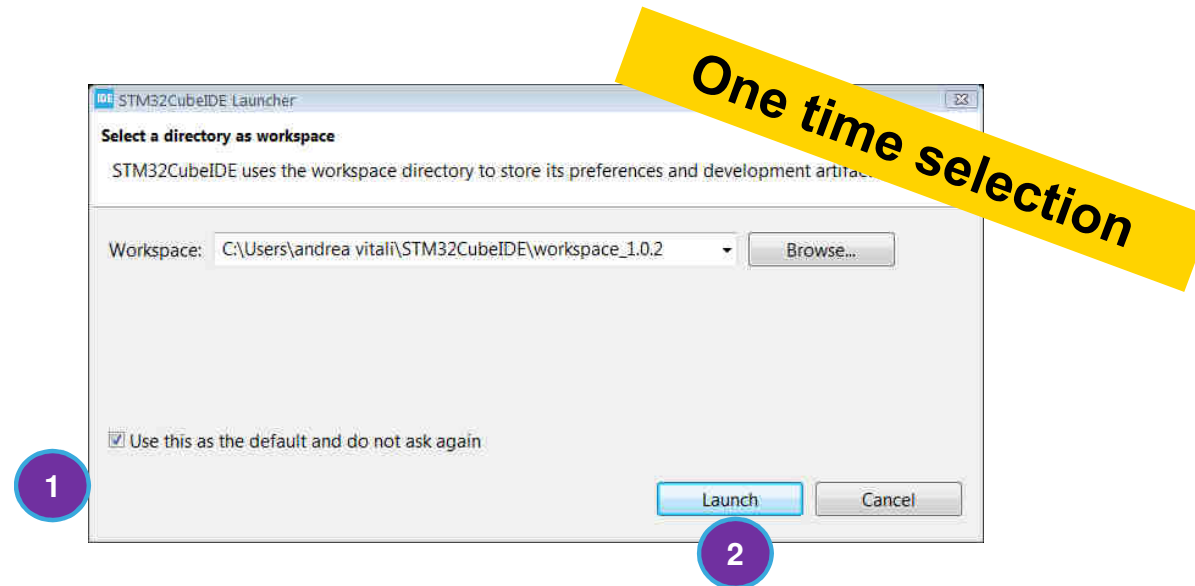
1. Open **STM32CubeIDE** by double clicking the icon on your desktop
2. Wait until **STM32CubeIDE** is loading



STM32CubeIDE Configuration

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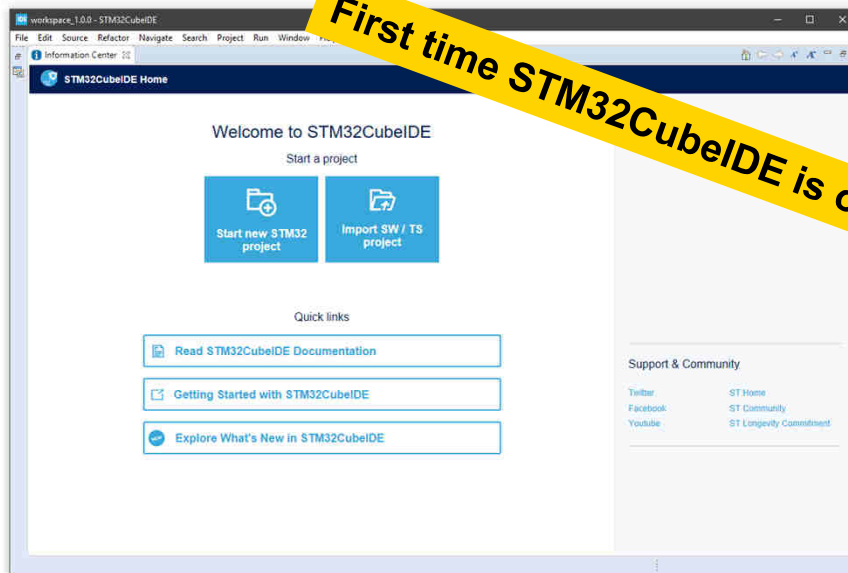
1. Check **Use this as the default and do not ask again**
2. Click **Launch**



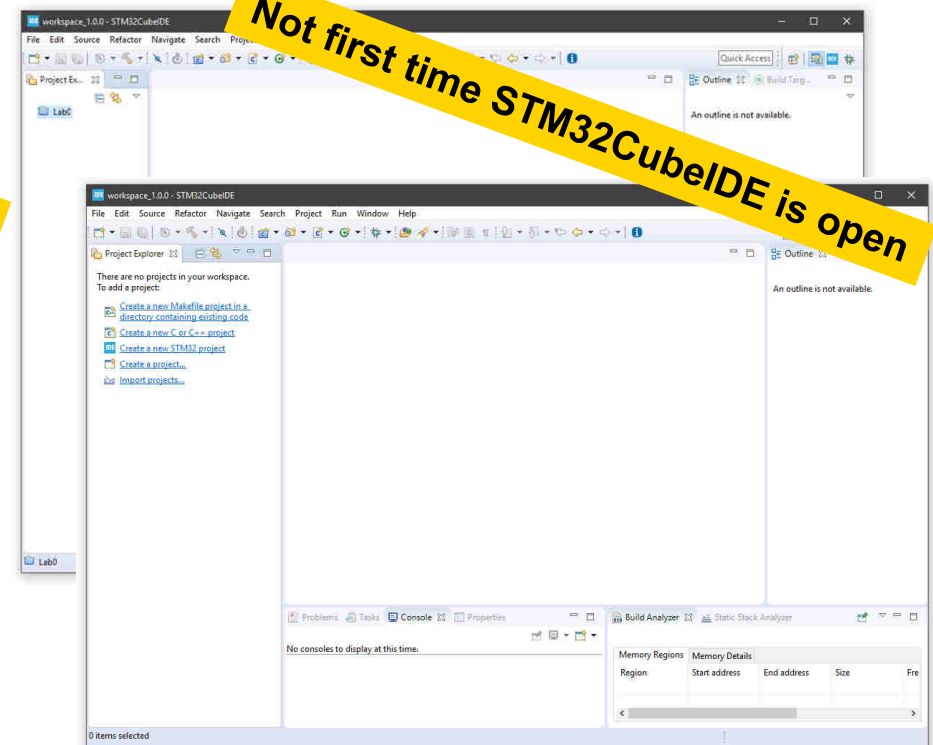
STM32CubeIDE Configuration

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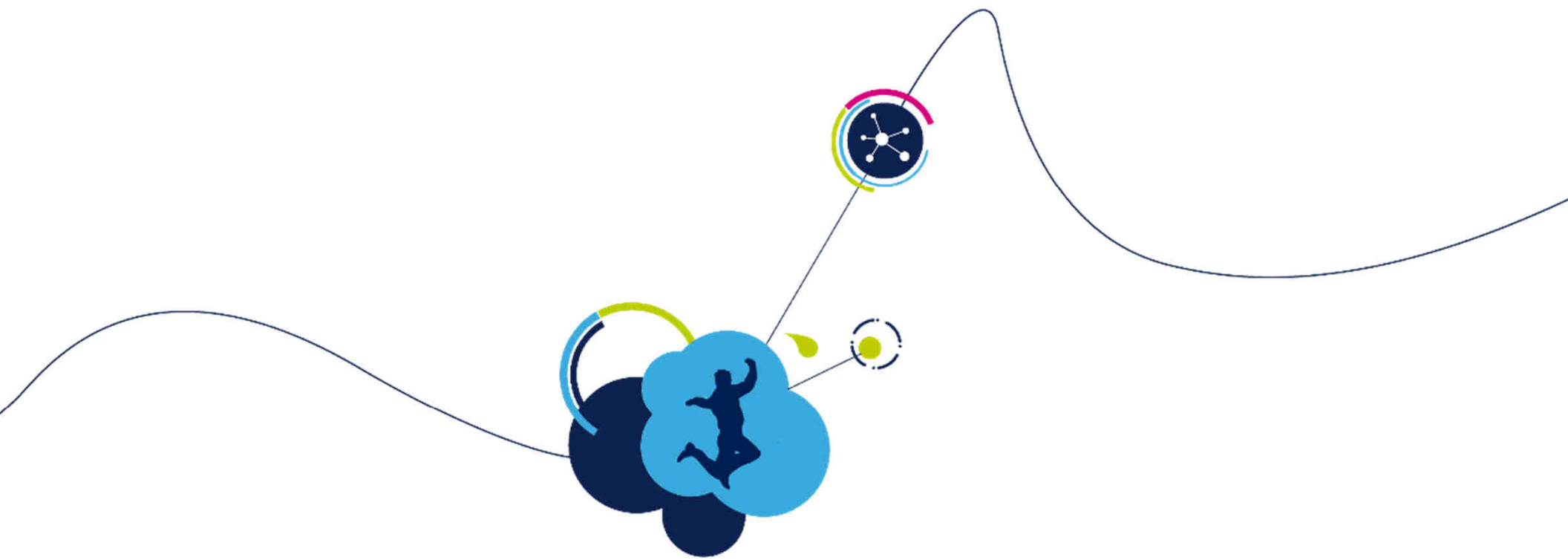
The main interface of STM32CubeIDE will appear differently, depending if it is the first time it has been run or not:



First time STM32CubeIDE is open



Not first time STM32CubeIDE is open



X-Cube-MEMS1 Installation

X-Cube-MEMS1 Installation

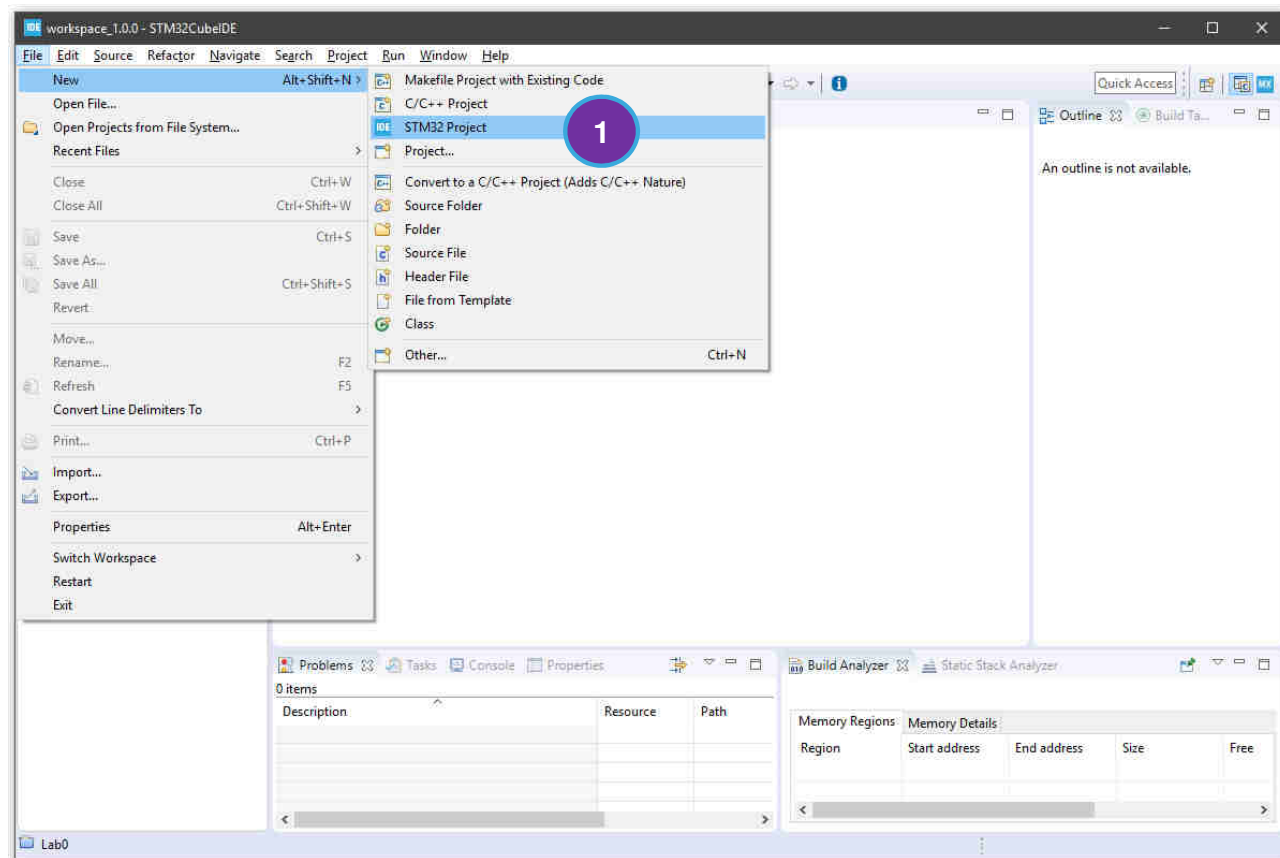
X-Cube-MEMS1 can be downloaded from STM32CubeIDE

- X-Cube downloads can be managed **only while a project is opened**
 - We will create a **temporary project** which will be deleted at the end of the installation, this is also an opportunity to test the STM32CubeIDE installation
- Cube downloads may be triggered if updates are available and deemed necessary
 - Currently STM32CubeIDE 1.0.2 needs to download **STM32Cube_FW_I4_v1140.zip** package
- **NOTE:** If you are in a VPN and/or behind a proxy that requires authentication, you may need to change the network connection setting. You will find details the relevant information in the section “Network Setting Configuration”
 - It is always possible to configure network connection settings in Window > Preferences then in General > Network Connections

X-Cube-MEMS1 Installation

275

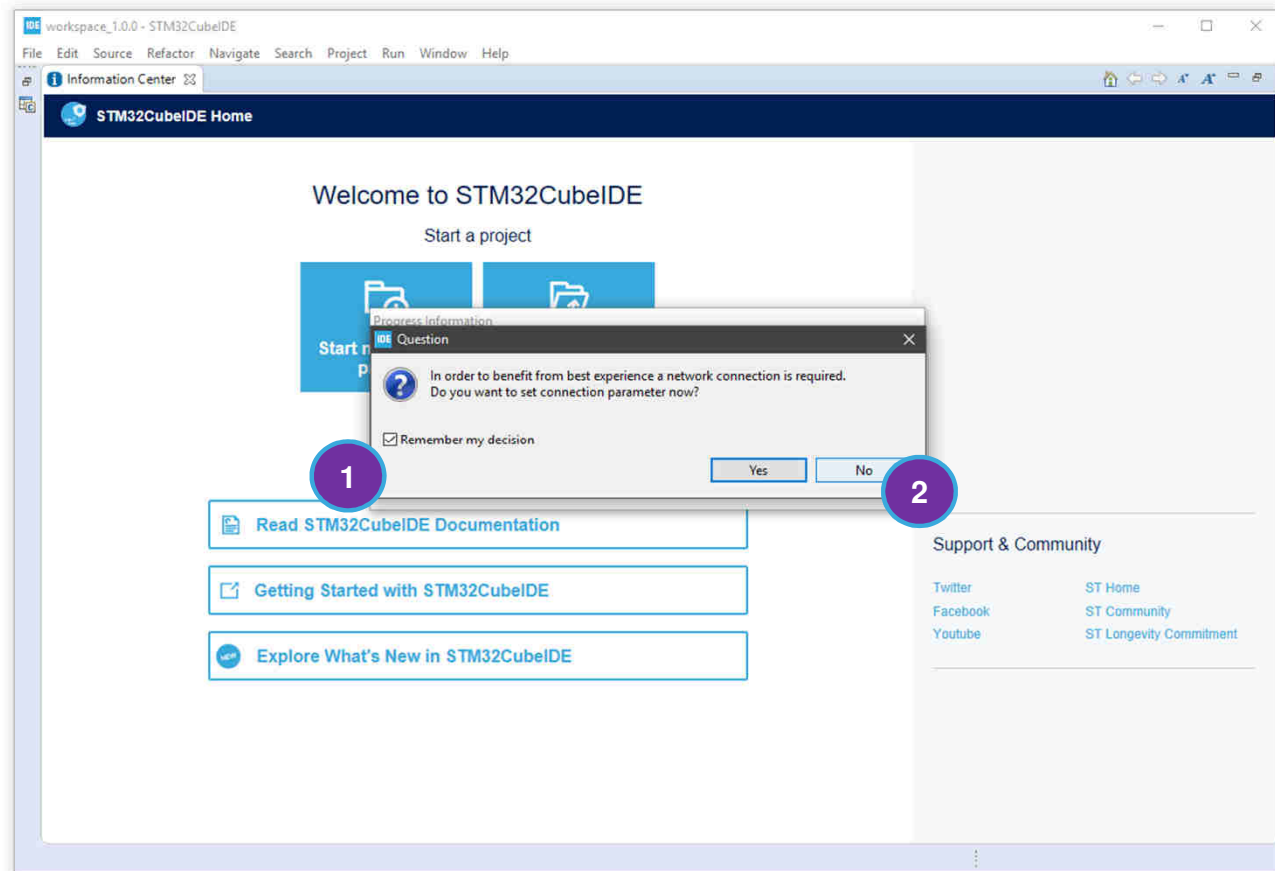
1. Click on **File > New > STM32 Project**



X-Cube-MEMS1 Installation 276

1. Check **Remember my decision***
2. Click **No***

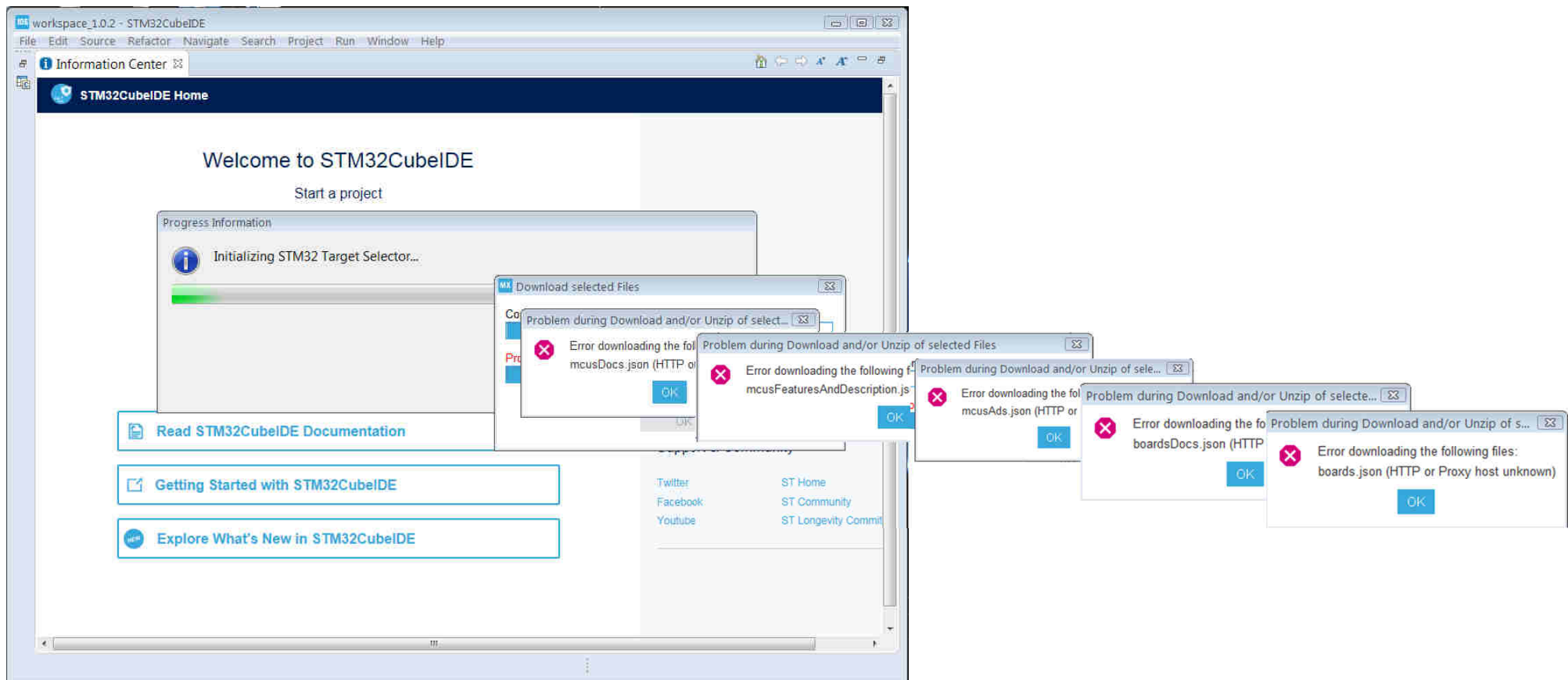
* It is always possible to reconfigure internet connection parameter in **Window > Preferences** then in **General > Network Connections**



X-Cube-MEMS1 Installation

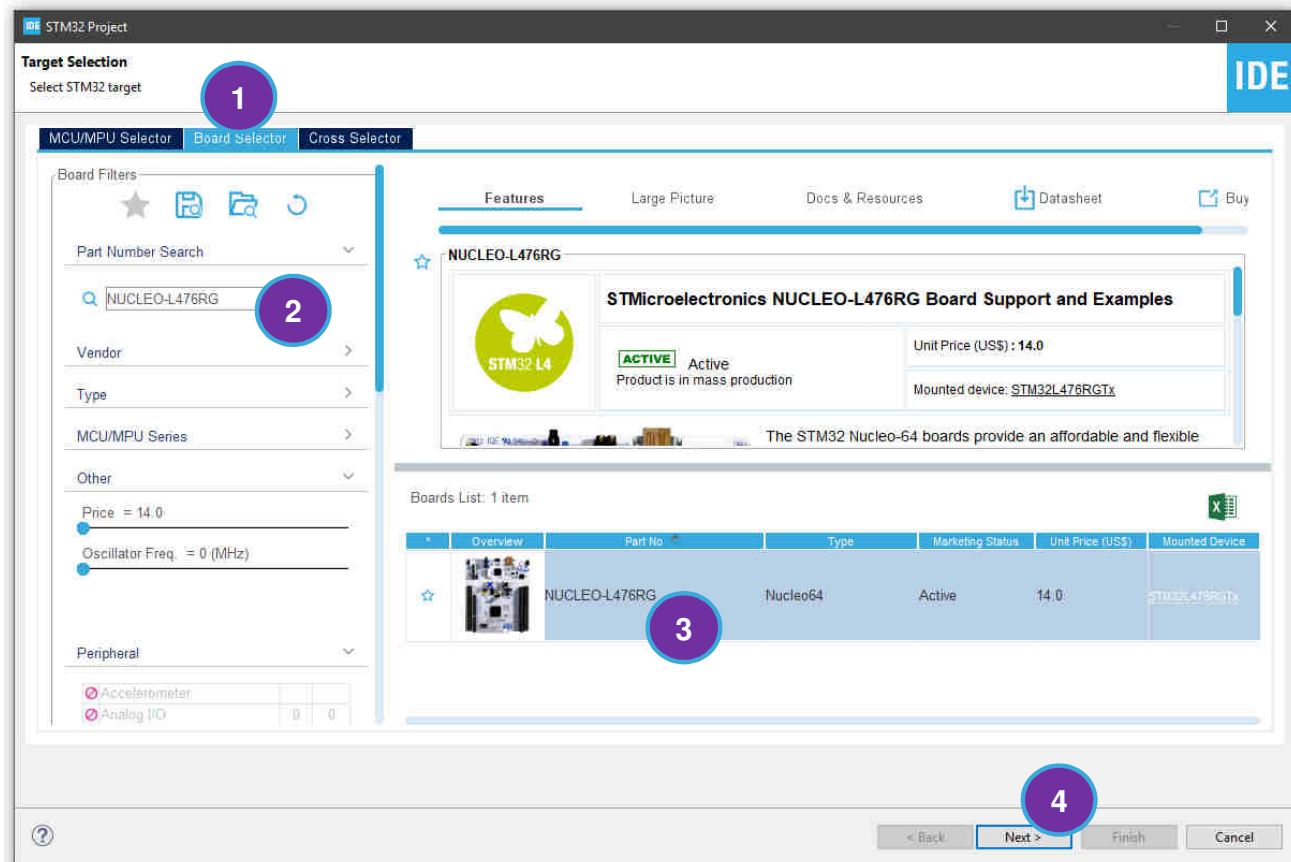
277

If you answer Yes and network settings are wrong, required downloads will not be completed. Just click **Ok** and ignore it. We can fix this later.



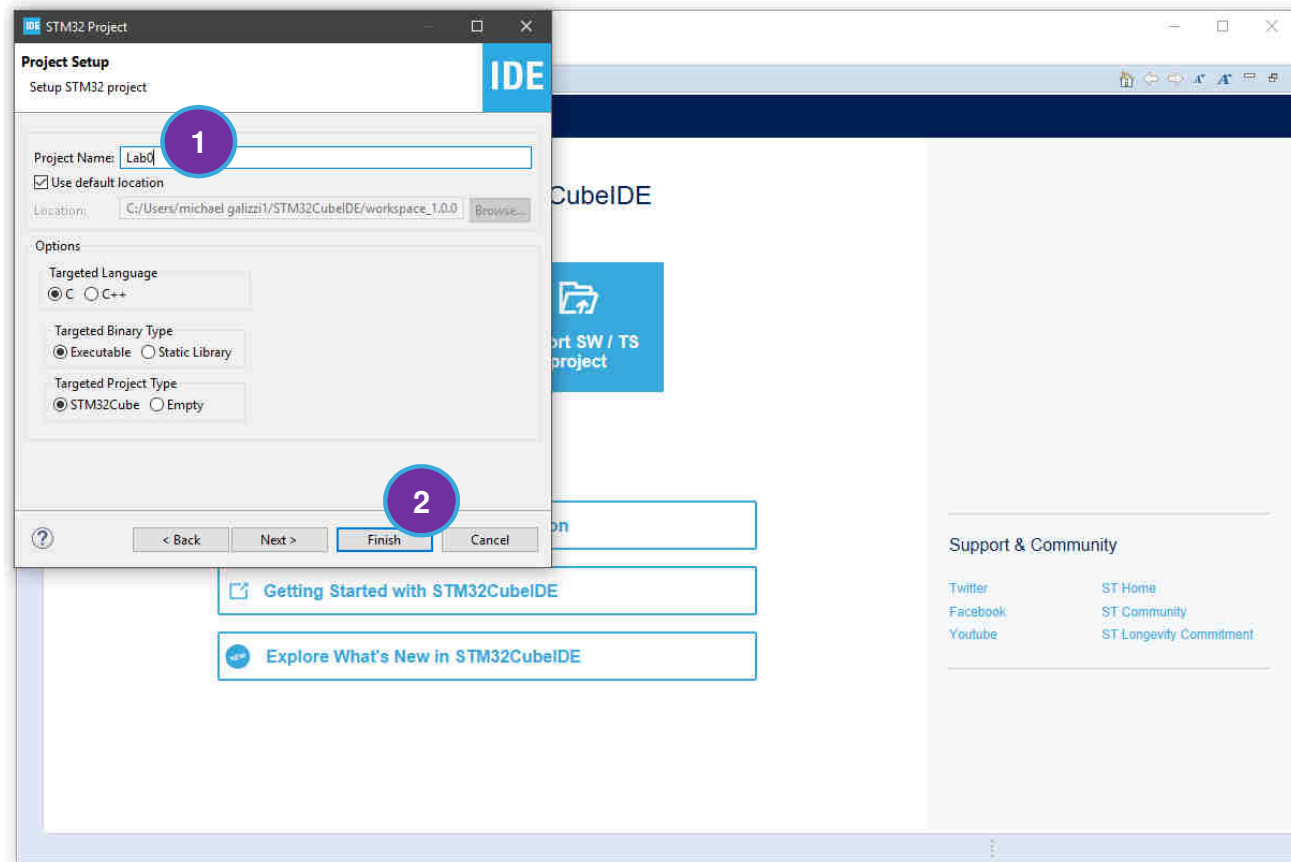
X-Cube-MEMS1 Installation 278

1. Click on **Board Selector**
2. Type **NUCLEO-L476RG**
3. Click on the board
4. Click **Next >**



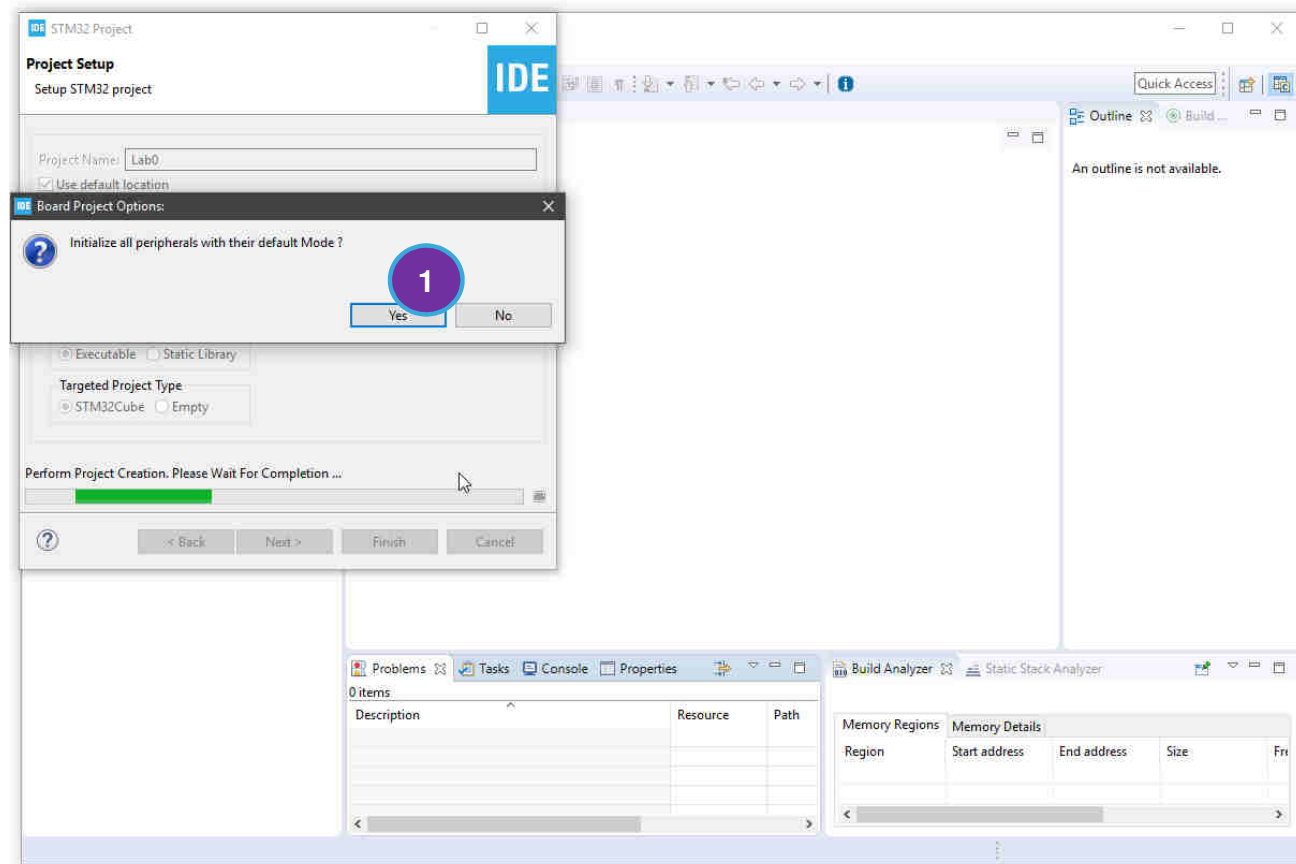
X-Cube-MEMS1 Installation 279

1. Project Name **Lab0** (any name is OK)
2. Click **Finish**



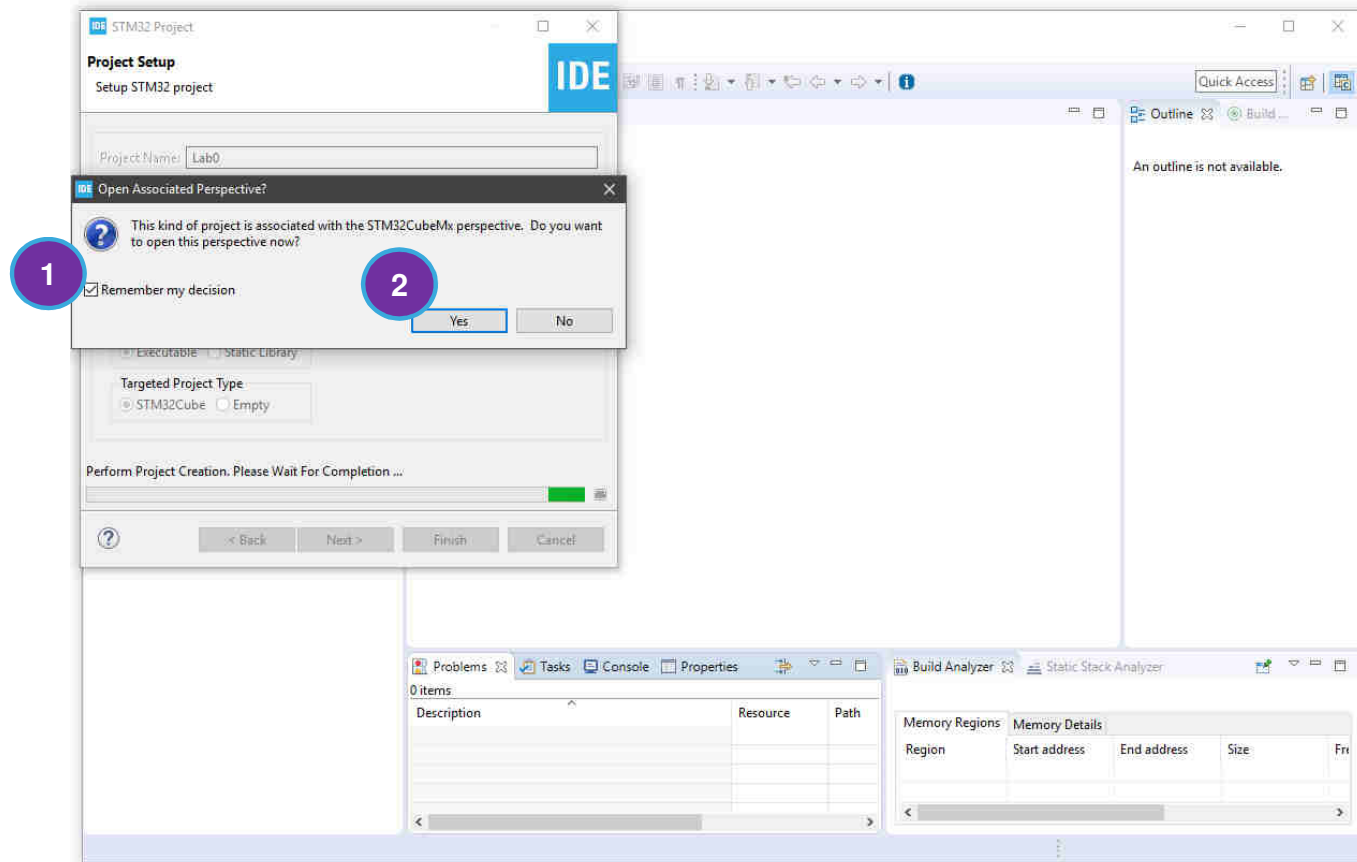
X-Cube-MEMS1 Installation 280

1. Click **Yes** to init peripherals in default mode



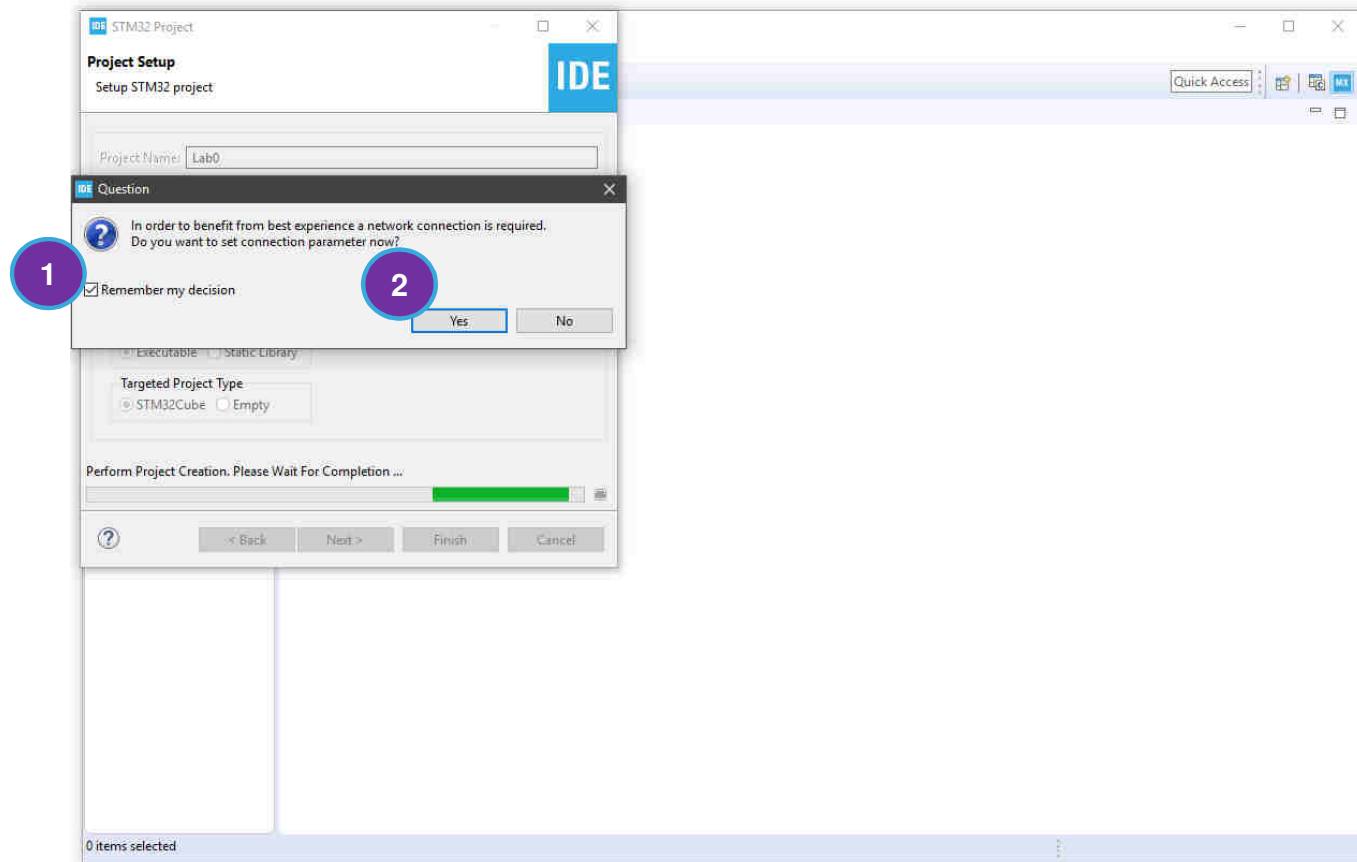
X-Cube-MEMS1 Installation 281

1. Check **Remember my decision**
2. Click **Yes** to open the project perspective



X-Cube-MEMS1 Installation 282

1. Check **Remember my decision**
2. Click **No***

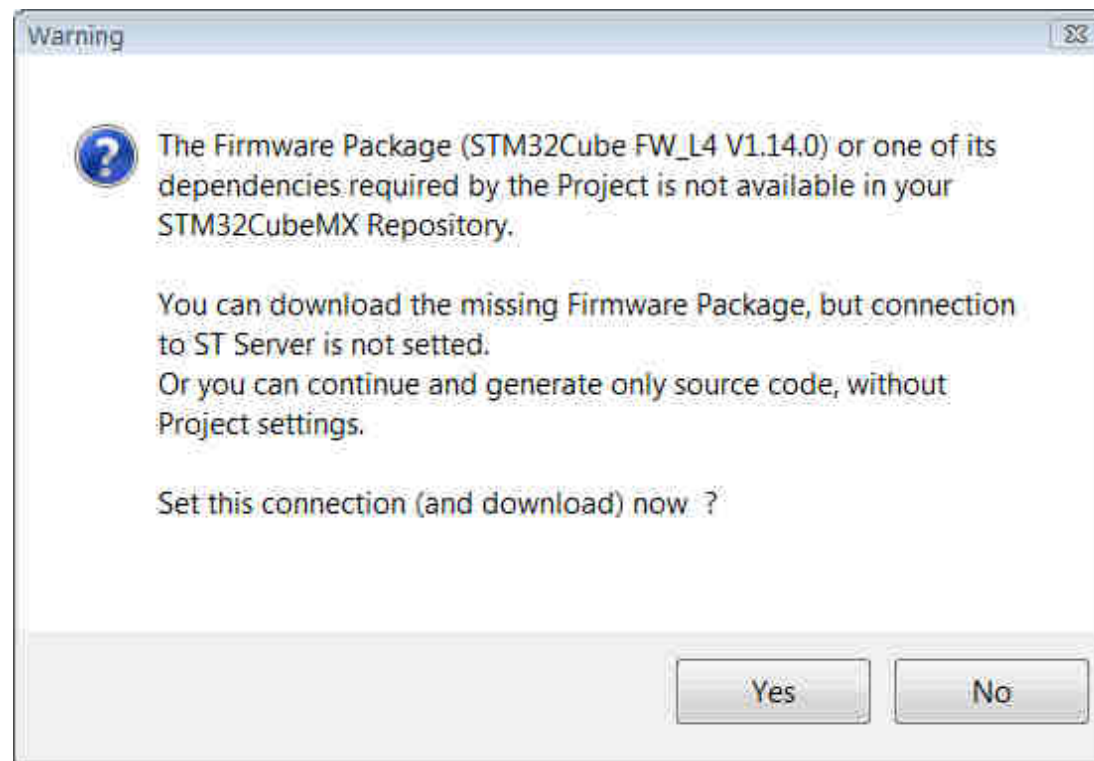


* It is always possible to reconfigure internet connection parameter in **Window > Preferences** then in **General > Network Connections**

STM32CubeIDE Configuration

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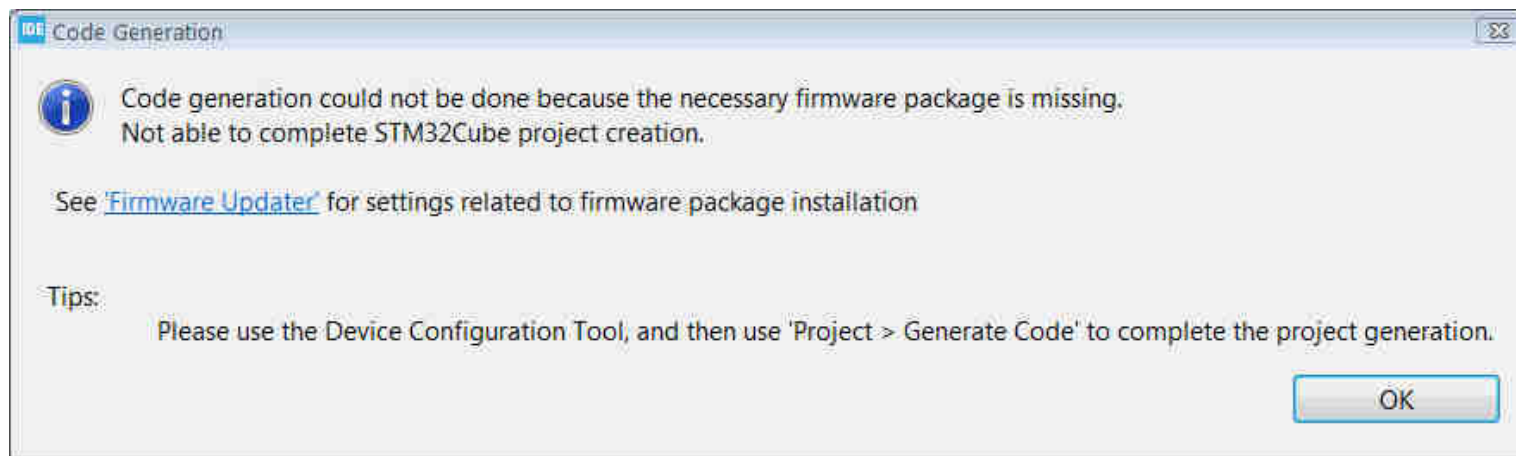
1. Click **No*** (we will download it later)



STM32CubeIDE Configuration

284

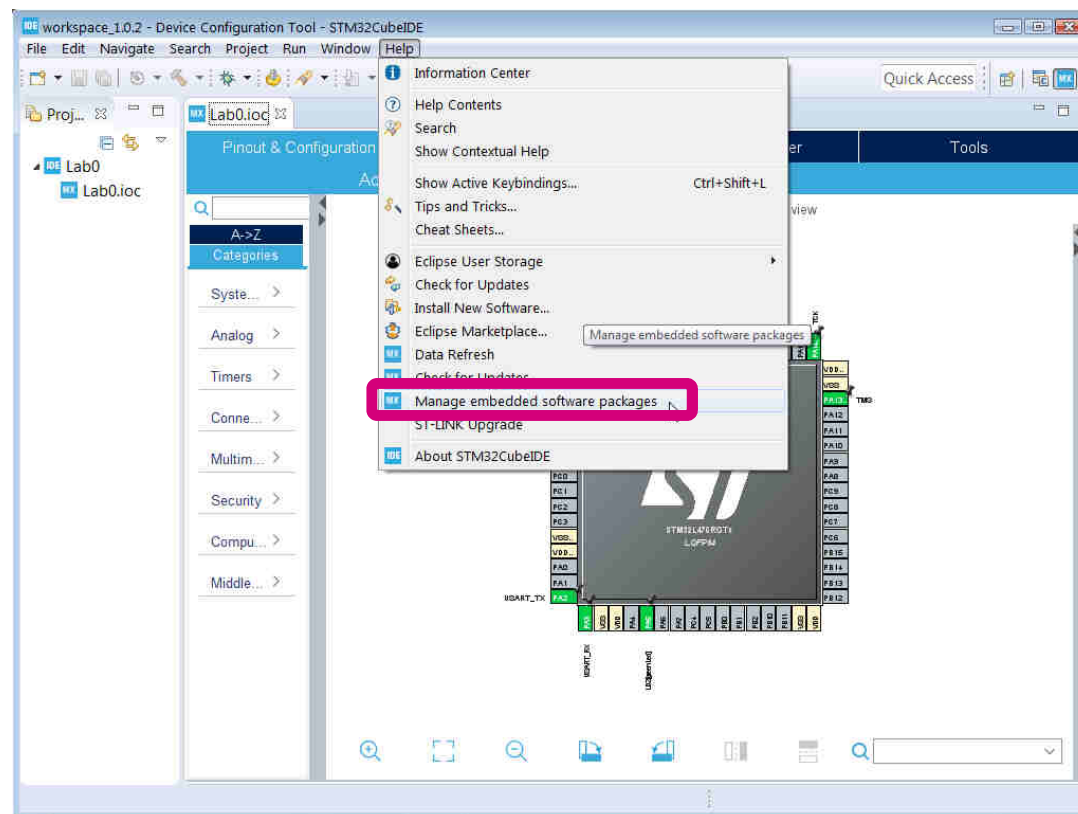
1. Click **Ok**



STM32CubeIDE Configuration

285

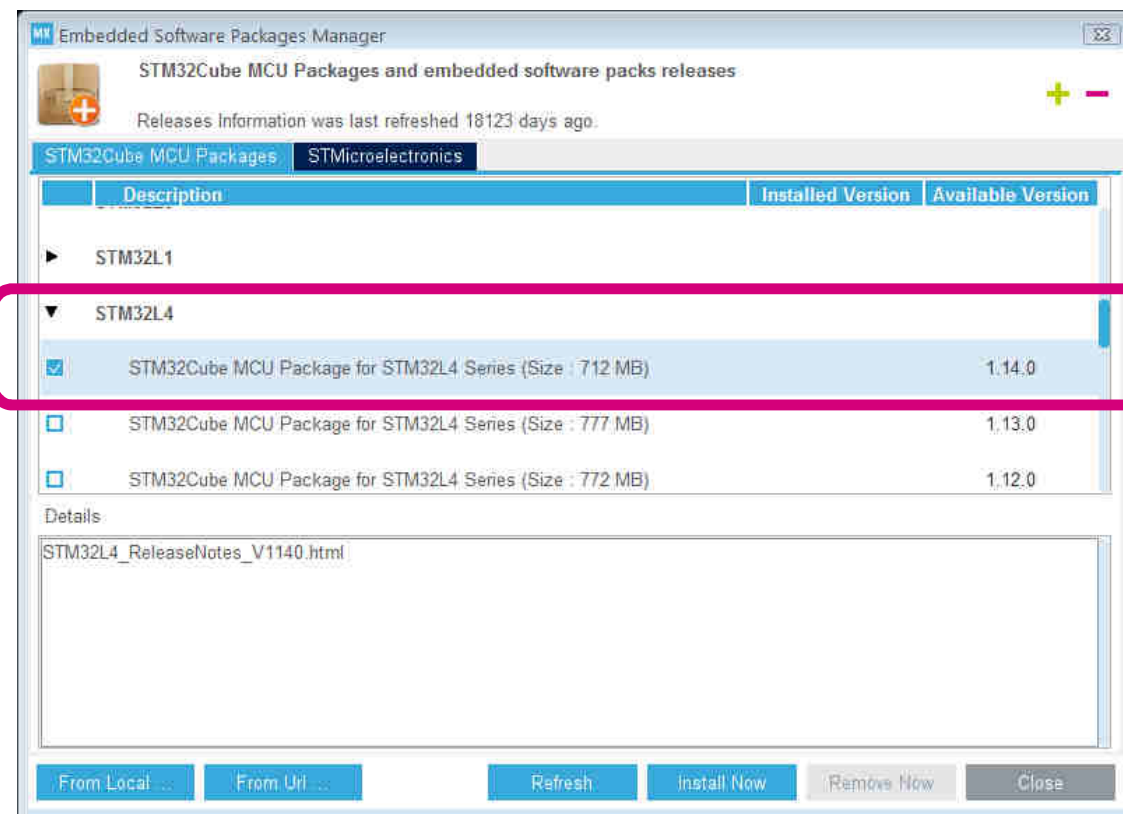
1. Click on **Help > Manage embedded software packages**



STM32CubeIDE Configuration

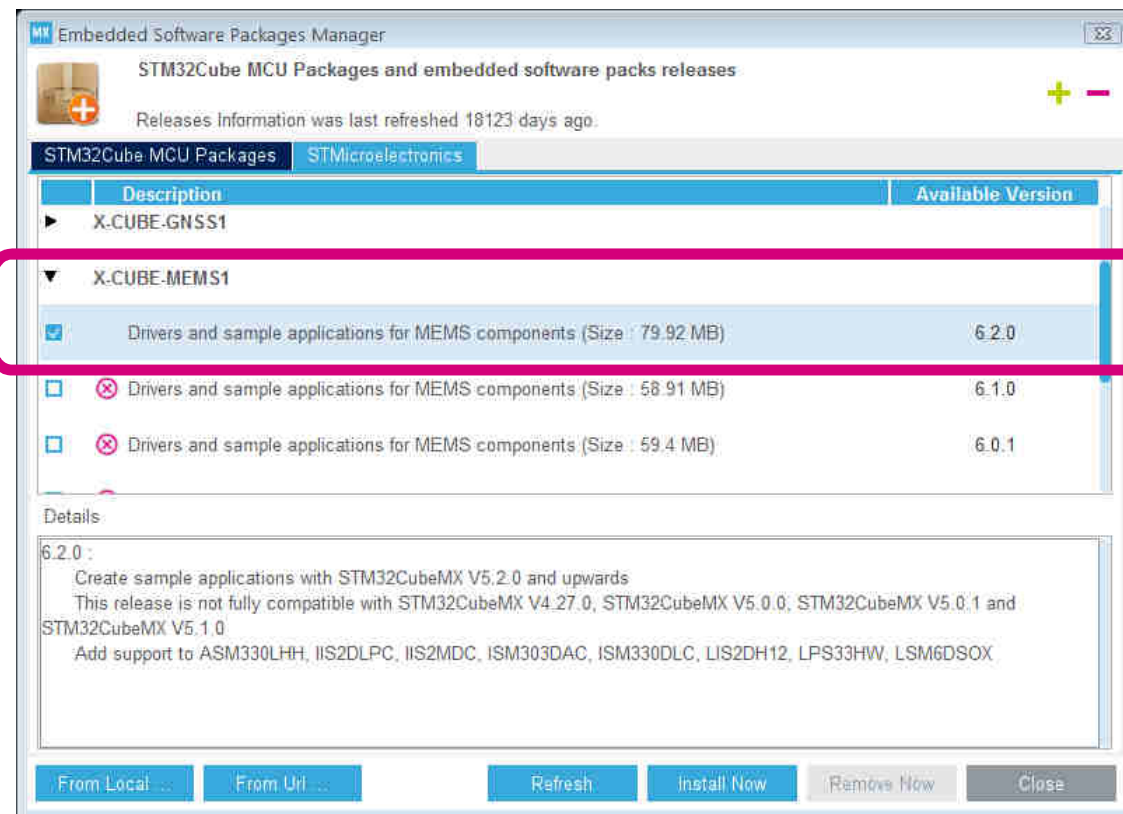
286

1. Scroll down to **STM32L4**, click to expand tree, select latest package **1.14.0**



STM32CubeIDE Configuration 287

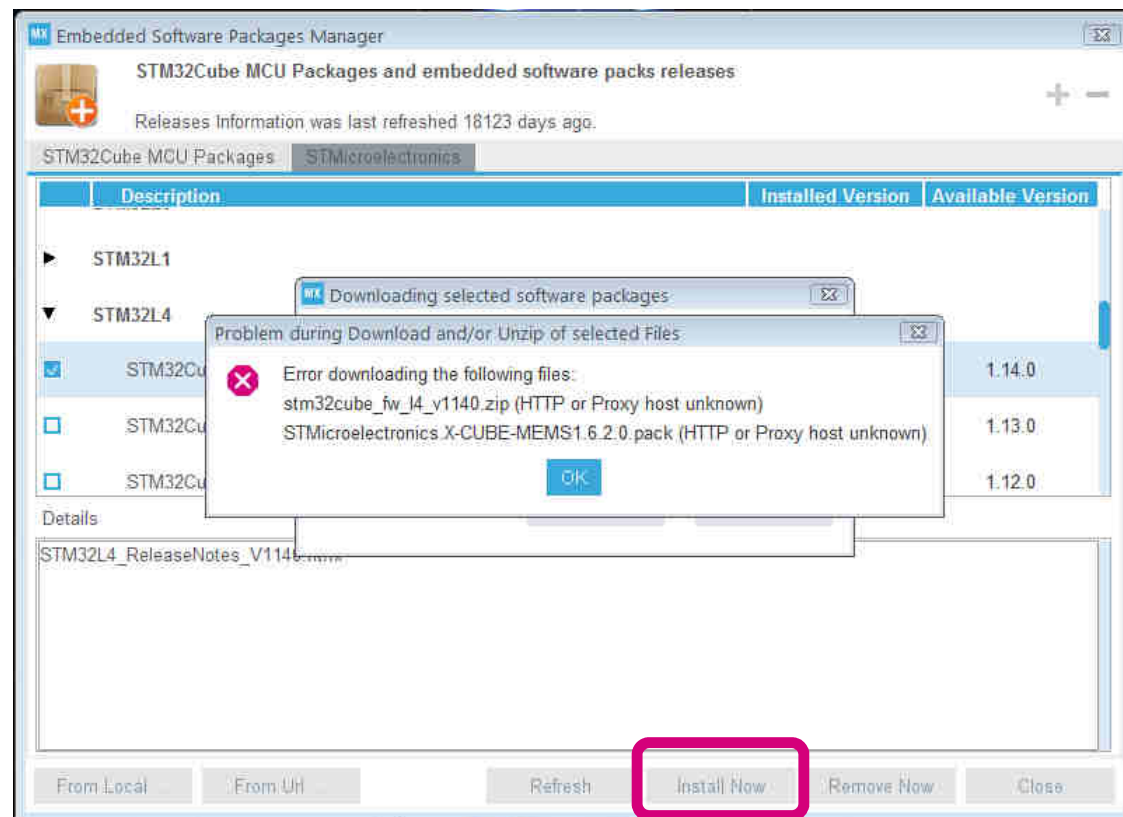
1. Scroll down to **X-CUBE-MEMS1**, click to expand, select latest package **6.2.0** (older packages are marked as not compatible with this IDE version)

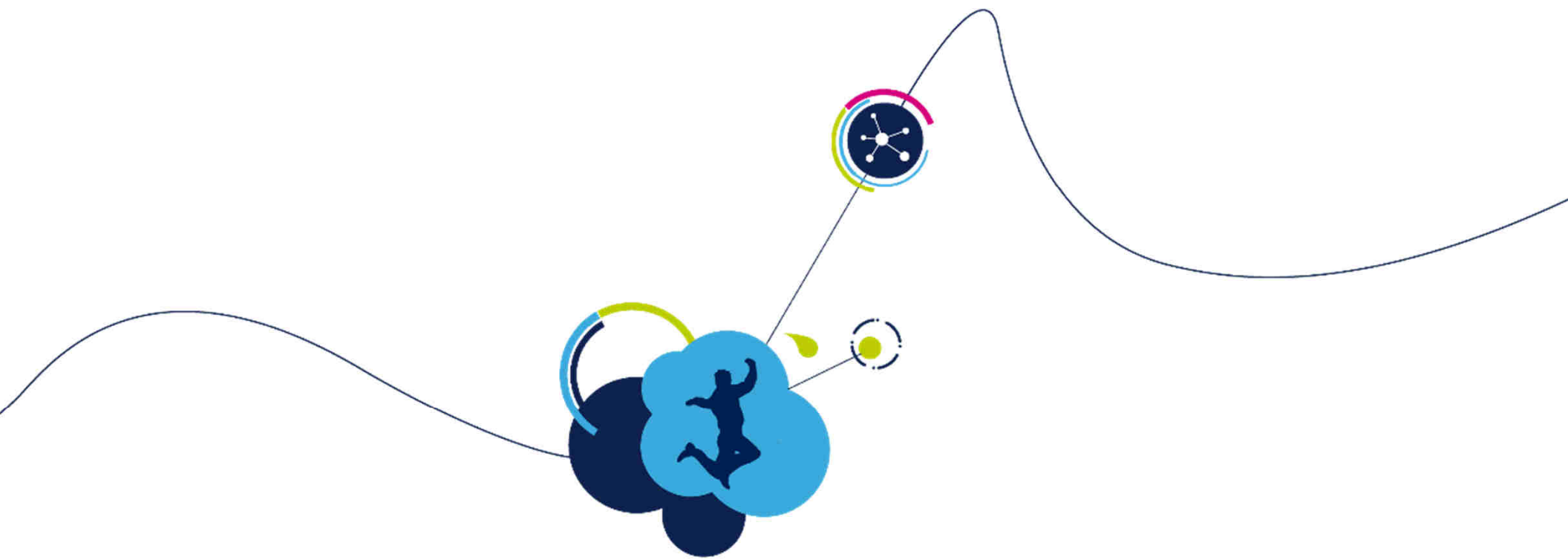


STM32CubeIDE Configuration

288

1. Click **Install Now**. If you get an error you must configure the network settings (see next slides).





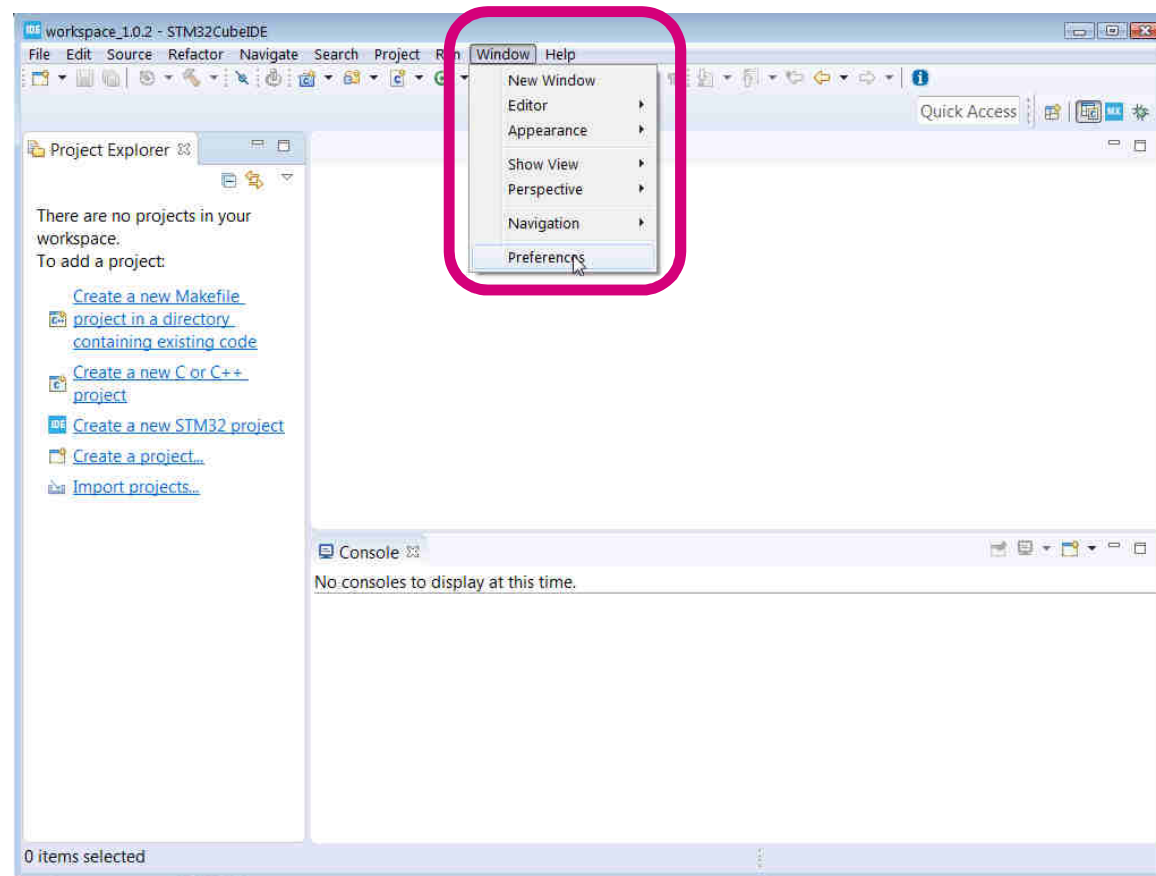
Network Setting Configuration

NOTE: this section applies only if you are in a VPN and/or behind a proxy that requires authentication. Otherwise you can go directly to the following section.

Network Setting Configuration

290

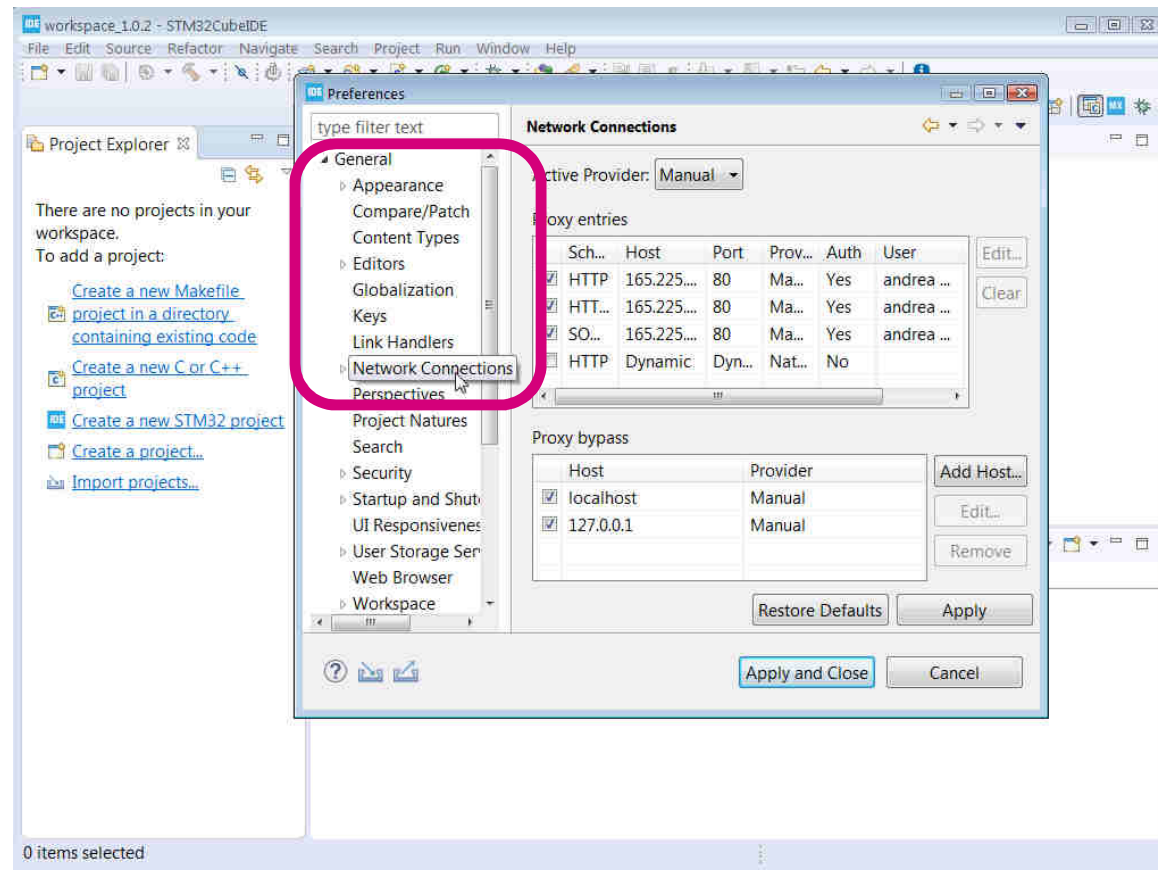
1. Click on **Window > Preferences**



Network Setting Configuration

291

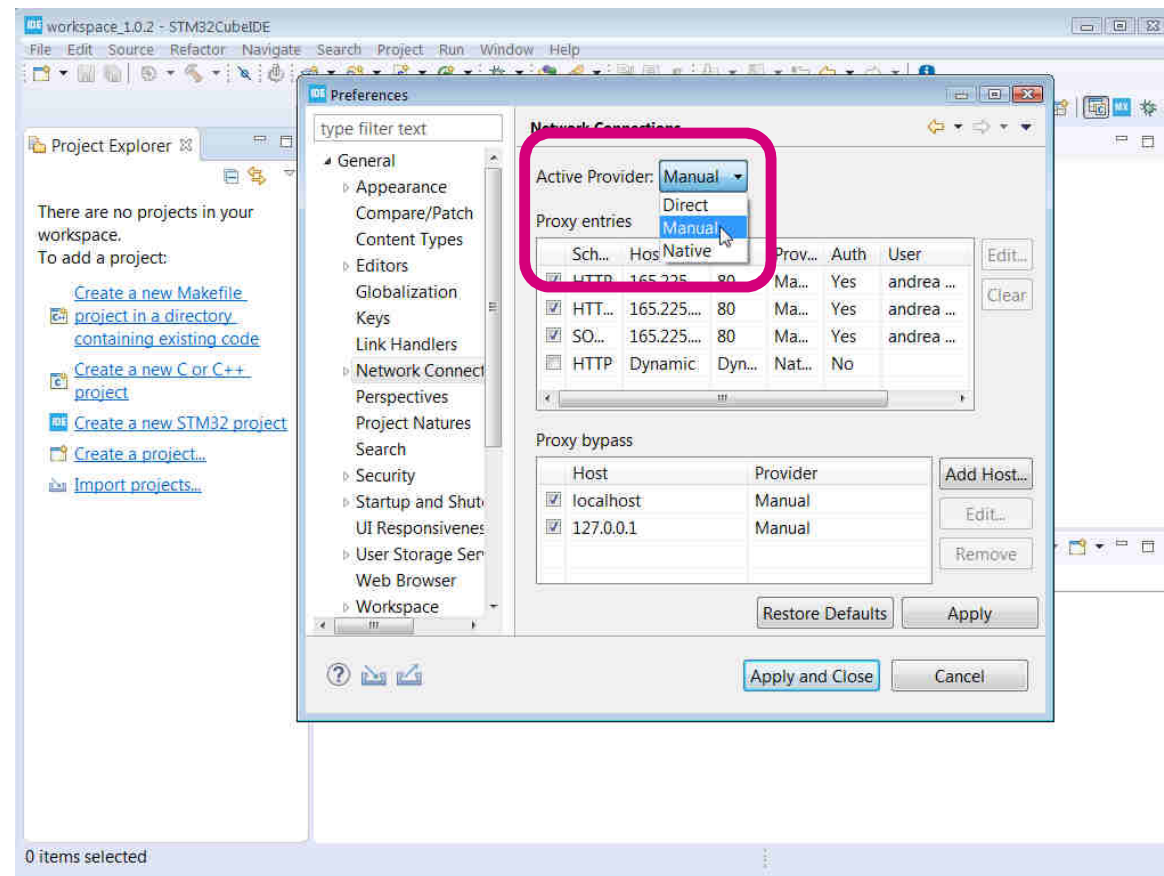
1. Click on **General > Network Connection**



Network Setting Configuration

292

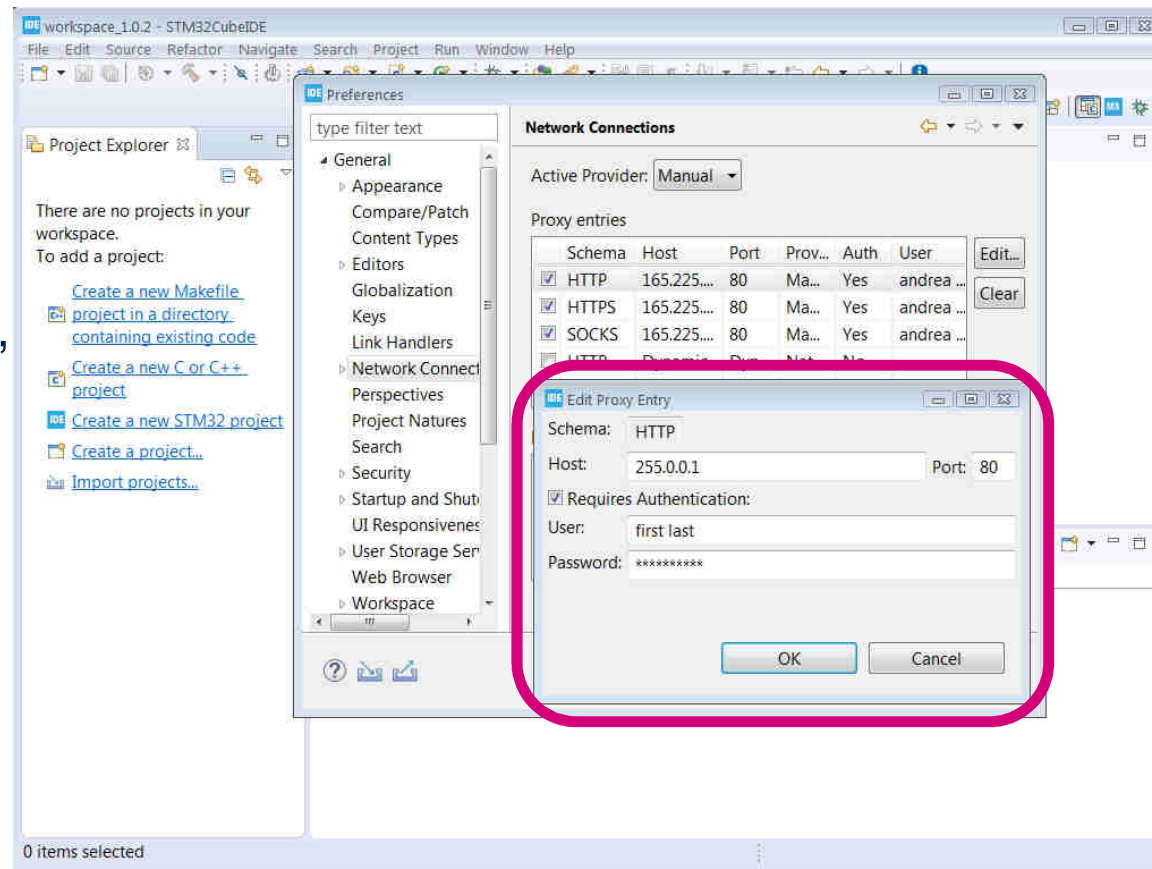
1. Change Active Provider to **Manual**



Network Setting Configuration

293

1. Select the protocol (**repeat for each protocol**, HTTP, HTTPS and SOCKS)
2. Press **Edit**
3. Insert proxy **IP address** and **port** number
4. Check “Requires Authentication” if needed, and insert user name and password
5. Click **OK**



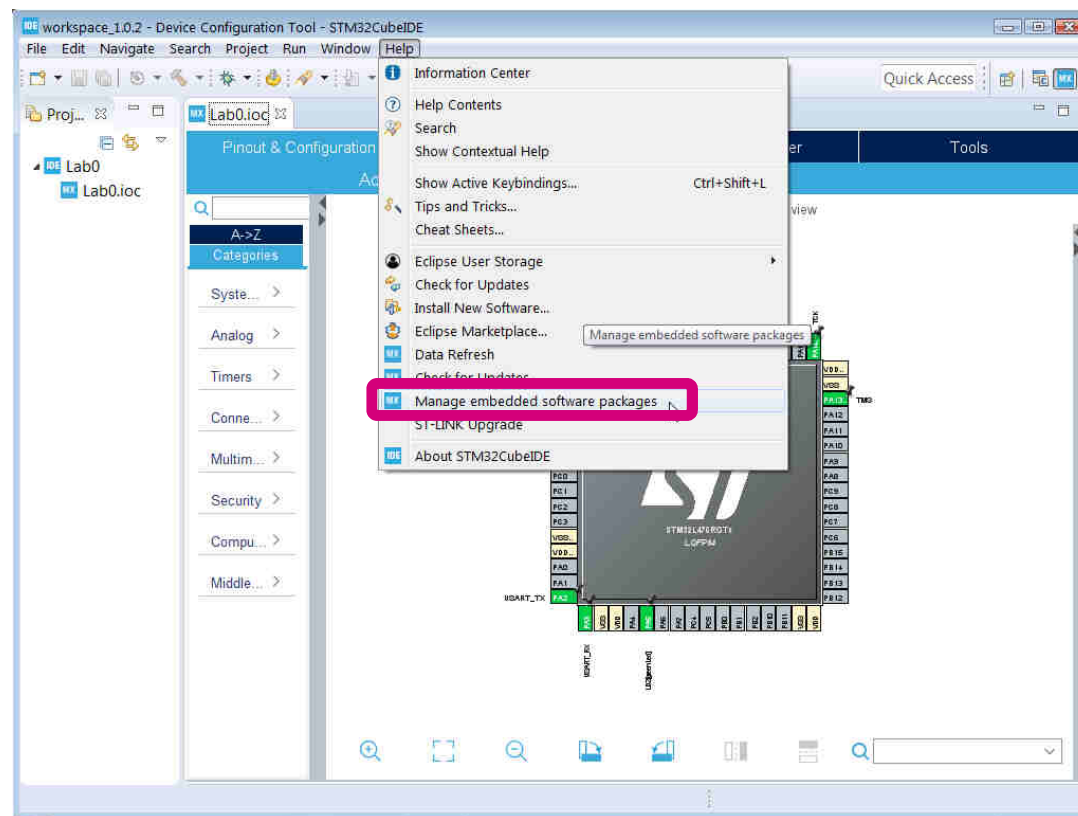


STM32CubeIDE Configuration

STM32CubeIDE Configuration

295

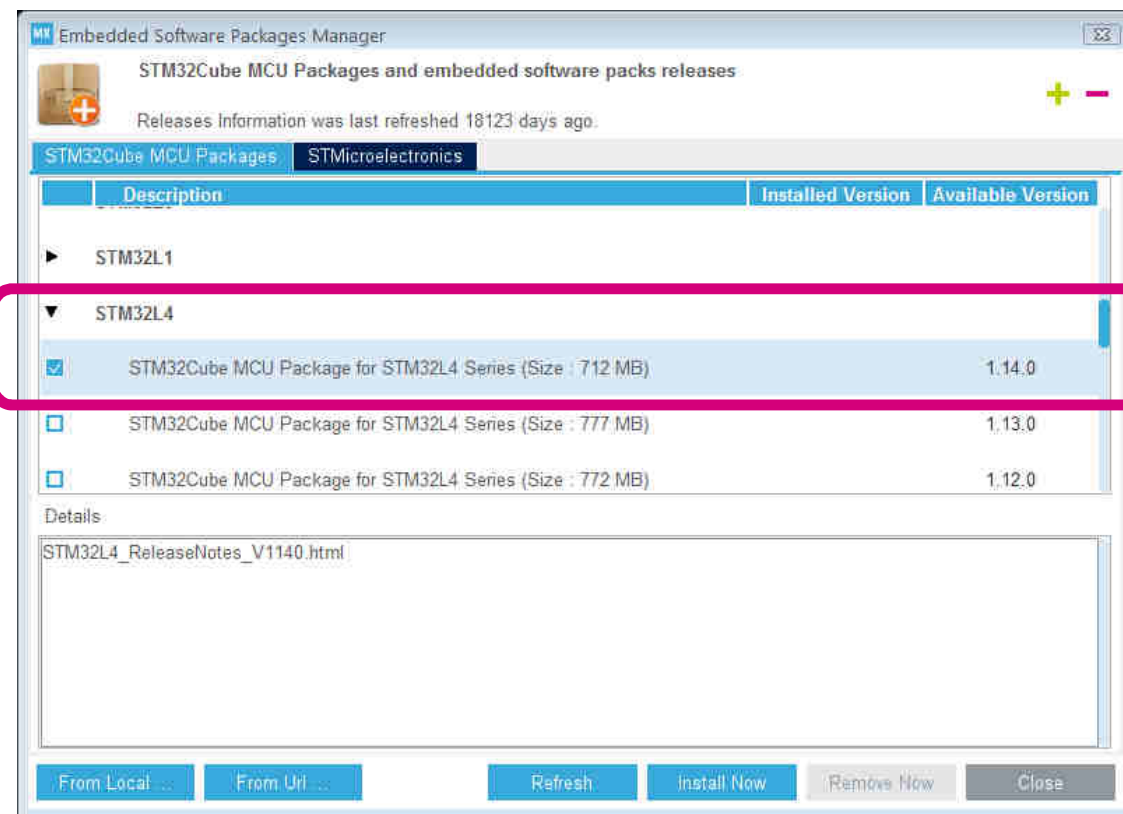
1. Click on **Help > Manage embedded software packages**



STM32CubeIDE Configuration

296

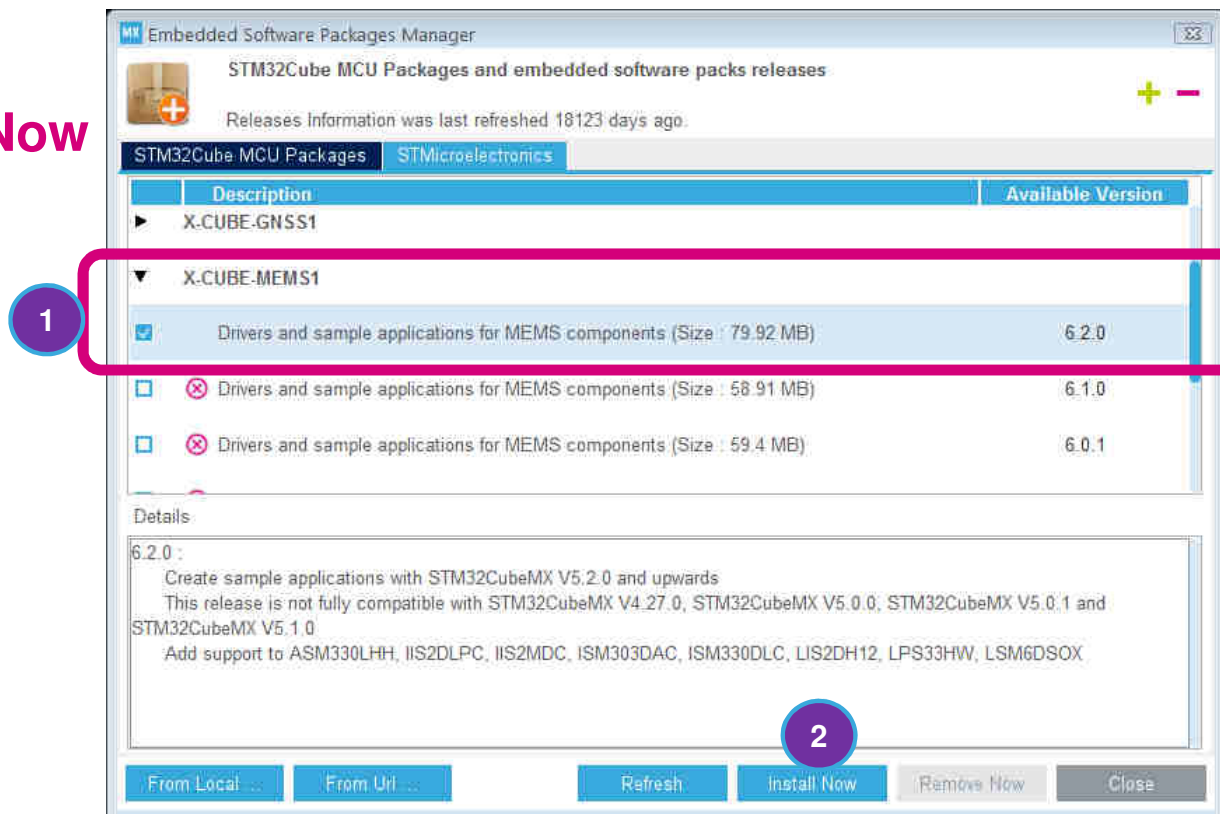
1. Scroll down to **STM32L4**, click to expand tree, select latest package **1.14.0**



STM32CubeIDE Configuration 297

1. Scroll down to **X-CUBE-MEMS1**, click to expand, select latest package **6.2.0** (older packages are marked as not compatible with this IDE version)

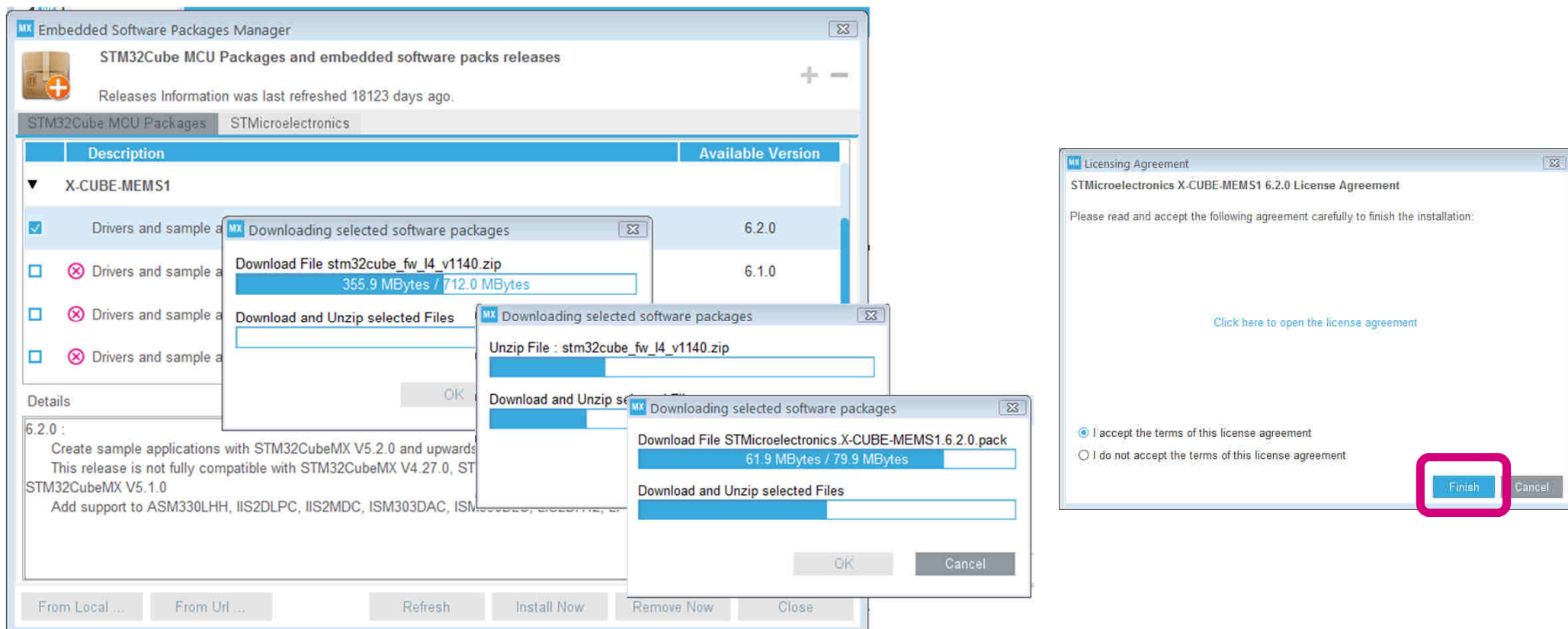
2. Click **Install Now**



STM32CubeIDE Configuration

298

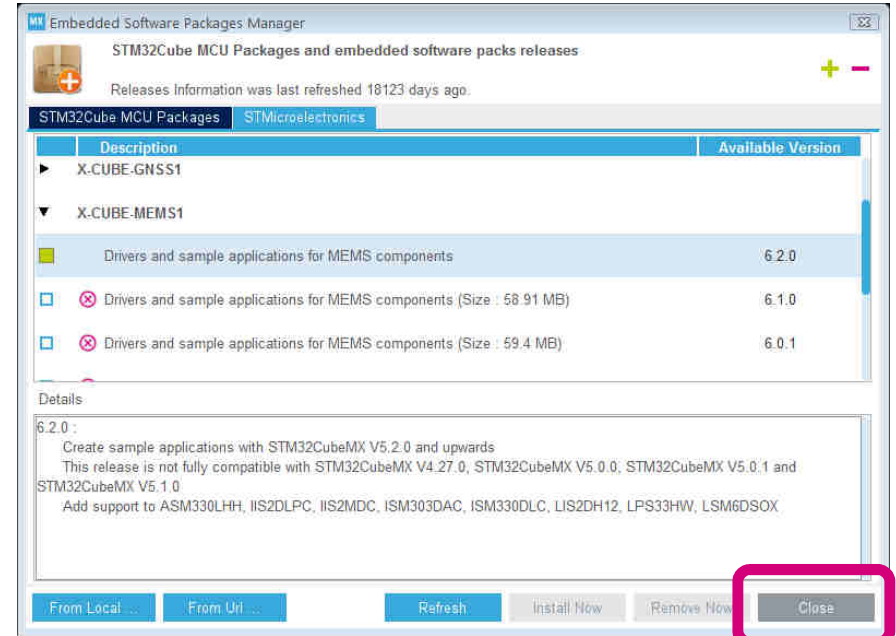
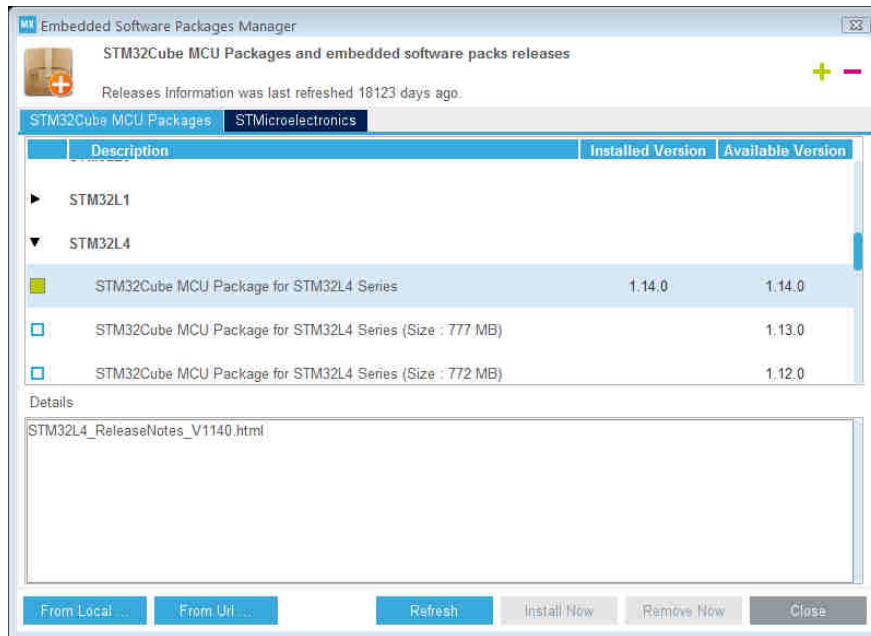
1. Wait for the download and unzip to be completed. Accept terms and conditions.



STM32CubeIDE Configuration

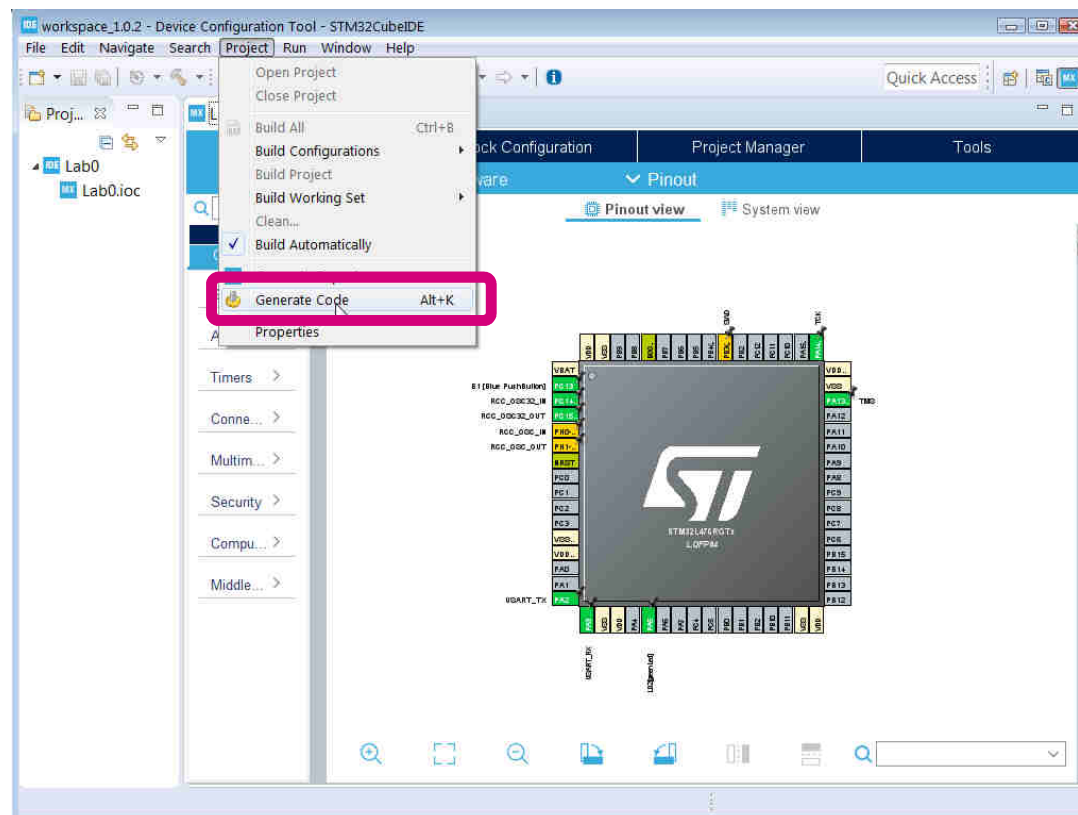
299

1. When STM32CUBE-L4 package is updated and X-CUBE-MEMS1 package is installed the corresponding checkboxes become green. **Close** window.



STM32CubeIDE Configuration 300

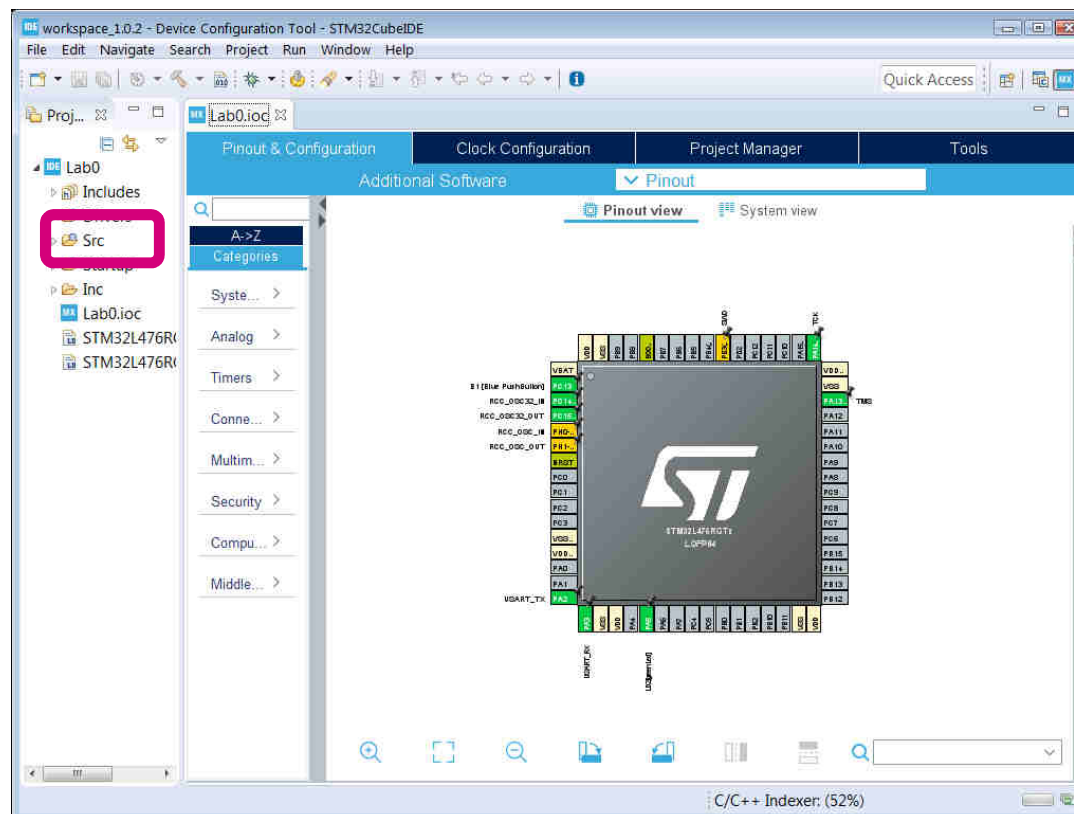
1. Let's check the code generator: **Project > Generate Code**



STM32CubeIDE Configuration

301

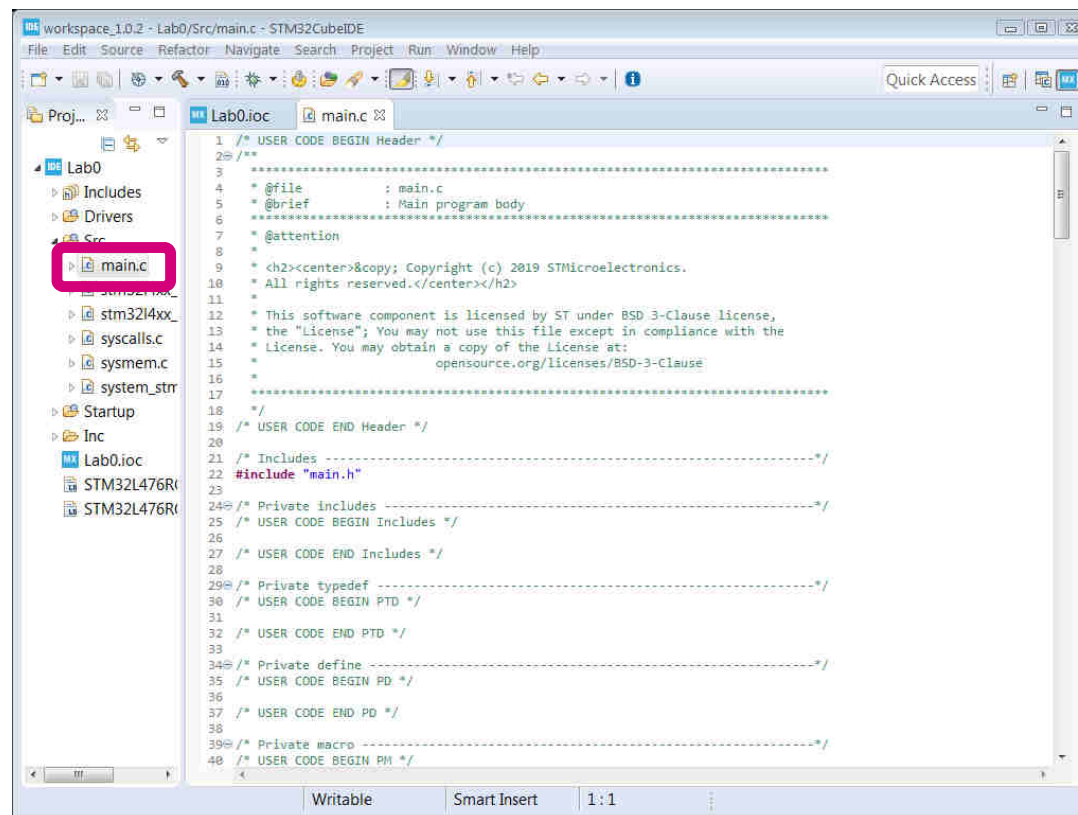
1. Let's have a look at the generated code: expand the **Src** folder.



STM32CubeIDE Configuration

302

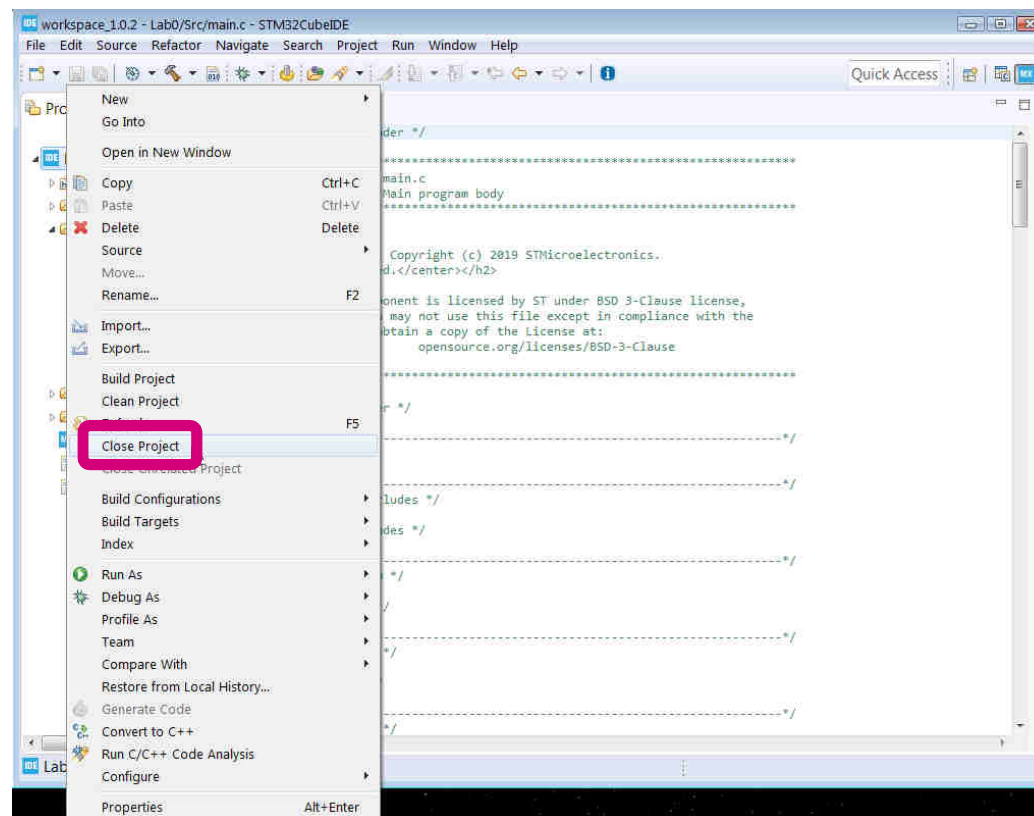
1. Let's have a look at the generated code: double click on **main.c** to open it.



STM32CubeIDE Configuration

303

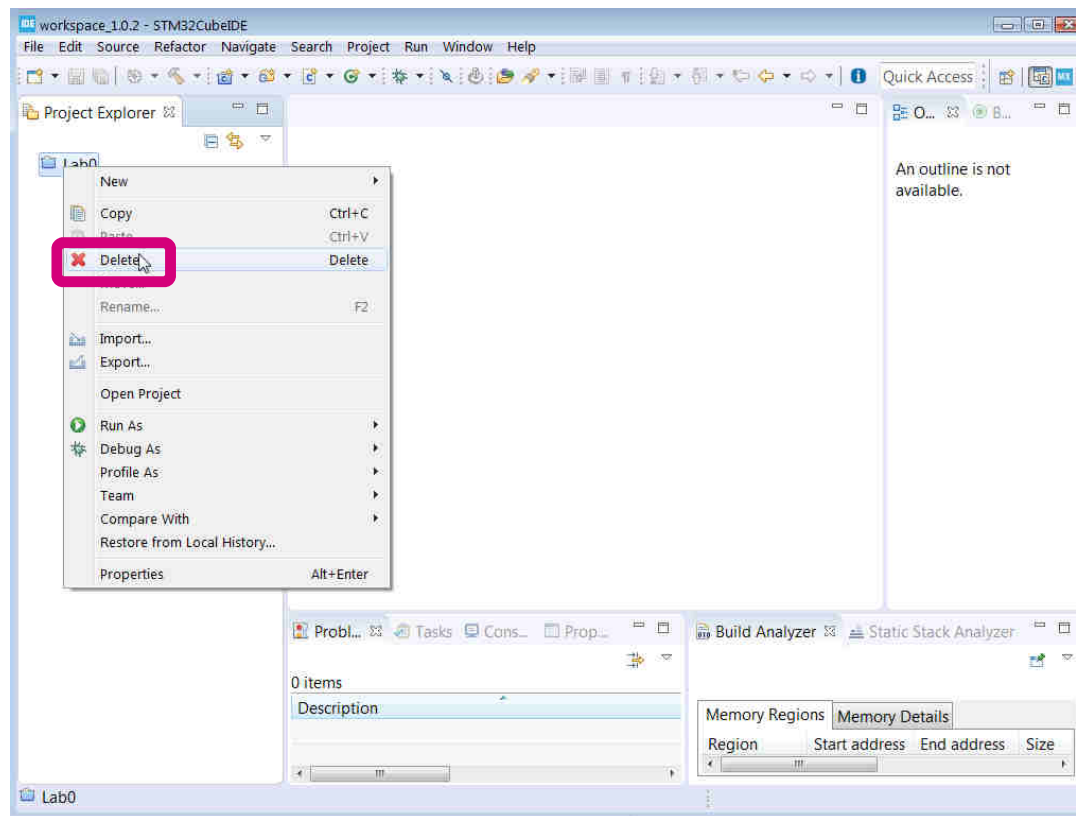
1. Right click on the project name and select **Close Project**



STM32CubeIDE Configuration

304

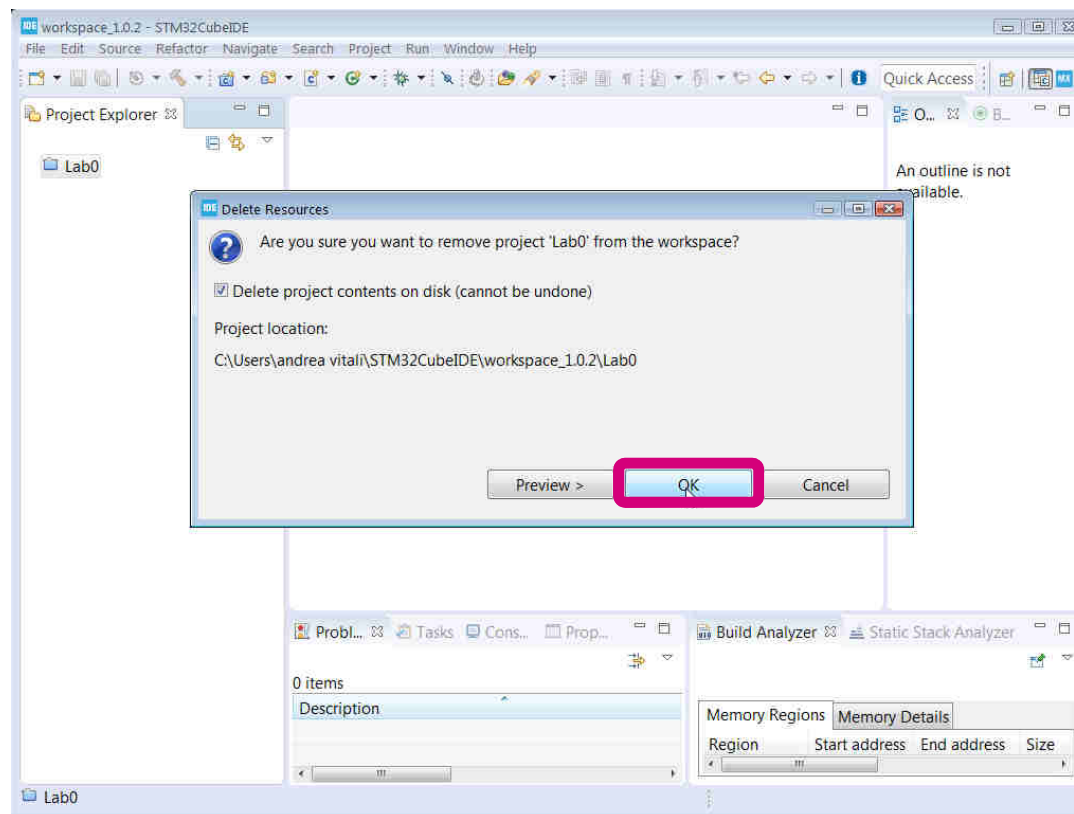
1. Right click on the project name and select **Delete**



STM32CubeIDE Configuration

305

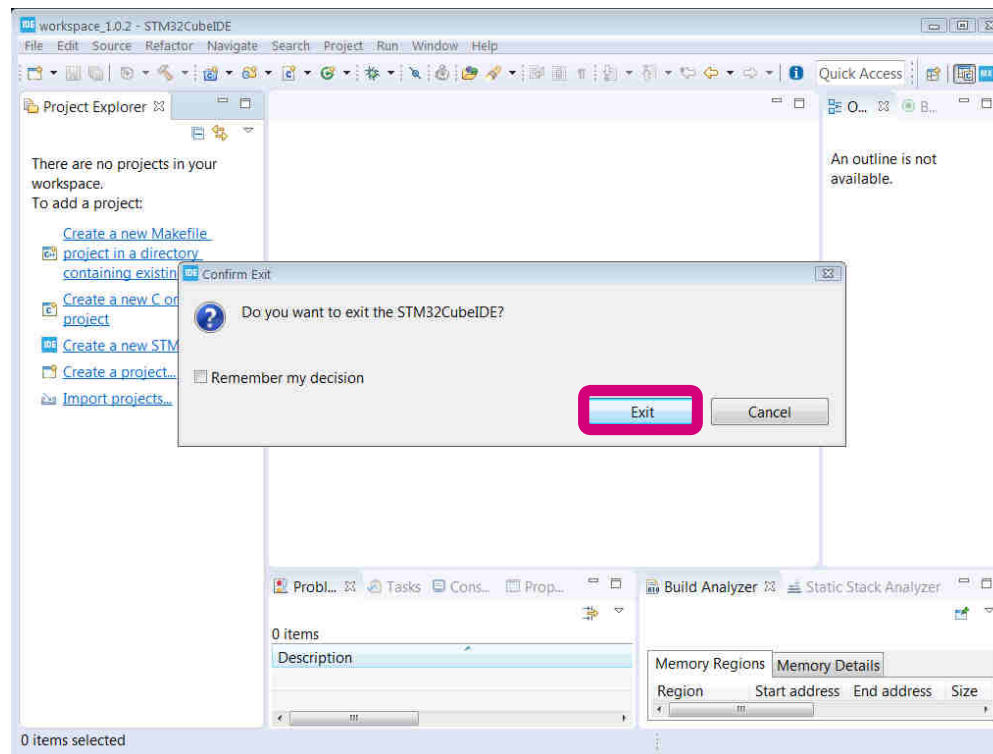
1. Check to delete files on disk and then click **Ok**

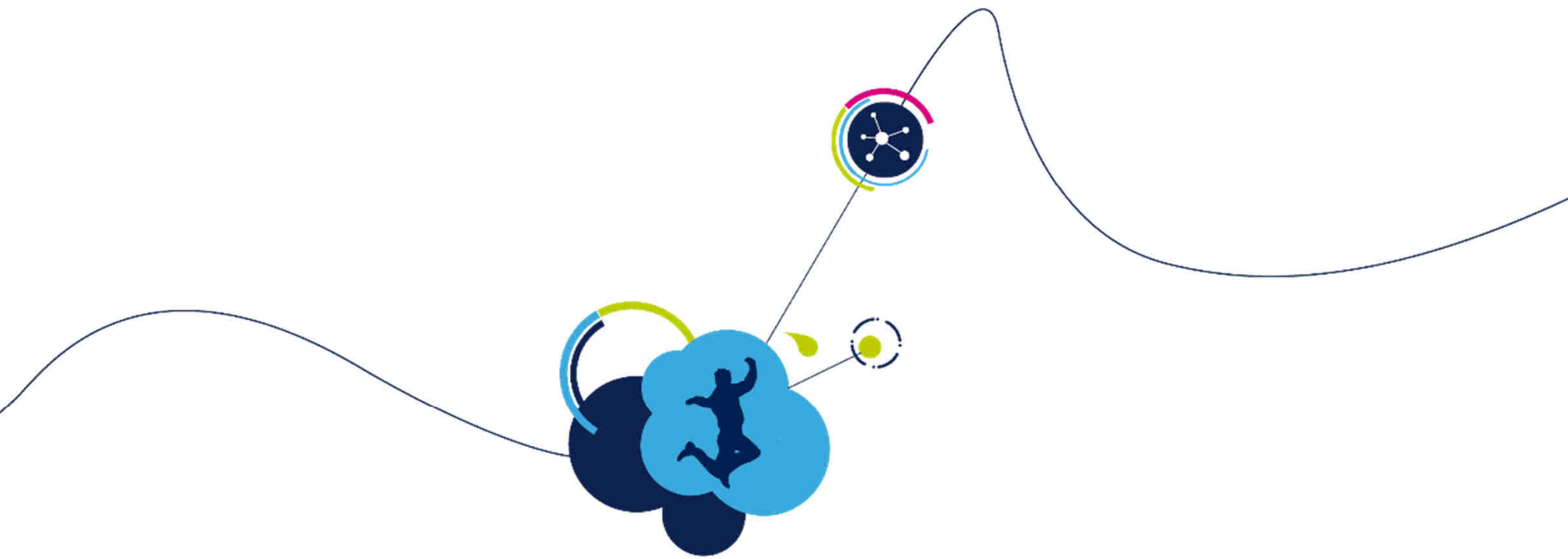


STM32CubeIDE Configuration

306

1. Close the window and confirm **Exit**





Tera Term Installation

Tera Term Setup 1/9

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1. Launch the ***teraterm-4.102.exe*** installer

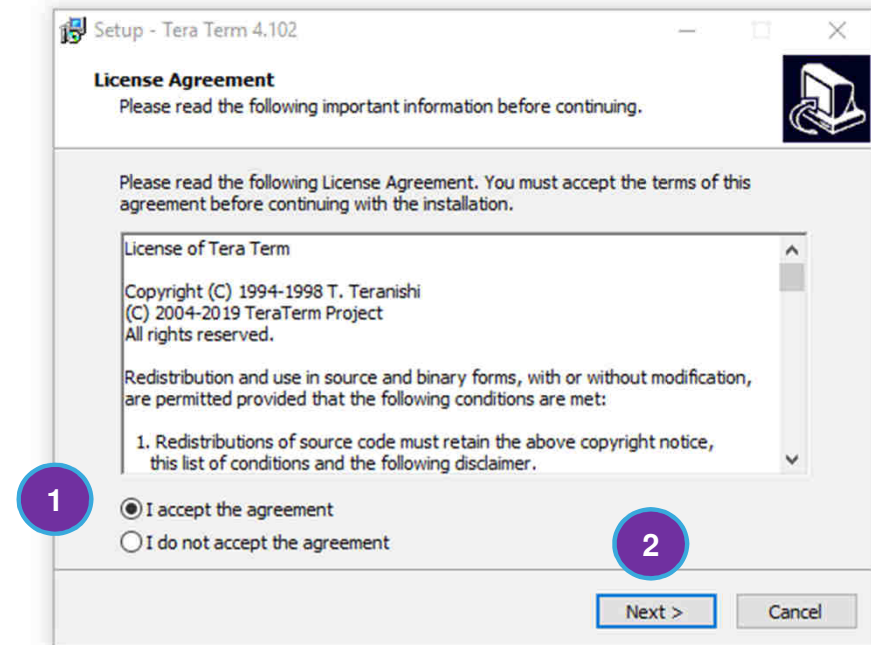


teraterm-4.102.exe

Tera Term Setup 2/9

309

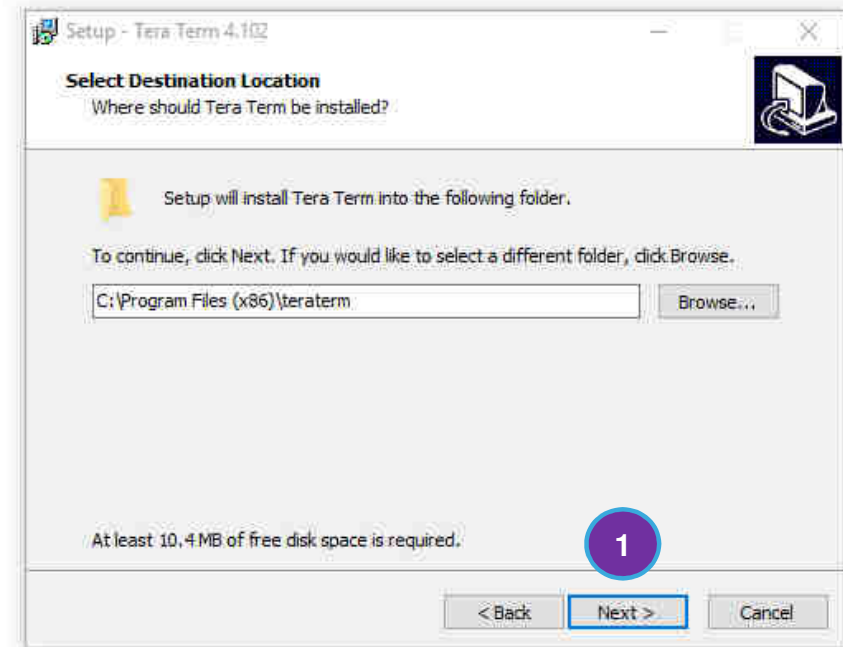
1. Accept the agreement
2. Click on **Next**



Tera Term Setup 3/9

310

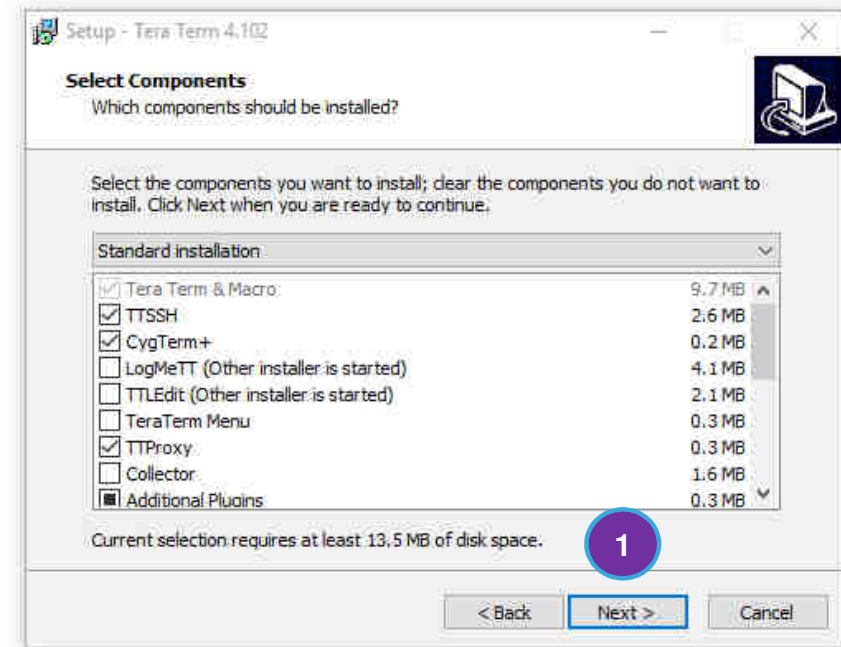
1. Click on **Next**



Tera Term Setup 4/9

311

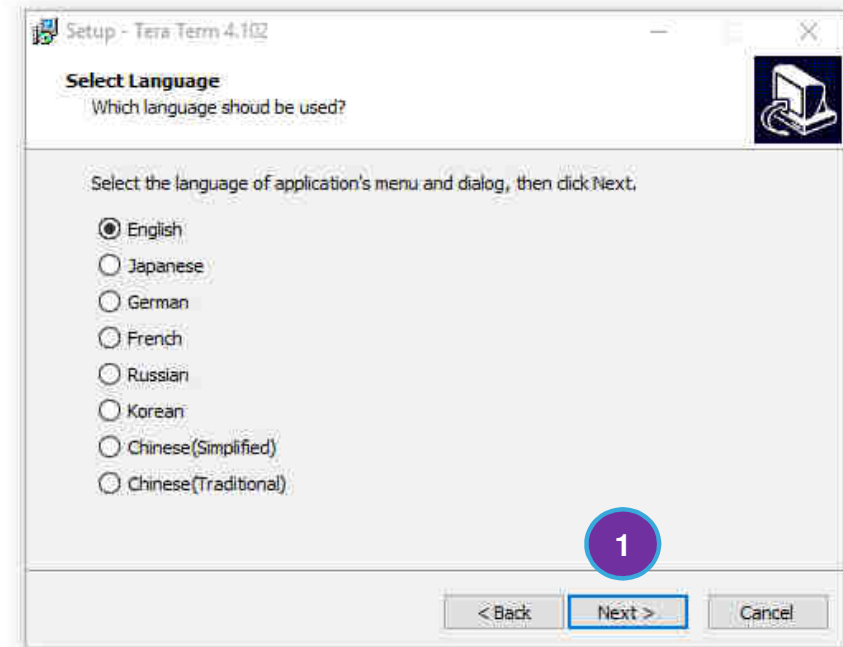
1. Click on **Next**



Tera Term Setup 5/9

312

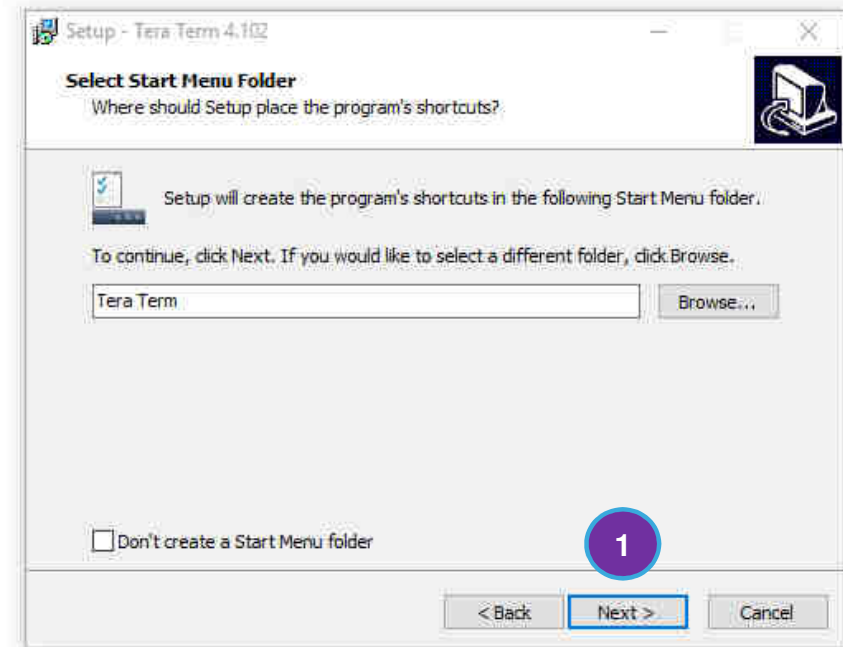
1. Click on **Next**



Tera Term Setup 6/9

313

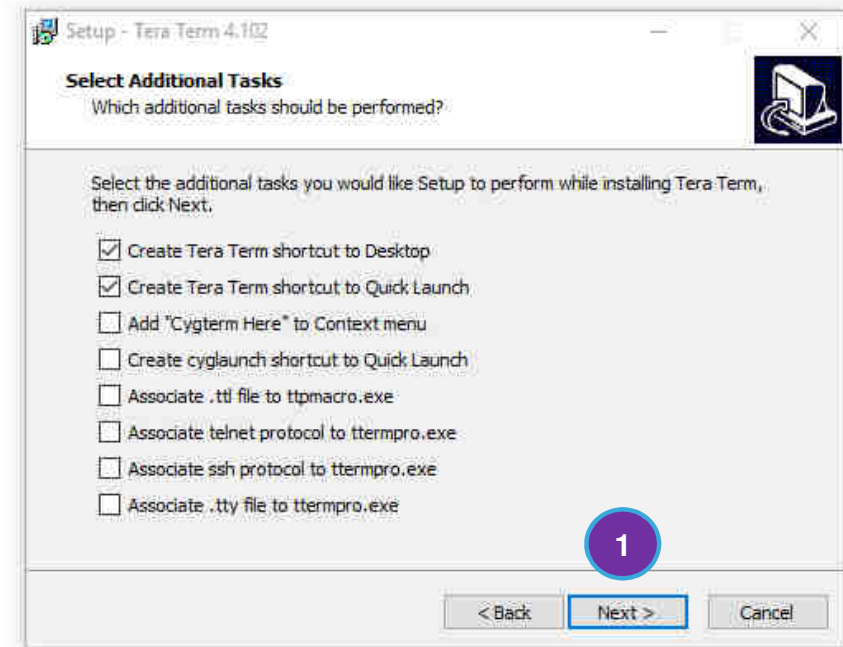
1. Click on **Next**



Tera Term Setup 7/9

314

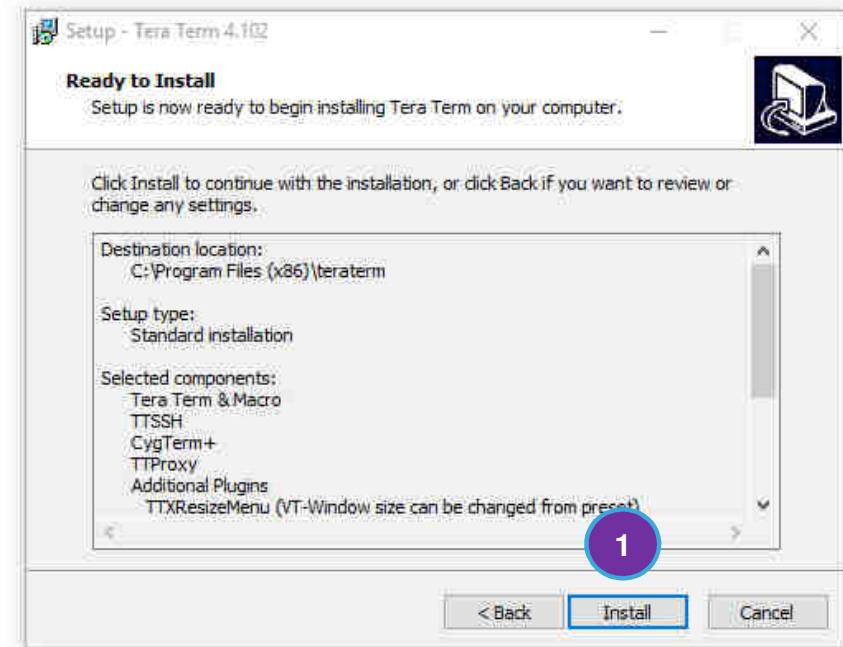
1. Click on **Next**



Tera Term Setup 8/9

315

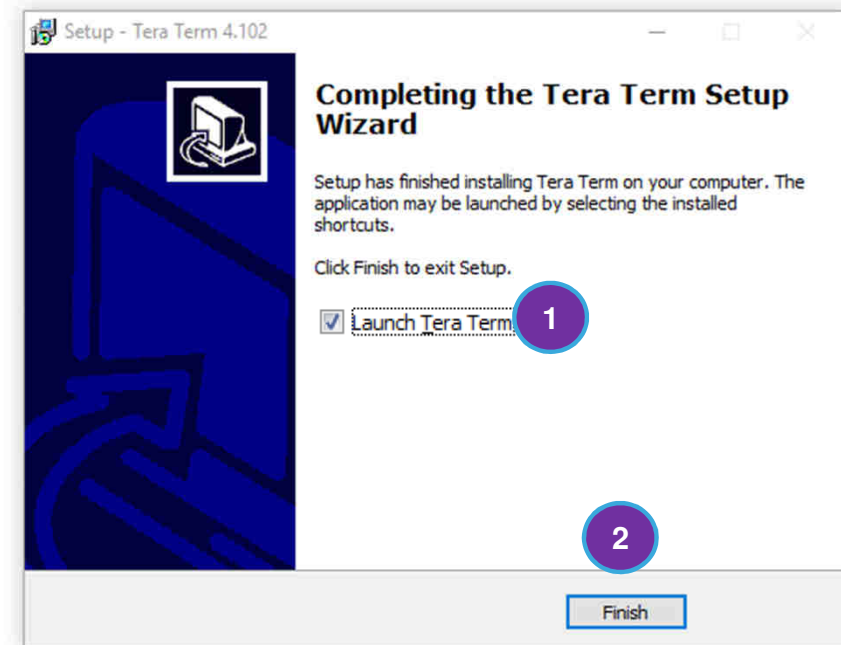
1. Click on **Install**

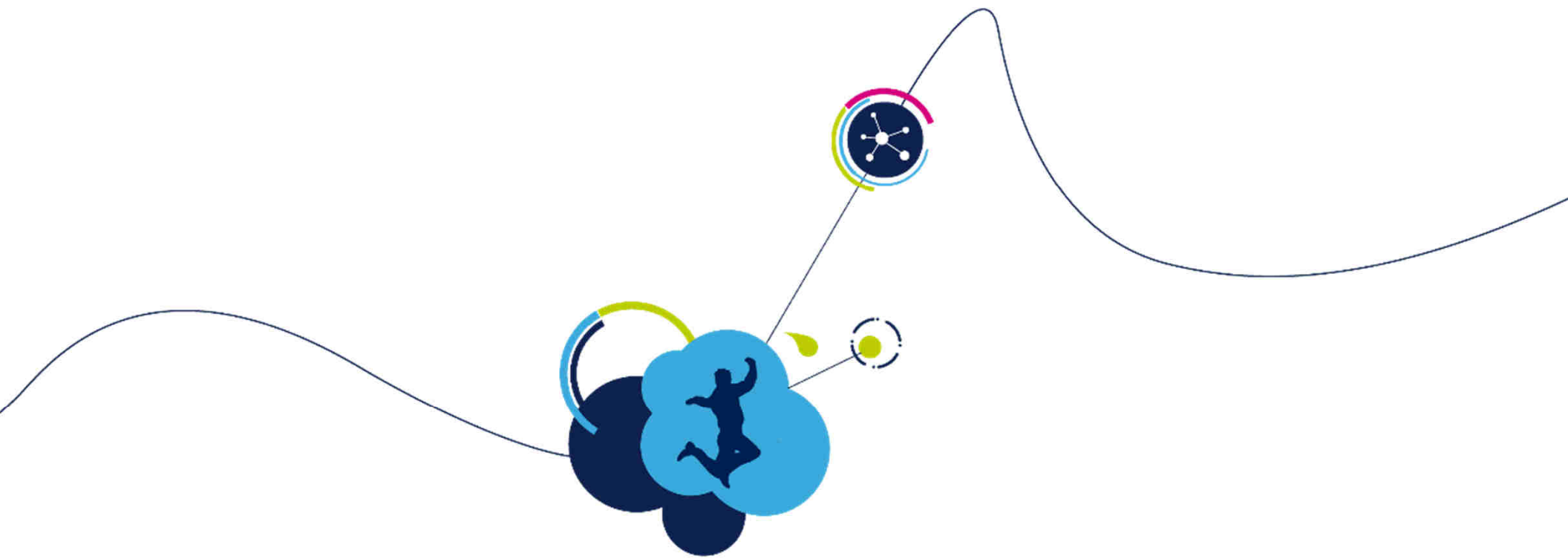


Tera Term Setup 9/9

316

1. Select **Launch Tera Term**
2. Click on **Finish**





Tera Term Configuration

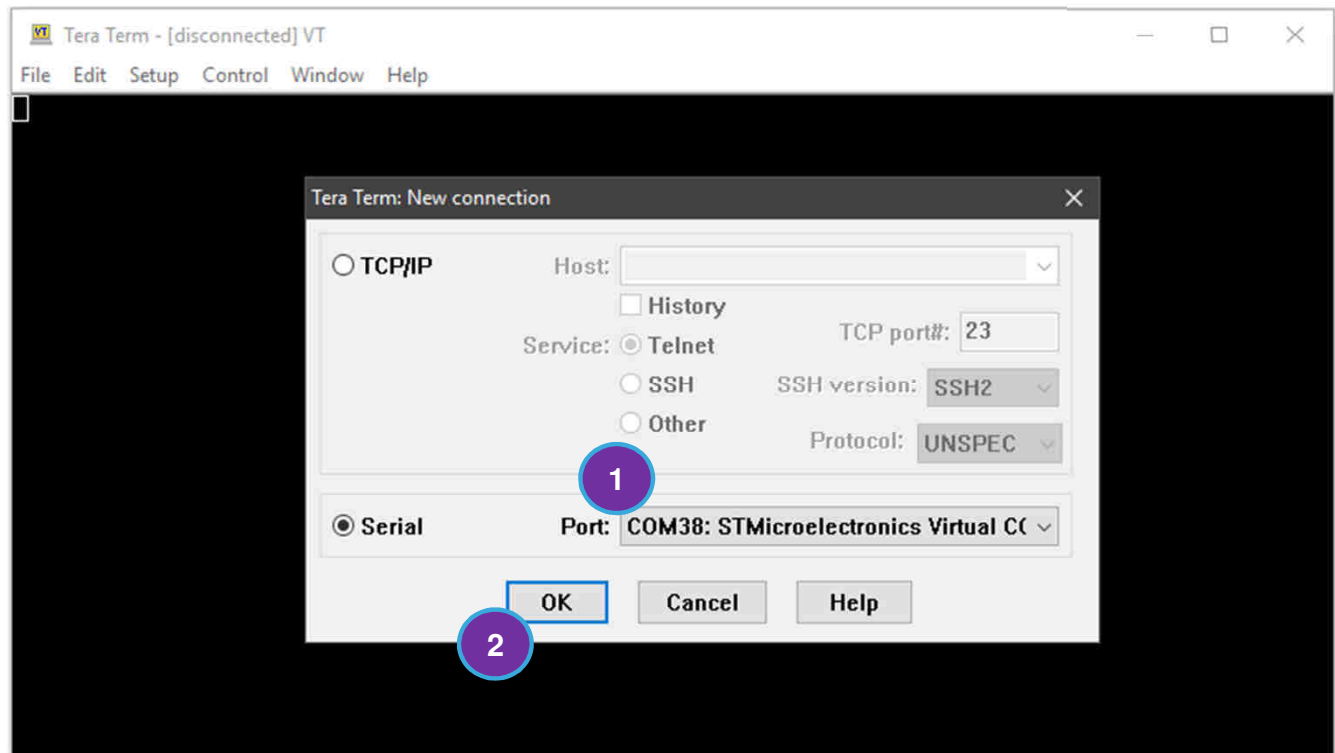
Tera Term Configuration 1/5

318

Plug the board to the PC using the micro USB cable provided



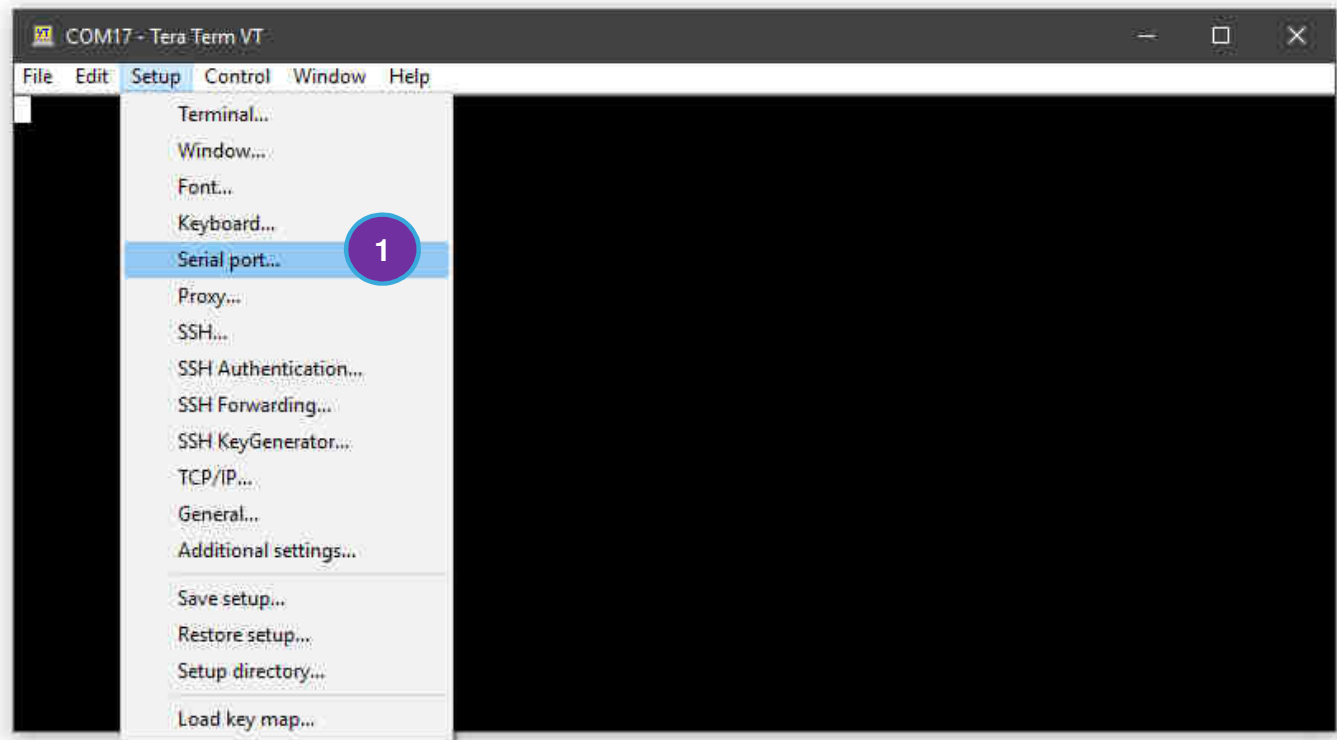
1. Select the **STMicroelectronics Virtual COM Port**
2. Click **OK**



Tera Term Configuration 2/5

319

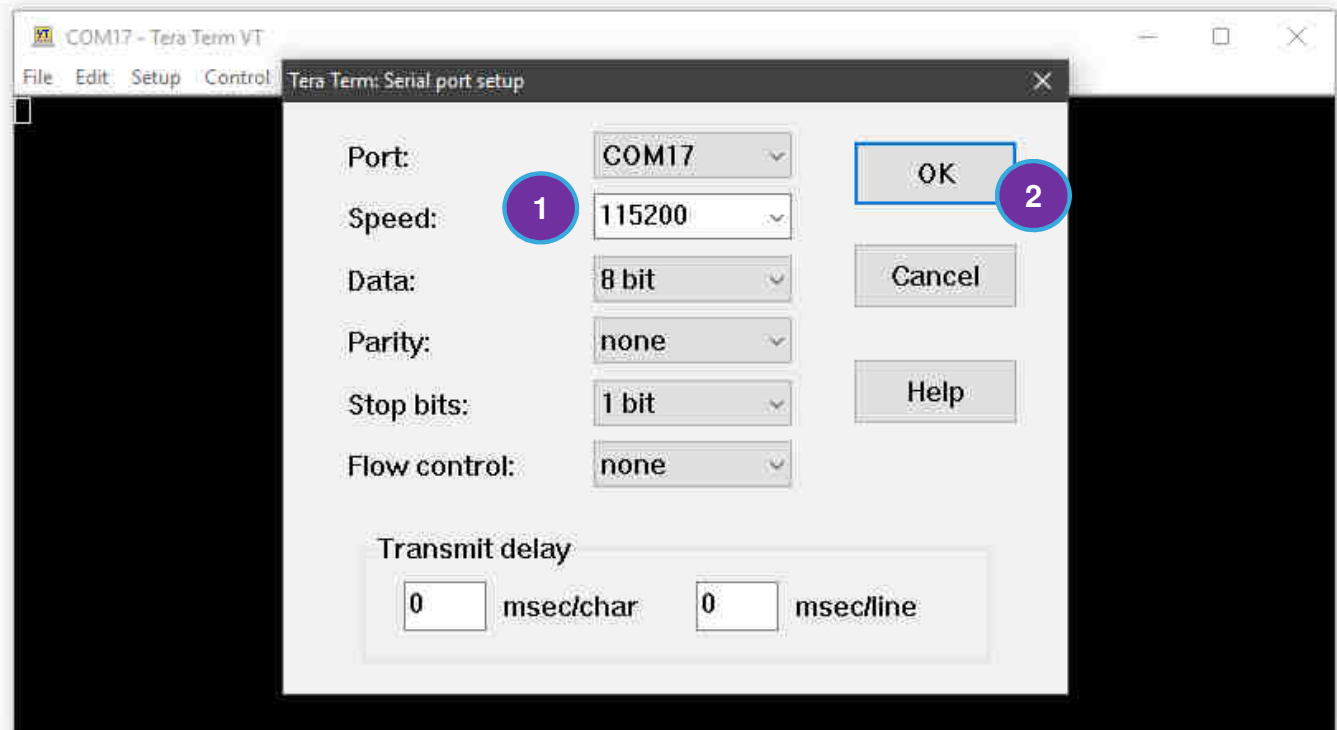
1. Click **Setup** -> **Serial port...**



Tera Term Configuration 3/5

320

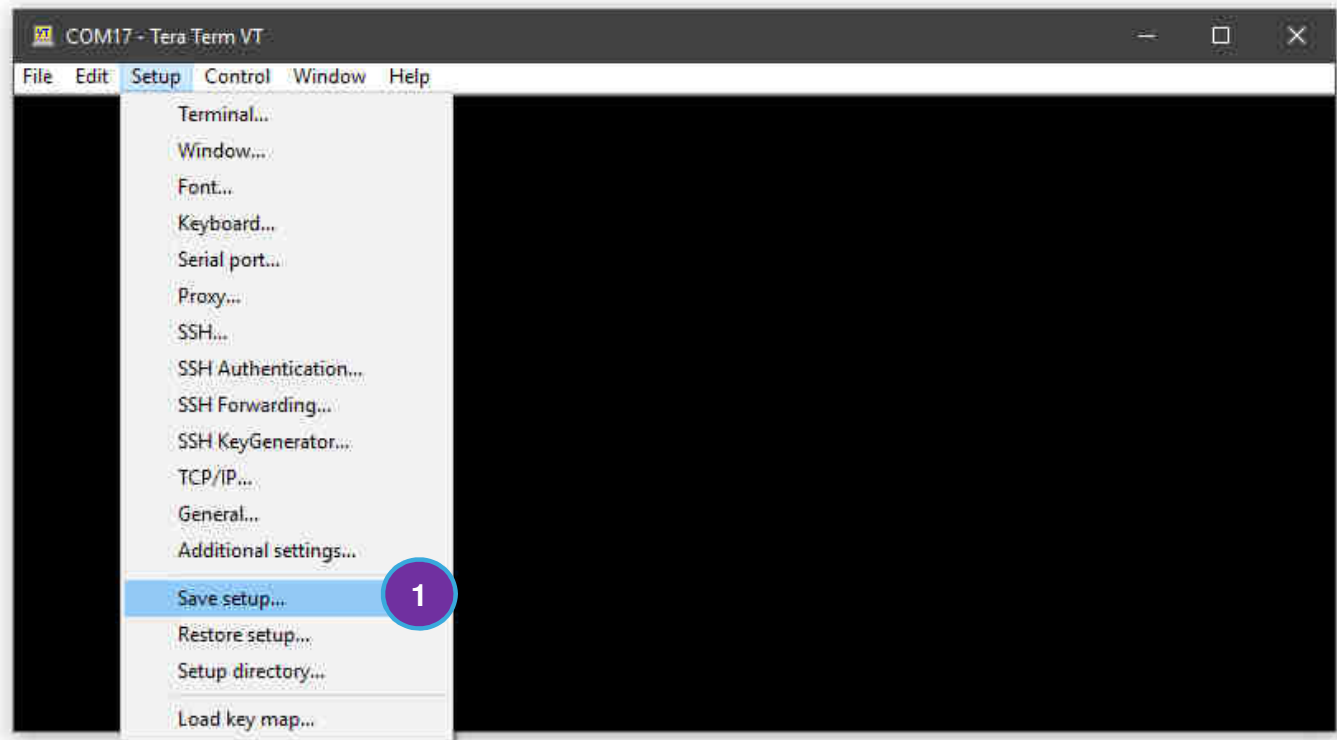
1. Set the following:
Baud Rate: **115200**
Data: **8 bit**
Parity: **none**
Stop: **1 bit**
Flow control: **none**
2. Click **OK**



Tera Term Configuration 4/5

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1. Click **Setup** -> **Save setup...**



Tera Term Configuration 5/5

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1. Click **Save**

