

How to use a sensor on a DIL 24 socket in X-CUBE-MEMS1 package applications

Introduction

The [X-CUBE-MEMS1](#) software package provides example applications for STM32 Nucleo development platforms connected to an X-NUCLEO expansion board with inertial and environmental MEMS sensors.

Examples of expansion boards are [X-NUCLEO-IKS01A1](#), [X-NUCLEO-IKS01A2](#), [X-NUCLEO-IKS01A3](#) (the latest, embedding consumer sensors) and [X-NUCLEO-IKS02A1](#) (embedding industrial sensors).

The expansion board can be further extended by plugging an additional sensor board, such as [STEVAL-MKI194V1](#) with [LSM6DSR](#), onto the DIL 24 socket.

1 Example description

In this document, we build an example application for the [NUCLEO-L476RG](#) development board, stacked with the [X-NUCLEO-IKS01A3](#) expansion board, on which the [STEVAL-MKI194V1](#) is plugged on the DIL 24 socket.

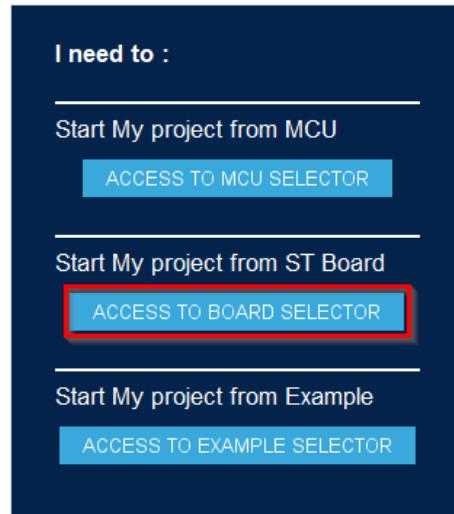
The application reads the sensor data (accelerometer, gyroscope, magnetometer) and transmit them to the MotionFX sensor fusion library which performs the orientation estimation and computes the corresponding quaternion and Euler angles (roll, pitch, and yaw).

2 Create a new project

Step 1. Run STM32CubeMX and create the new project.

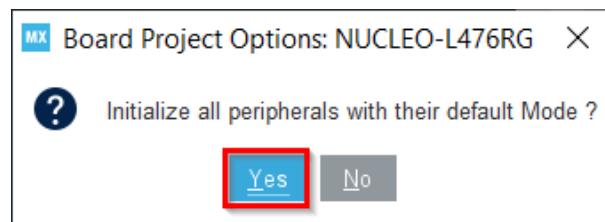
Step 2. In the main window choose [ACCESS TO BOARD SELECTOR] and select NUCLEO-L476RG development board.

Figure 1. Board selection



Step 3. Accept [Initialize all peripherals with their default Mode].

Figure 2. Default peripheral settings



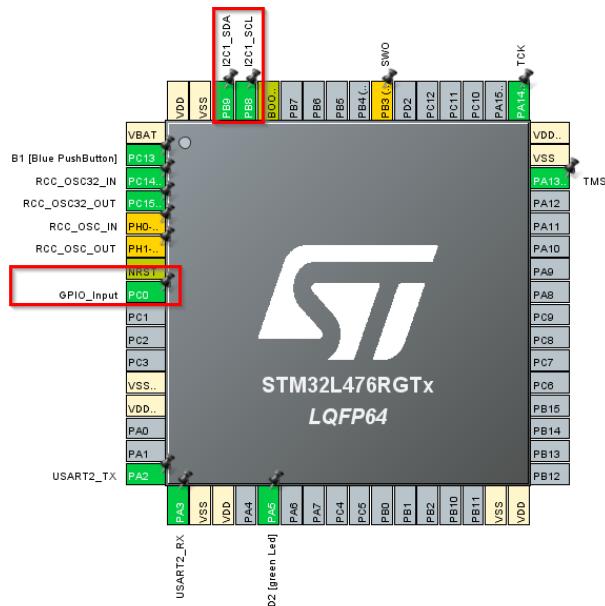
3 Pin-out setup

In the *Pinout* view you have to set pins as follows:

- PB9: I2C_SDA
- PB8: I2C_SCL
- PC0: GPIO_Input

The other pins should be already set as shown in the picture below:

Figure 3. Pin assignment



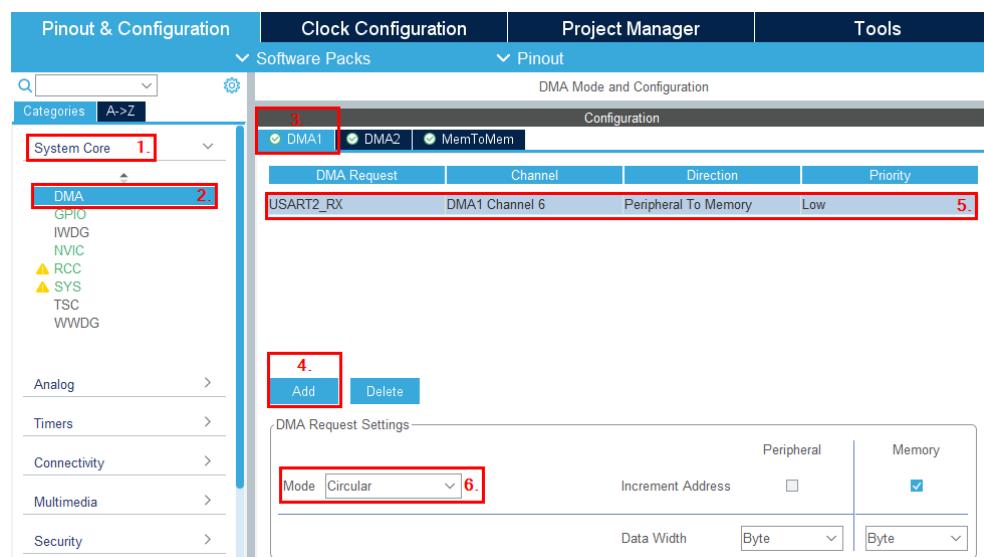
4 Peripheral configuration

4.1 DMA configuration

Referring to [Figure 4](#), follow the steps below.

- Step 1. In [Pinout & Configuration] tab open [System Core group] (1).
- Step 2. Choose [DMA] peripheral (2) - part [DMA1] (3).
- Step 3. Click on [Add] button (4) to add [DMA Request: USART2_RX] (5).
- Step 4. Set [Circular] mode (6) for DMA.

[Figure 4. DMA configuration](#)

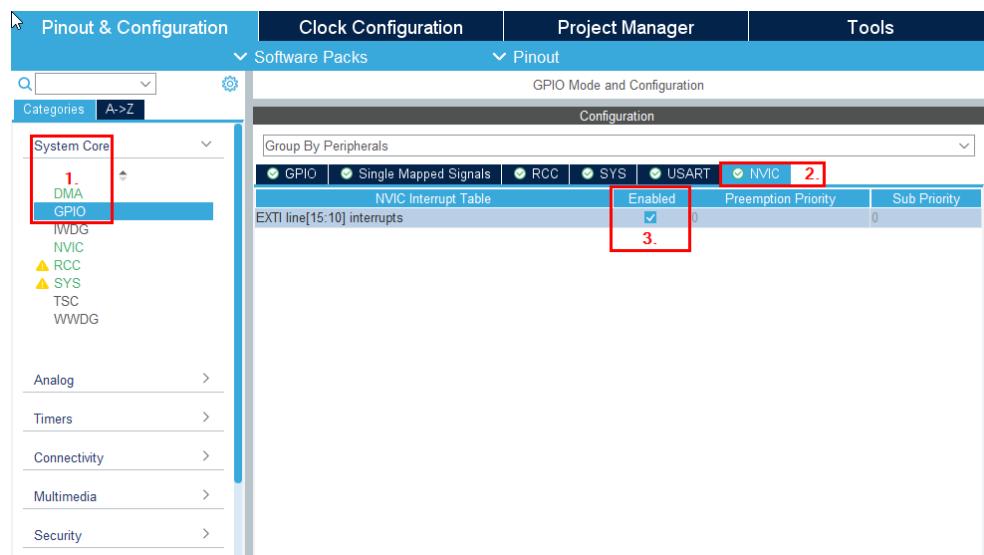


4.2 GPIO configuration

Referring to [Figure 5](#), follow the steps below.

- Step 1. For [System Core - GPIO] (1), select [NVIC] tab (2).
- Step 2. Check [Enabled] (3) for EXTI line[15:10] interrupts

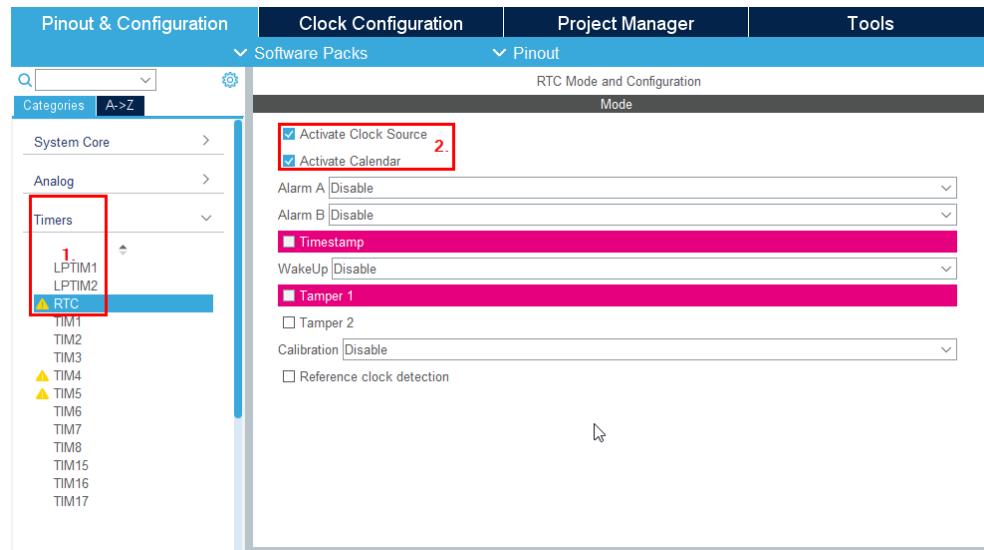
Figure 5. GPIO configuration



4.3 RTC configuration

For [Timers - RTC] (1), check [Activate Clock Source] and [Activate Calendar] (2).

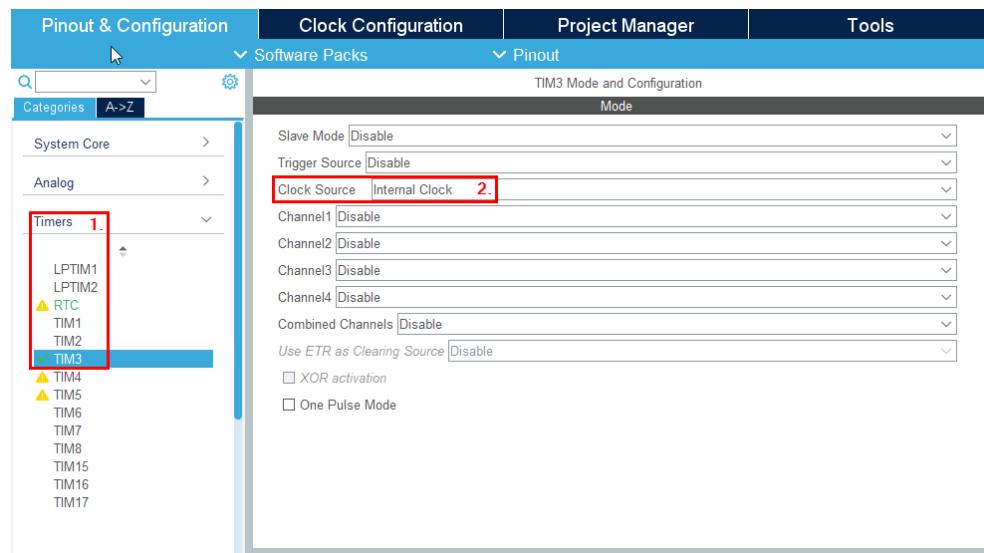
Figure 6. RTC configuration



4.4 TIM3 configuration

For [Timers - TIM3] (1), select [Internal Clock] for [Clock Source] (2).

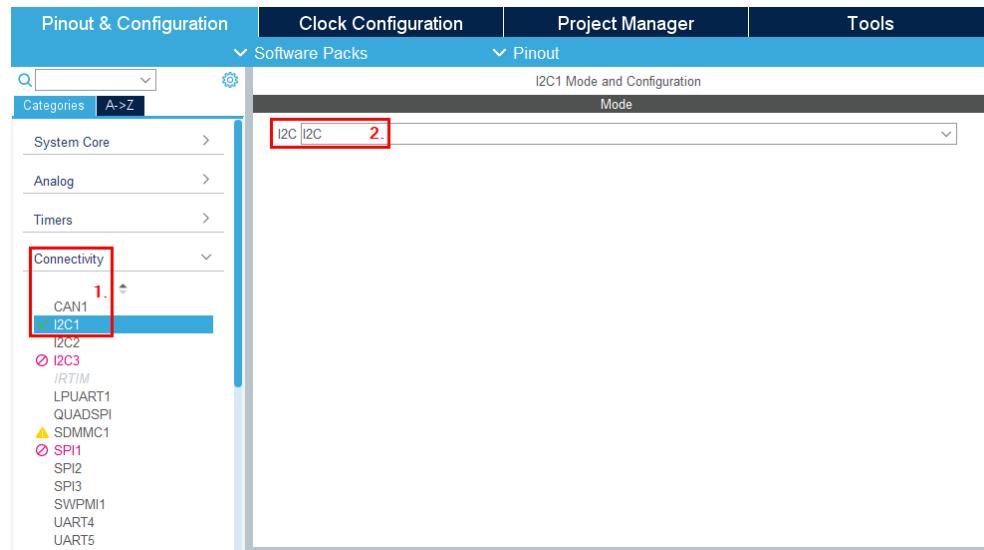
Figure 7. TIM3 configuration



4.5 I2C1 configuration

For [Connectivity - I2C1] (1), select [I2C] mode (2).

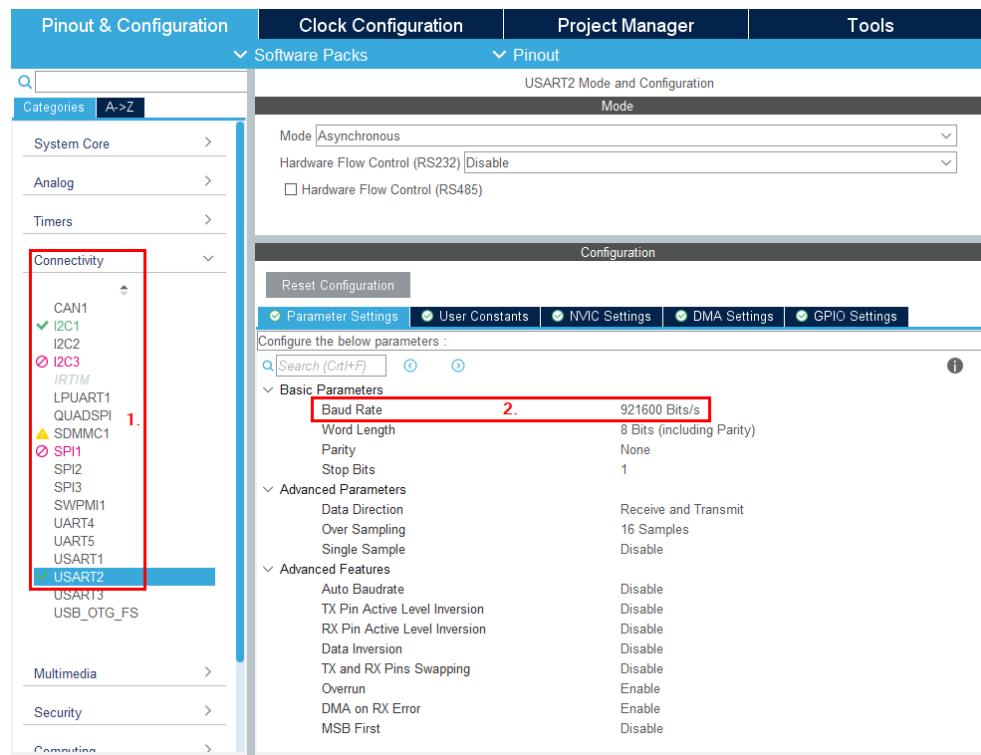
Figure 8. I2C1 configuration



4.6 USART2 configuration

For [Connectivity - USART2] (1), change [Baud Rate] to 921600 Bits/s (2) in [Parameter Settings] tab.

Figure 9. USART2 configuration

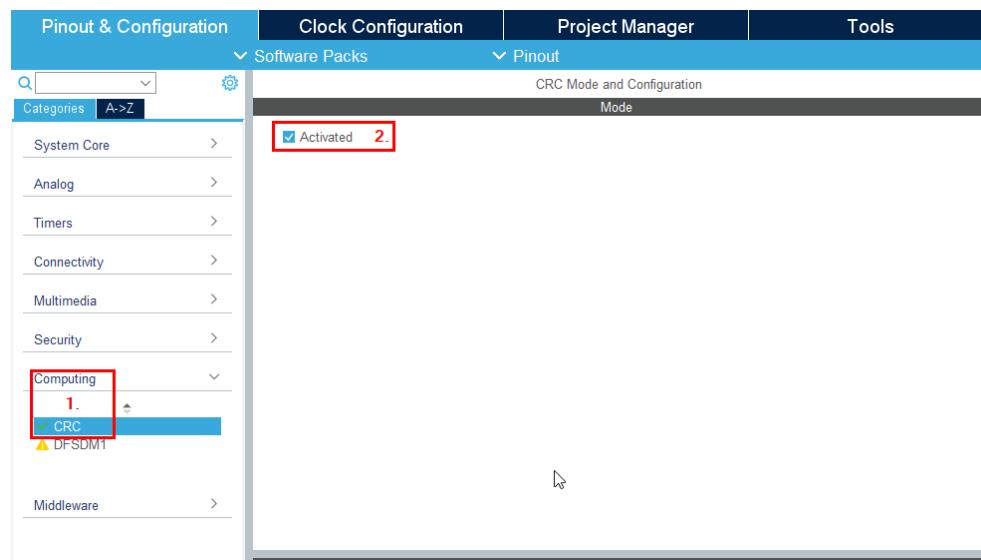


4.7 CRC configuration

Referring to [Figure 10. CRC configuration](#), follow the procedure below.

Step 1. For [Computing - CRC] (1), check [Activated] (2).

Figure 10. CRC configuration



4.8 NVIC configuration

For [System Core - NVIC] (1), check [Enabled] for TIM3 global interrupt (2).

Figure 11. NVIC configuration

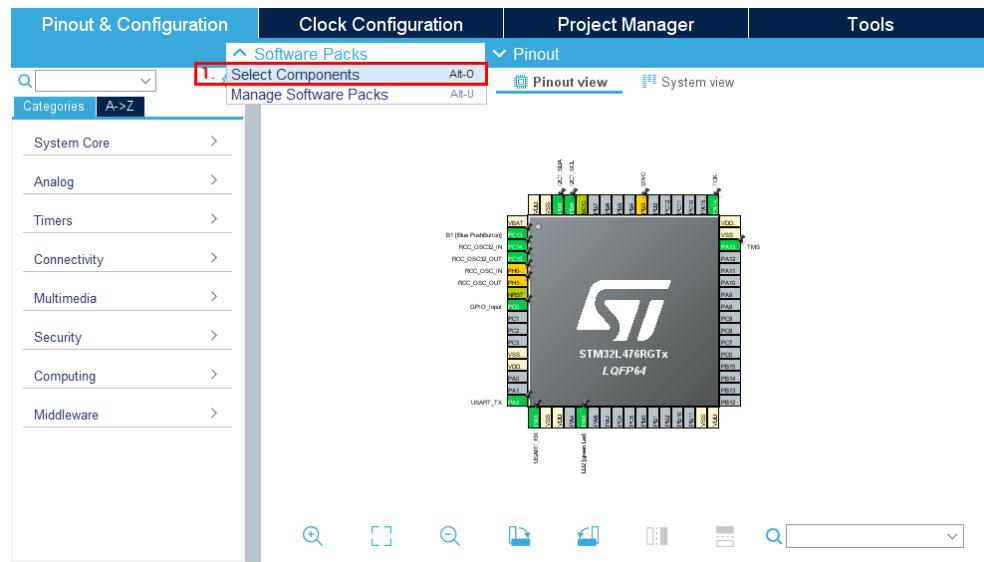
Interrupt	Enabled	Preemption Priority	Sub Priority
Hard fault interrupt	<input checked="" type="checkbox"/>	0	0
Memory management fault	<input checked="" type="checkbox"/>	0	0
Prefetch fault, memory access fault	<input checked="" type="checkbox"/>	0	0
Undefined instruction or illegal state	<input checked="" type="checkbox"/>	0	0
System service call via SWI instruction	<input checked="" type="checkbox"/>	0	0
Debug monitor	<input checked="" type="checkbox"/>	0	0
Pendable request for system service	<input checked="" type="checkbox"/>	0	0
Time base: System tick timer	<input checked="" type="checkbox"/>	0	0
PVD/PVM1/PVM2/PVM3/PVM4 interrupts through EXTI lines 16/35/36/37/...	<input type="checkbox"/>	0	0
Flash global interrupt	<input type="checkbox"/>	0	0
RCC global interrupt	<input type="checkbox"/>	0	0
DMA1 channel6 global interrupt	<input checked="" type="checkbox"/>	0	0
TIM3 global interrupt	<input checked="" type="checkbox"/>	0	2.
I2C1 event interrupt	<input type="checkbox"/>	0	0
I2C1 error interrupt	<input type="checkbox"/>	0	0
USART2 global interrupt	<input type="checkbox"/>	0	0
EXTI line[15:10] interrupts	<input checked="" type="checkbox"/>	0	0
FPU global interrupt	<input type="checkbox"/>	0	0

5 Software pack setup

5.1 Software Packs menu

From [Software Packs], choose [Select Components] (1).

Figure 12. Software components selection



5.2 Software pack selection

From [Packs], choose STMicroelectronics.X-CUBE-MEMS1 8.2.0 (2).

Figure 13. X-CUBE-MEMS1 pack selection

Pack / Bundle / Component	Version	Selection
> STM icroelectronics.X-CUBE-AI	5.2.0	
> STM icroelectronics.X-CUBE-ALGOBUILD	1.1.0	
> STM icroelectronics.X-CUBE-BLE1	6.1.0	
> STM icroelectronics.X-CUBE-BLE2	3.1.0	
> STM icroelectronics.X-CUBE-DISPLAY	1.0.0	Install
> STM icroelectronics.X-CUBE-EEPRMA1	3.0.0	Install
> STM icroelectronics.X-CUBE-GNSS1	5.1.0	
STMicroelectronics.X-CUBE-MEMS1	8.2.0	2.
<i>Board Part</i> AccGyr / LSM6DSL		Not selected
<i>Board Part</i> AccGyr / LSM6DSO		Not selected
<i>Board Part</i> AccMag / LSM303AGR		Not selected
<i>Board Part</i> Acc / LIS2DW12		Not selected
<i>Board Part</i> Mag / LIS3MDL		Not selected
<i>Board Part</i> Mag / LIS2MDL		Not selected
<i>Board Part</i> HumTemp / HTS221		Not selected
<i>Board Part</i> PressTemp / LPS22HB		Not selected
<i>Board Part</i> PressTemp / LPS22HH		Not selected
<i>Board Part</i> Temp / STTS751		Not selected
<i>Board Part</i> AccGyr / LSM6DSOX		Not selected
<i>Board Part</i> PressTemp / LPS33HW		Not selected
<i>Board Part</i> Acc / LIS2DH12		Not selected
<i>Board Part</i> AccGyr / ASM330LHH		Not selected
<i>Board Part</i> AccGyr / ISM330DLC		Not selected
<i>Board Part</i> AccMag / ISM303DAC		Not selected
<i>Board Part</i> Acc / IIS2DLPC		Not selected
<i>Board Part</i> Mag / IIS2MDC		Not selected
<i>Board Part</i> AccGyr / ISM330DHGX		Not selected
<i>Board Part</i> AccGyr / LSM6DSO		Not selected

5.3 Application selection

From [STMicroelectronics.X-CUBE-MEMS1 8.2.0], choose [Device MEMS1_Applications]>[Application: CUSTOM_DataLogFusion] (3).

Figure 14. Application selection

Packs	Pack / Bundle / Component	Version	Selection
	Board Part PressTemp / LPS33K		Not selected
	Board Part PressTemp / LPS22CH		Not selected
	Board Part PressTemp / LPS27HHTW		Not selected
	Board Extension IKS01A3	1.5.0	<input type="checkbox"/>
	Board Extension IKS01A2	5.3.1	<input type="checkbox"/>
	Board Extension IKS02A1	1.1.1	<input type="checkbox"/>
>	Board Support STM32Cube_Custom_BSP_Drivers	8.2.0	
<	Device MEMS1_Applications	8.2.0	
<	Application	3.	CUSTOM_DataLogFusion
>	Sensors STM32_MotionID_Library	2.2.1	
>	Sensors STM32_MotionFX_Library	2.4.1	
>	Sensors STM32_MotionGC_Library	2.3.1	

Component dependencies

Component Application CUSTOM_DataLogFusion (from bundle Device MEMS1_Applications in pack STMicroelectronics.X-CUBE Click on solutions below to highlight them in the pack tree above:

- > ⓘ Requires: condition ACCELEROMETER_SENSOR
- > ⓘ Requires: condition GYROSCOPE_SENSOR
- > ⓘ Requires: component class Sensors, bundle STM32_MotionFX_Library, group STM32_MotionFX_Library, sub Core
- > ⓘ Requires: component class Board Support, bundle STM32Cube_Custom_BSP_Drivers, group Custom, sub MOTION_

5.4

Accelerometer and gyroscope selection

From [STMicroelectronics.X-CUBE-MEMS1 8.2.0], choose [Board Part AccGyr / LSM6DSR 1.0.1 I2C] (4). We will use I²C communication in this example.

Figure 15. Accelerometer and gyroscope selection

Pack	Pack / Bundle / Component	Version	Selection
	Board Part AccGyr / ASM330LHH		Not selected
	Board Part AccGyr / ISM330DLC		Not selected
	Board Part AccMag / ISM303DAC		Not selected
	Board Part Acc / IIS2DLPC		Not selected
	Board Part Mag / IIS2MDC		Not selected
	Board Part AccGyr / ISM330DHCH		Not selected
	Board Part AccGyr / LSM6DSR	4.	I2C
	Board Part Acc / AIS2DW12		Not selected
	Board Part Temp / STTS22H		Not selected
	Board Part Gyr / A3G4250D		Not selected
	Board Part Acc / AIS328DQ		Not selected
	Board Part Acc / AIS3624DQ		Not selected

Component dependencies

Component Application CUSTOM_DataLogFusion (from bundle Device MEMS1_Applications in pack STMicroelectronics.X-CUBE Click on solutions below to highlight them in the pack tree above:

- ✓ ⓘ Requires: component class Sensors, bundle STM32_MotionFX_Library, group STM32_MotionFX_Library, sub Core
 - ✓ ⓘ Solutions in STMicroelectronics.X-CUBE-MEMS1.8.2.0:
 - ? Component STM32_MotionFX_Library/Core
- ✓ ⓘ Requires: component class Board Support, bundle STM32Cube_Custom_BSP_Drivers, group Custom, sub MOTION_!
 - ✓ ⓘ Solutions in STMicroelectronics.X-CUBE-MEMS1.8.2.0:
 - ? Component Custom/MOTION_SENSOR

5.5 Magnetometer selection (optional)

From [STMicroelectronics.X-CUBE-MEMS1 8.2.0], choose [Board Part Mag / LIS2MDL 1.2.2 I2C] (5). We will use I²C communication in this example.

Figure 16. Magnetometer selection

Packs			Collapse all
Pack / Bundle / Component	Version	Selection	
> STMicroelectronics.X-CUBE-GNSS1	5.1.0	Not selected	▼
▽ STMicroelectronics.X-CUBE-MEMS1	8.2.0	Not selected	▼
Board Part AccGyr / LSM6DSL		Not selected	▼
Board Part AccGyr / LSM6DSO		Not selected	▼
Board Part AccMag / LSM303AGR		Not selected	▼
Board Part Acc / LIS2DW12		Not selected	▼
Board Part Mag / LIS3MDL		Not selected	▼
Board Part Mag / LIS2MDL	5.	I2C	▼
Board Part HumTemp / HTS221		Not selected	▼
Board Part PressTemp / LPS22HB		Not selected	▼
Board Part PressTemp / LPS22HH		Not selected	▼
Board Part Temp / STTS751		Not selected	▼

Component dependencies

Component *Board Part Mag / LIS2MDL I2C* (from pack STMicroelectronics.X-CUBE-MEMS1.8.2.0)
All conditions are solved.

5.6 BSP driver selection

From [STMicroelectronics.X-CUBE-MEMS1 8.2.0], choose [Board Support STM32Cube_custom_BSP_Drivers]>[Custom]>[MOTION_SENSOR] (6).

Figure 17. BSP driver selection

Packs		
Pack / Bundle / Component	Version	Selection
Board Part PressTemp / LPS33K		Not selected
Board Part PressTemp / LPS22CH		Not selected
Board Part PressTemp / LPS27HHTW		Not selected
Board Extension IKS01A3	1.5.0	<input type="checkbox"/>
Board Extension IKS01A2	5.3.1	<input type="checkbox"/>
Board Extension IKS02A1	1.1.1	<input type="checkbox"/>
Board Support STM32Cube_Custom_BSP_Drivers 6.	8.2.0	<input checked="" type="checkbox"/>
Custom / MOTION_SENSOR		
Custom / ENV_SENSOR		<input type="checkbox"/>
Device MEMS1_Applications	8.2.0	
Application		CUSTOM_DataLogFusion
Sensors STM32_MotionID_Library	2.2.1	

Component dependencies

Component Application CUSTOM_DataLogFusion (from bundle Device MEMS1_Applications in pack STMicroelectronics.X-CUBE Click on solutions below to highlight them in the pack tree above:

- Requires: component class Sensors, bundle STM32_MotionFX_Library, group STM32_MotionFX_Library, sub Core
- Solutions in STMicroelectronics.X-CUBE-MEMS1.8.2.0:
 - Component STM32_MotionFX_Library/Core

5.7

Algorithm library selection

Step 1. From [STMicroelectronics.X-CUBE-MEMS1 8.2.0], choose [Sensors STM32_MotionFX_Library]>[STM32_MotionFX_Library/Core] (7).

Figure 18. Middleware selection

Packs		
Pack / Bundle / Component	Version	Selection
Board Support STM32Cube_Custom_BSP_Drivers	8.2.0	<input checked="" type="checkbox"/>
Custom / MOTION_SENSOR		<input checked="" type="checkbox"/>
Custom / ENV_SENSOR		<input type="checkbox"/>
Device MEMS1_Applications	8.2.0	
Application		CUSTOM_DataLogFusion
Sensors STM32_MotionID_Library	2.2.1	
Sensors STM32_MotionFX_Library	2.4.1	<input checked="" type="checkbox"/>
STM32_MotionFX_Library / Core	7.	<input checked="" type="checkbox"/>
Sensors STM32_MotionGC_Library	2.3.1	
Sensors STM32_MotionAC_Library	2.4.1	
Sensors STM32_MotionMC_Library	2.3.1	
Sensors STM32_MotionTL_Library	1.2.1	

Component dependencies

Component Application CUSTOM_DataLogFusion (from bundle Device MEMS1_Applications in pack STMicroelectronics.X-CUBE) All conditions are solved.

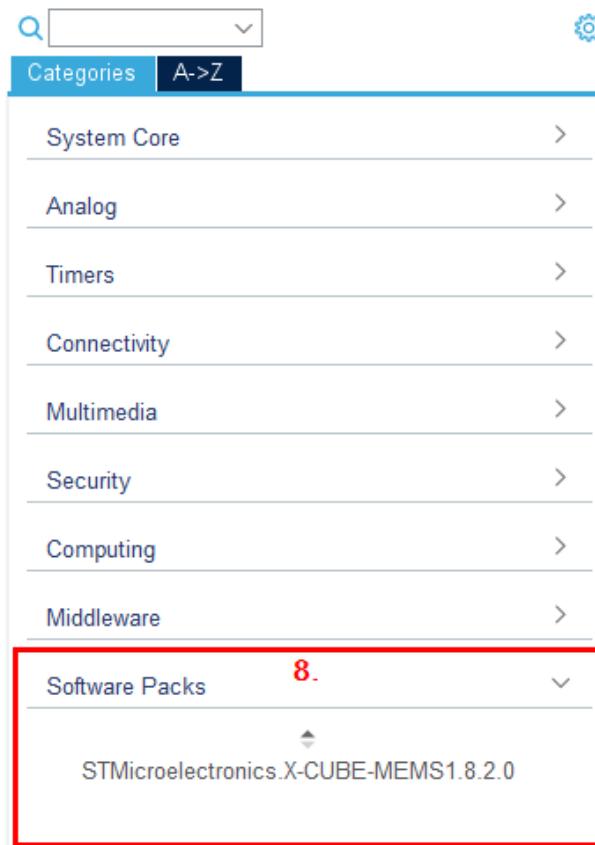
Step 2. Click [OK] to confirm the selected [Software Packs] setup.

5.8

Software pack configuration

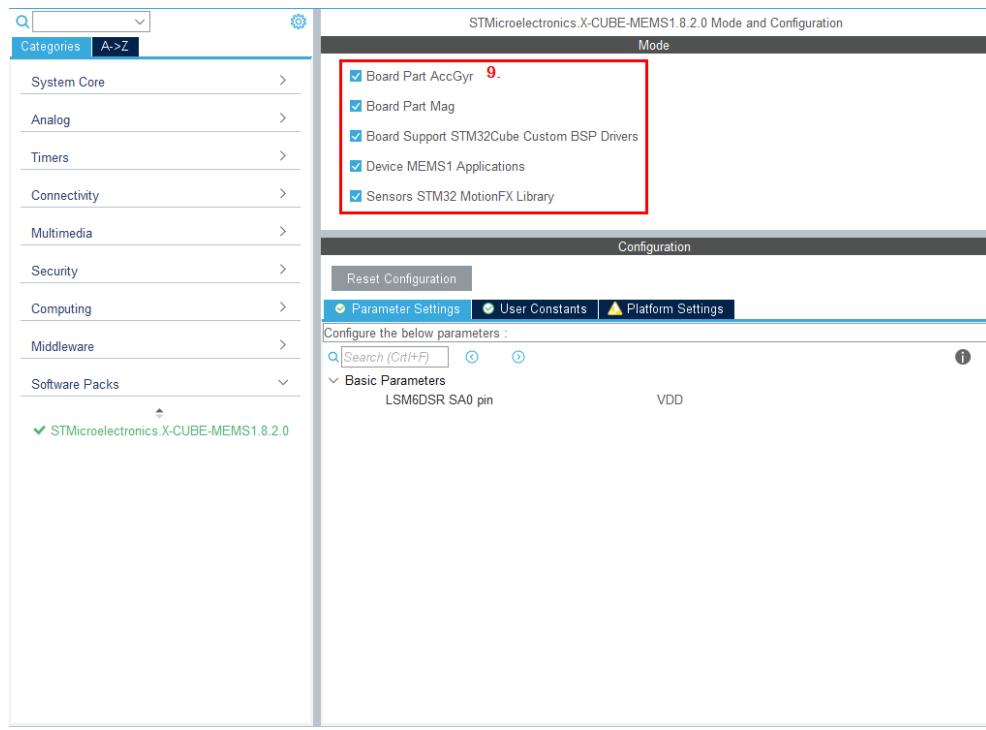
Step 1. Select [Software Packs]>[STMicroelectronics.X-CUBE-MEMS1.8.2.0] (8).

Figure 19. Software pack



Step 2. Check all check-boxes (9).

Figure 20. Software pack mode selection



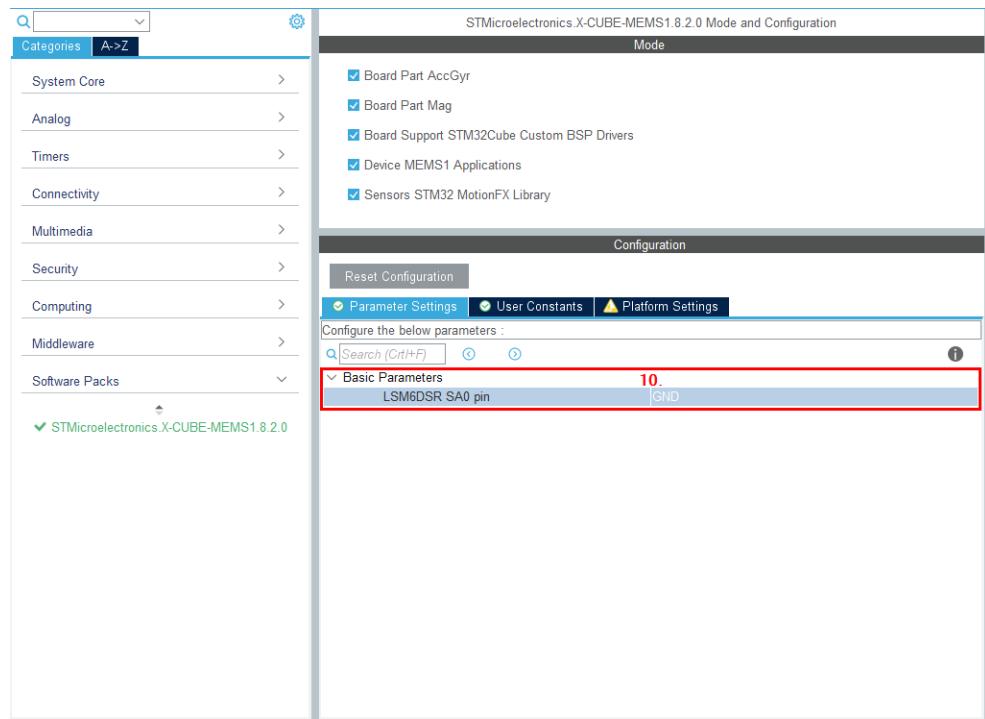
5.9

DIL 24 component custom configuration

Step 1. Change LSM6DSR SA0 pin to GND - DIL24 components by using SA0 = 0 (10).

I²C address for sensors is determined by the SA0 pin. The sensors on the board have SA0 pull-up. The sensor on the DIL24 socket must use SA0 pull-down to avoid conflicts (a conflict is when two different sensors have the same I²C address and try to talk over each other).

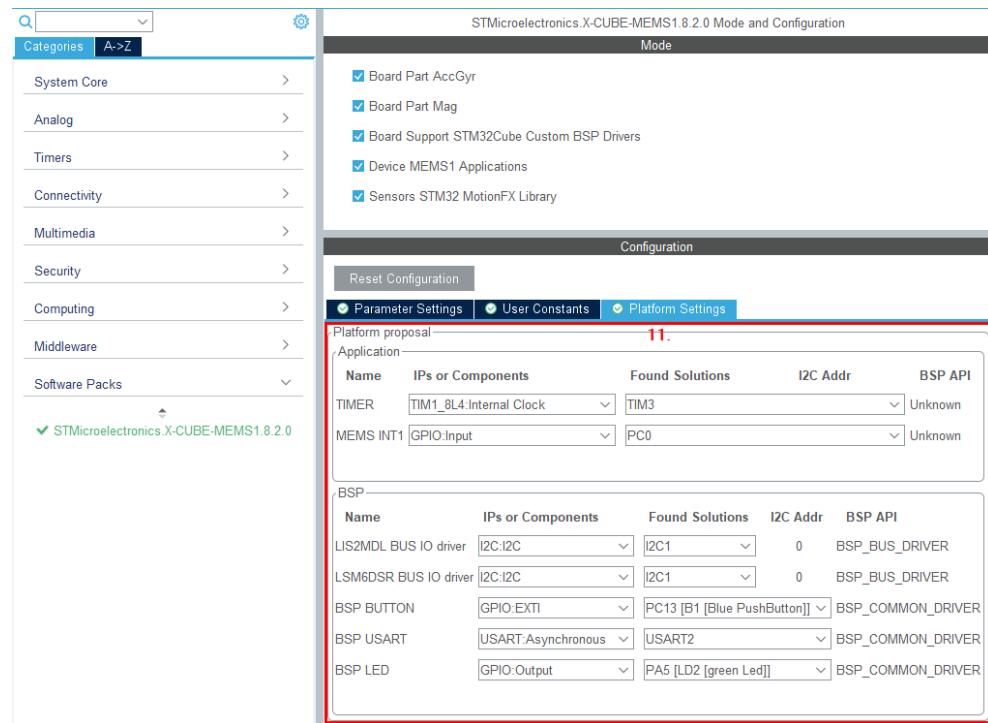
Figure 21. LSM6DSR SA0 pin configuration



5.10 Platform configuration

Step 1. Assign previously configured peripherals to required peripherals by the application example in [Platform Settings] (11).

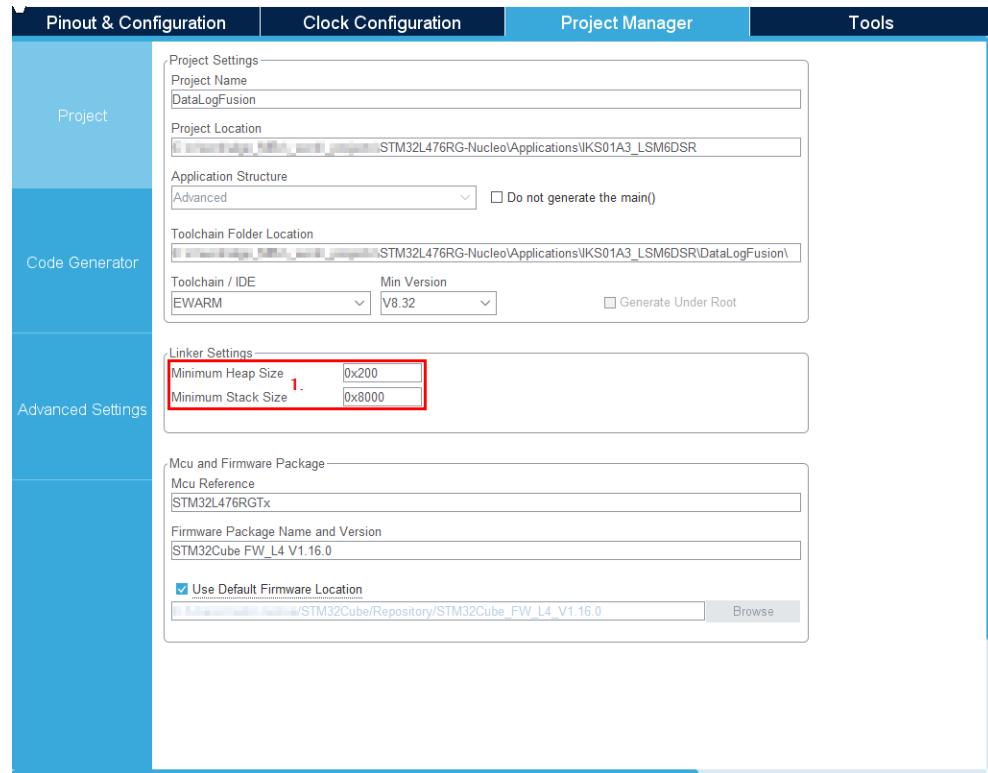
Figure 22. Platform configuration



6 Project setup

- Step 1.** In [Project Manager]>[Project], set [Minimum Heap Size/Minimum Stack Size] as shown in the picture below (1).

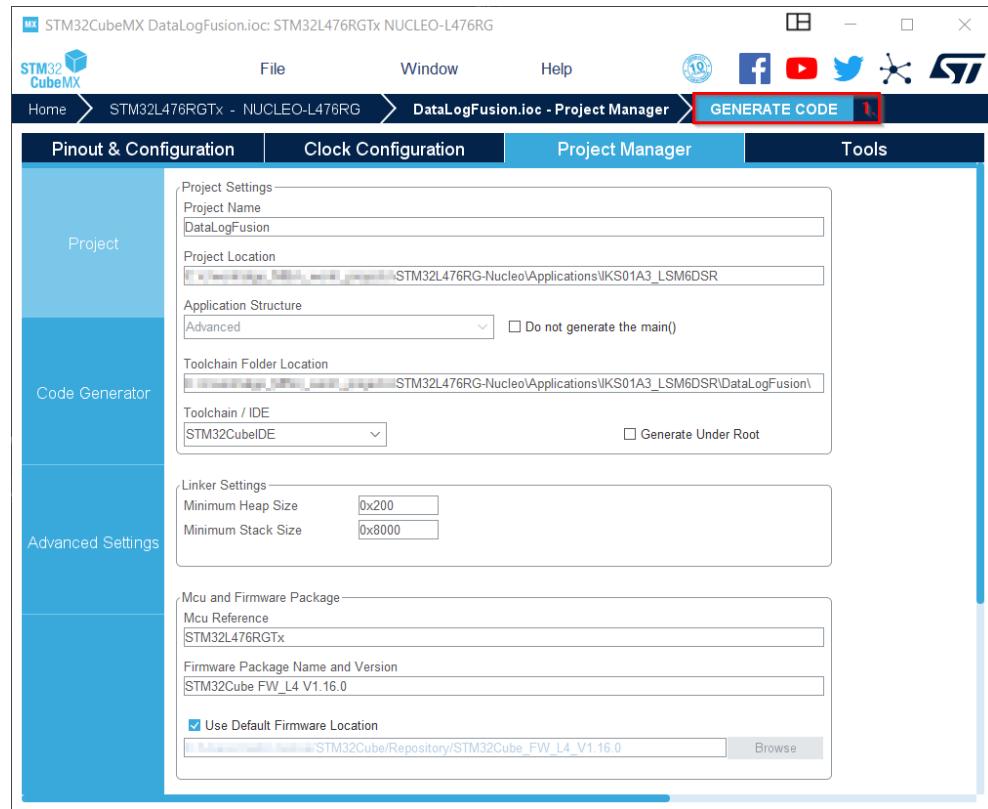
Figure 23. Heap and Stack size configuration



7 Project generation

Step 1. Click on [GENERATE CODE] (1) to generate project files and sources.

Figure 24. Code generation



8 Code update (optional)

It is necessary modify the source code for algorithms and sensors whose correct functionality depends on the orientation. In our case the DataLogFusion application depends on the correct orientation of MEMS sensors. When building a project, the following warning messages might appear:

```
#warning Function BSP_SENSOR_ACC_GetOrientation is not implemented  
#warning Function BSP_SENSOR_GYR_GetOrientation is not implemented  
#warning Function BSP_SENSOR_MAG_GetOrientation is not implemented
```

These warnings are built into the project to set forced orientation according to the actual hardware setup. For example, concerning the accelerometer, part of the source code is:

```
/**  
 * @brief Get accelerometer sensor orientation  
 * @param Orientation Pointer to sensor orientation  
 * @retval None  
 */  
void BSP_SENSOR_ACC_GetOrientation(char *Orientation)  
{  
#if (defined BSP_MOTION_SENSORS)  
#ifdef CUSTOM_ACC_INSTANCE_0  
#warning Function BSP_SENSOR_ACC_GetOrientation is not implemented  
/*  
 Example:  
 Orientation[0] = 's';  
 Orientation[1] = 'e';  
 Orientation[2] = 'u';  
*/  
#endif  
#endif  
}
```

The hardware configuration for this example is:

- STEVAL-MKI194V1 DIL24 module - [LSM6DSR](#) accelerometer and gyroscope sensor in DIL 24 socket
- X-NUCLEO-IKS01A3 expansion board

Figure 25. LSM6DSR sensor orientation

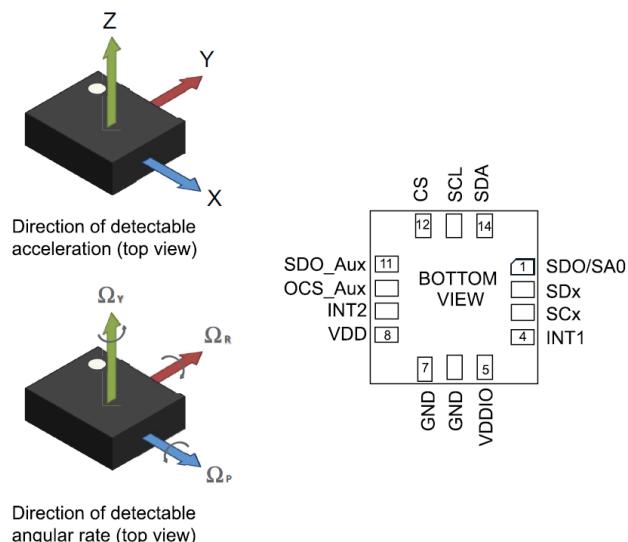


Figure 26. STEVAL-MKI194V1 evaluation board

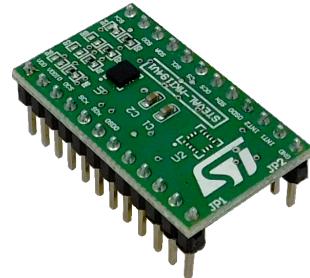
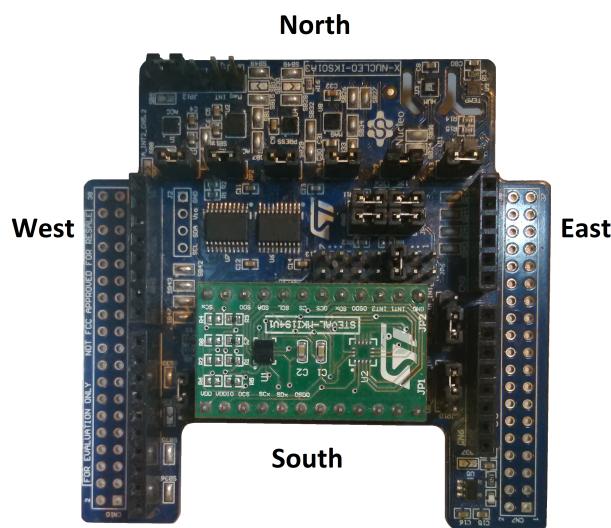


Figure 27. STEVAL-MKI194V1 stacked on top of X-NUCLEO-IKS01A3



The orientation of the accelerometer ([LSM6DSR](#)) is North-West-Up (NWU). The above code should be modified as follows:

```
/**  
 * @brief Get accelerometer sensor orientation  
 * @param Orientation Pointer to sensor orientation  
 * @retval None  
 */  
void BSP_SENSOR_ACC_GetOrientation(char *Orientation)  
{  
    Orientation[0] = 'n';  
    Orientation[1] = 'w';  
    Orientation[2] = 'u';  
}
```

A similar change has to be done for gyroscope ([LSM6DSR](#), orientation = NWU) and magnetometer ([LIS2MDL](#), orientation = NEU).

9 Sensors with I3C

9.1 Description

Some sensors have the option of using the I3C interface unlike the X-NUCLEO expansion boards and the STM32 Nucleo development boards which use I2C interface only.

Due to the connection to ST2378E level shifter (Figure 28), the sensor (in DIL 24) interrupt pins (Figure 29) are pulled high through a 9 kOhm resistor (Figure 30); thus, devices with I3C bus enable the I3C interface. As the boards use the I2C only, the I3C must be disabled.

The procedures described hereafter are available to ensure that I3C is disabled and I2C is enabled.

Figure 28. Level shifter circuit

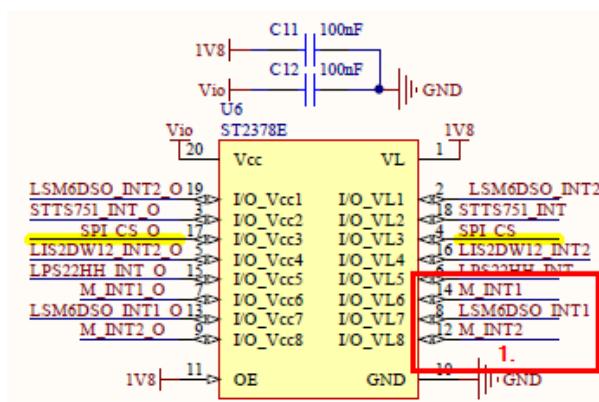


Figure 29. DIL 24 socket wiring

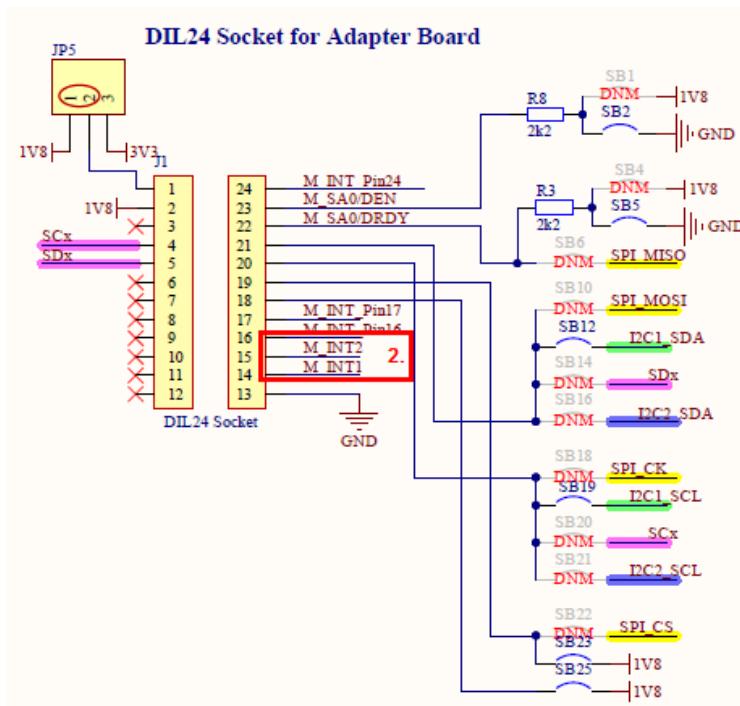
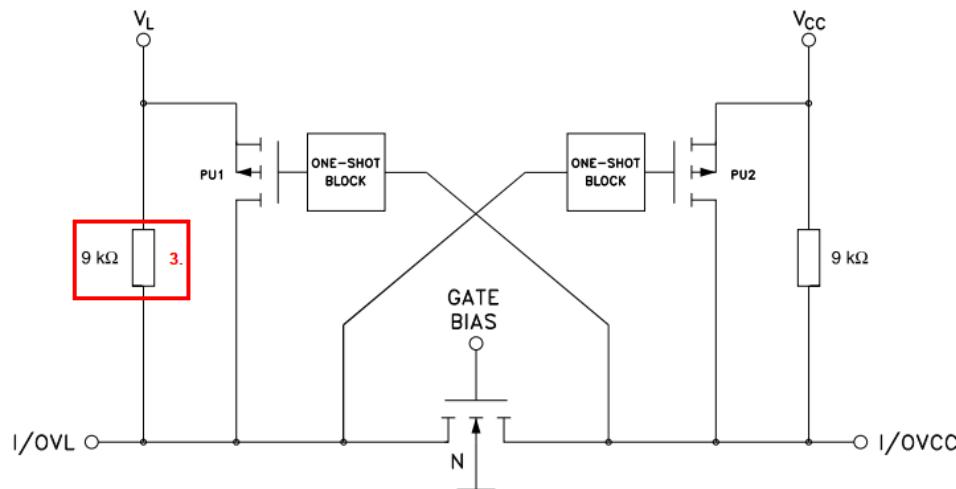


Figure 30. Level shifter internal circuitry



9.2 Hardware solution

Connect a strong external pull-down resistor (< 1 kOhm) to INT1 pin.

9.3 Software solution

9.3.1 Motion sensors

To disable I3C via software, for motion sensors follow the procedure below.

- Step 1.** Configure GPIO for INT1 pin to output and set the output value to low.
- Step 2.** During the sensor initialization procedure, disable I3C in the sensor register.
- Step 3.** Reconfigure the GPIO for INT1 pin to input.

9.3.2 Environmental sensors

To disable I3C via software, for environmental sensors (without hot-join, e.g.: LPS22HH) follow the procedure below.

- Step 1.** Configure GPIO for INT1 pin to output and set the output value to low.
- Step 2.** Manually generate 9 clock pulses on SCL to unlock the bus.
- Step 3.** During the sensor initialization procedure, disable I3C in the sensor register.
- Step 4.** Reconfigure the GPIO for INT1 pin to input.

9.4

Solution used in STM32CubeMX

The following solution has been applied in the project generated by STM32CubeMX as described hereafter.

In lines 166 .. 173 of MEMS/APP/app_mems.c file:

```
#ifdef BSP_IP_MEMS_INT1_PIN_NUM
    /* Force MEMS INT1 pin of the sensor low during startup in order to disable I3C and enable
I2C. This function needs
     * to be called only if user wants to disable I3C / enable I2C and didn't put the pull-
down resistor to MEMS INT1 pin
     * on his HW setup. This is also the case of usage X-NUCLEO-IKS01A2 or X-NUCLEO-IKS01A3
expansion board together with
     * sensor in DIL24 adapter board where the LDO with internal pull-up is used.
    */
    MEMS_INT1_Force_Low();
#endif
```

and in lines 196 .. 199:

```
#ifdef BSP_IP_MEMS_INT1_PIN_NUM
    /* Initialize MEMS INT1 pin back to it's default state after I3C disable / I2C enable */
    MEMS_INT1_Init();
#endif
```

Revision history

Table 1. Document revision history

Date	Revision	Changes
11-Jun-2019	1	Initial release
19-Mar-2021	2	Updated all content to add guidelines on how to create example applications for sensors in DIL 24 socket.

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