
Getting started with the X-CUBE-MEMS1-V4 legacy motion MEMS and environmental sensor software expansion for STM32Cube

Introduction

The X-CUBE-MEMS1 expansion software package for STM32Cube runs on the STM32 and includes drivers that recognize the sensors and collect temperature, humidity, pressure and motion data from the HTS221, LPS25HB, LSM6DS0, LSM6DS3, LPS22HB, LSM6DSL, LSM303AGR and LIS3MDL devices.

The expansion is built on STM32Cube software technology to ease portability across different STM32 microcontrollers.

The software comes with a sample implementation of the drivers running on the X-NUCLEO-IKS01A1 or X-NUCLEO-IKS01A2 expansion boards connected to a NUCLEO-F401RE, NUCLEO-L053R8, NUCLEO-L152RE or NUCLEO-L476RG development board.

The software provides advanced motion libraries together with sample applications available only for NUCLEO-F401RE and NUCLEO-L476RG. The motion libraries include MotionAC (accelerometer calibration library), MotionAR (activity recognition library), MotionAW (activity recognition for wrist library), MotionCP (carrying position library), MotionEC (eCompass library), MotionFA (fitness activities library), MotionFD (fall detection library), MotionFX (sensor fusion library), MotionGC (gyroscope calibration library), MotionGR (gesture recognition library), MotionID (intensity detection library), MotionMC (magnetometer calibration library), MotionPE (pose estimation library) and MotionPM (pedometer library), MotionSD (standing and sitting desk detection library), MotionTL (tilt sensing library).

1 What is STM32Cube?

1.1 STM32Cube overview

STM32Cube™ is an STMicroelectronics initiative aimed at making life easier for the developer by reducing development effort, time and cost for the STM32 range of products.

Version 1.x includes:

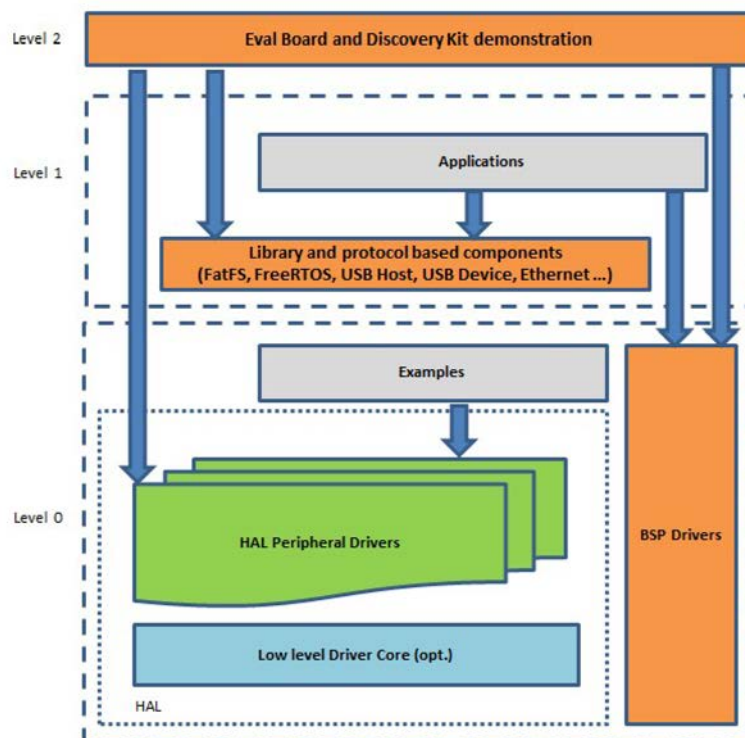
- The STM32CubeMX graphical software configuration tool to generate C initialization code using graphical wizards.
- A comprehensive embedded software platform for each series (e.g., STM32CubeF4 for the STM32F4 series)
 - the embedded STM32Cube HAL abstraction layer software which maximizes portability across the STM32 portfolio
 - a consistent set of middleware components, including RTOS, USB, TCP/IP and graphics
 - all the embedded software utilities come with a full set of examples

Information regarding STM32Cube is available on www.st.com at: <http://www.st.com/stm32cube>.

1.2 STM32Cube architecture

The STM32Cube firmware solution is based on three independent levels that freely interact with each other, as shown below:

Figure 1. Firmware architecture



Level 0 is divided into three sub-layers:

- The Board Support Package (BSP) layer offers a set of board hardware APIs (audio codec, IO expander, touchscreen, SRAM driver, LCD drivers, etc.) based on modular architecture which can be rendered compatible with any hardware by simply running the low-level routines. The BSP has two parts:
 - component: the driver associated with the external device on the board (not the STM32); the component driver provides specific APIs to the BSP driver external components and can be ported to any other board.
 - BSP driver: links the component driver to a specific board and provides a set of user-friendly APIs. The naming rule of the APIs is BSP_FUNCT_Action(): ex. BSP_LED_Init(), BSP_LED_On()
- The Hardware Abstraction Layer (HAL) provides the low level drivers and the hardware interfacing methods to interact with the upper layers (application, libraries and stacks). It provides generic, multi-instance and function-oriented APIs which render user applications unnecessary by providing ready to use processes. For example, it provides APIs for the communication peripherals (I²S, UART, etc.) for initialization and configuration, data transfer management based on polling, interrupts or DMA processes, and management of any communication errors. There are two types of HAL driver APIs:
 - generic APIs which provide common and generic functions to the entire STM32 series
 - extension APIs which provide specific, customized functions for a particular family or a certain part number
- Basic peripheral usage examples: this layer includes the examples built for the STM32 peripheral using the HAL and BSP resources only.

Level 1 is divided into two sub-layers:

- Middleware components: a set of libraries covering USB host and device libraries STemWin, FreeRTOS, FatFS, LwIP, and PolarSSL. Horizontal interaction between layer components is handled directly by calling the feature APIs, while vertical interaction with the low level drivers is managed through specific callbacks and static macros implemented in the library system call interface. For example, the FatFs accesses the microSD drive or the USB mass storage class via the disk I/O driver.
- Middleware examples (or applications) for individual components as well as integration examples across several middleware components are provided.

Level 2 is a single layer providing a global, real-time and graphical demonstration based on the middleware service layer, the low-level abstraction layer and basic peripheral usage applications involving board functions

2 X-CUBE-MEMS1 software expansion for STM32Cube

2.1 Overview

The X-CUBE-MEMS1 software package expands the STM32Cube functionality.

The key features are:

- Complete software to build applications using temperature and humidity sensors (HTS221 for both X-NUCLEO-IKS01A1 and X-NUCLEO-IKS01A2), pressure sensor (LPS25HB for X-NUCLEO-IKS01A1 and LPS22HB for X-NUCLEO-IKS01A2) and motion sensors (LIS3MDL and LSM6DS0 for X-NUCLEO-IKS01A1 and LSM303AGR and LSM6DSL for X-NUCLEO-IKS01A2)
- Several examples to show the innovative inertial and environmental sensors
- Sample application to transmit real-time sensor data to a PC
- Compatible with the Unicleo-GUI graphical user interface to display sensor data and configure outputs
- Sample implementation available on X-NUCLEO-IKS01A1 or X-NUCLEO-IKS01A2 board connected to a NUCLEO-F401RE, NUCLEO-L152RE, NUCLEO-L476RG or NUCLEO-L053R8 development board
- Advanced motion libraries with sample applications available only for NUCLEO-F401RE and NUCLEO-L476RG
- Easy portability across different MCU families, thanks to STM32Cube
- Free, user-friendly license terms

This software gathers the temperature, humidity, pressure and motion sensor drivers for the HTS221, LPS25HB, LPS22HB, LSM6DS0, LSM6DS3 with LSM6DSL, LSM303AGR and LIS3MDL devices running on STM32 Nucleo.

The package includes several sample applications that the developer can use to start experimenting with the code. One sample application was developed to enable sensor data logging on a PC. For this purpose, a Windows PC utility (Unicleo-GUI) is available on www.st.com, which allows the developer choosing between various sensors available on the expansion board, setting the appropriate delay/interval among consecutive data points.

Sensor data can be logged in a file selected by the user-selected file.

2.2 Architecture

This software is a fully compliant expansion for STM32Cube enabling development of applications using inertial and environmental sensors. See the previous chapter for a brief explanation of the STM32Cube architecture.

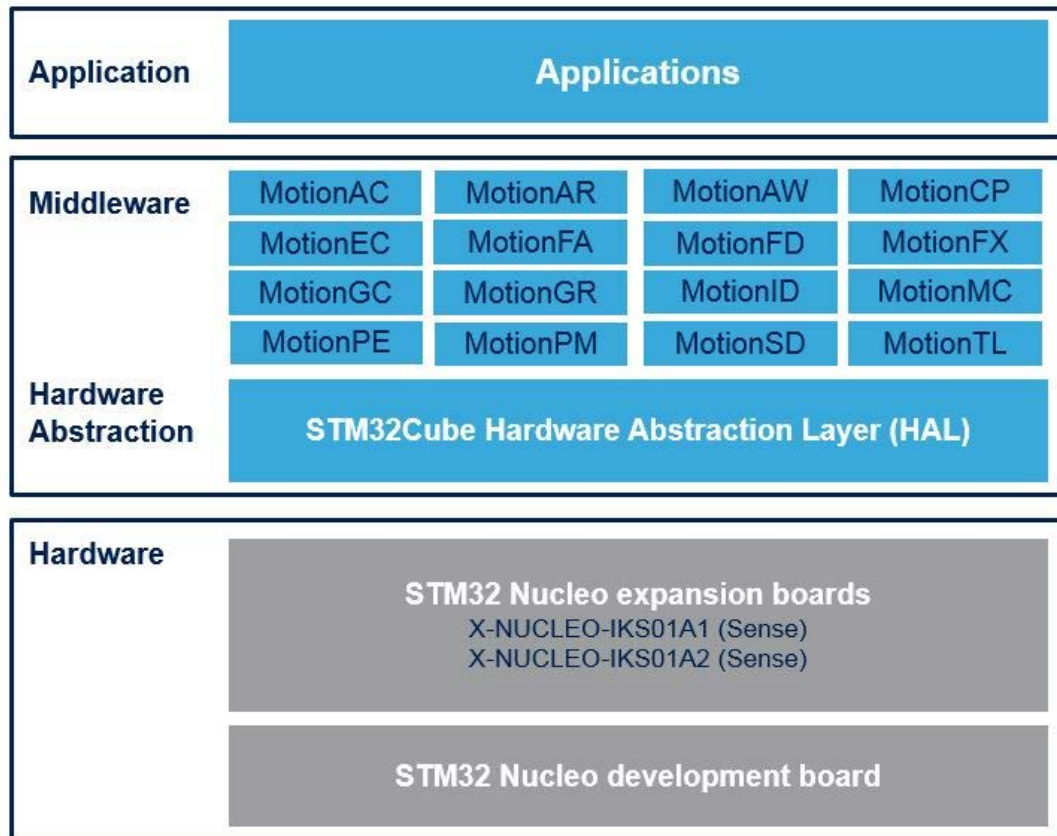
The software is based on the hardware abstraction layer for the STM32 microcontroller, STM32CubeHAL. The package extends STM32Cube by providing a Board Support Package (BSP) for the sensor expansion board and a sample application for serial communication with a PC.

The software layers used by the application software to access the sensor expansion board are:

- The STM32Cube HAL driver layer provides a simple, generic and multi-instance set of APIs (application programming interfaces) to interact with the upper layers (application, libraries and stacks). It includes generic and extension APIs and is based on a generic architecture which allows the layers built on it (such as the middleware layer) to implement their functionalities without dependence on the specific hardware configuration of a given Microcontroller Unit (MCU). This structure improves library code reusability and guarantees high portability across other devices.
- The Board Support Package (BSP) layer provides supporting software for the peripherals on the STM32 Nucleo board, except for the MCU. It has a set of APIs to provide a programming interface for certain board-specific peripherals (e.g. the LED, the user button etc.) and allow identification of the specific board version. For the sensor expansion board, it provides the programming interface for various inertial and environmental sensors and provides support for initializing and reading sensor data.
- The Middleware provides advanced motion libraries. The motion libraries include MotionAC (accelerometer calibration library), MotionAR (activity recognition library), MotionAW (activity recognition for wrist library), MotionCP (carrying position library), MotionEC (eCompass library), MotionFA (fitness activities library), MotionFD (fall detection library), MotionFX (sensor fusion library), MotionGC (gyroscope calibration library), MotionGR (gesture recognition library), MotionID (intensity detection library), MotionMC (magnetometer

calibration library), MotionPE (pose estimation library) and MotionPM (pedometer library), MotionSD (standing and sitting desk detection library), MotionTL (tilt sensing library).

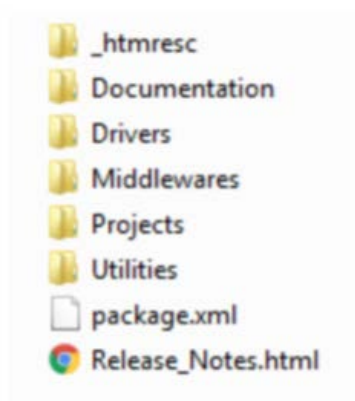
Figure 2. X-CUBE-MEMS1 software architecture



2.3 Folder structure

This section provides an overview of the package folder structure.
The figure below shows the architecture of the package

Figure 3. X-CUBE-MEMS1 package folder structure



The following folders are included in the software package:

- The **Documentation** folder contains a compiled HTML file generated from the source code and detailed documentation regarding the software components and APIs.
- The **Drivers** folder contains the HAL drivers, the board-specific drivers for each supported board or hardware platform, including those for the on-board components and the CMSIS layer, which is a vendor-independent hardware abstraction layer for the Cortex-M processor series.
- The **Middlewares** folder contains the motion libraries, a platform-independent software layer provided in binary format for the Cortex-M4 processor series.
- The **Projects** folder contains several sample applications for the NUCLEO-L053R8, NUCLEO-L152RE, NUCLEO-L476RG and NUCLEO-F401RE platforms to show the use of sensor APIs and many applications only for NUCLEO-L476RG and NUCLEO-F401RE to show the use of the motion libraries, provided with three development environments (IAR Embedded Workbench for ARM, RealView MDK-ARM Microcontroller Development Kit, System Workbench for STM32).
- The **Utilities** folder contains a "PC_software" subfolder containing a link for downloading the Unicleo-GUI, a Windows PC utility which shows real time sensor data.

2.4 APIs

Detailed technical information about the APIs available to the user can be found in the compiled HTML file "X_CUBE_MEMS1.chm" in the "Documentation" folder of the software package, where all the functions and parameters are fully described.

2.5 DataLog application

The DataLog sample application using the X-NUCLEO-IKS01A1 or X-NUCLEO-IKS01A2 expansion board with the NUCLEO-F401RE, NUCLEO-L053R8, NUCLEO-L152RE or NUCLEO-L476RG board is provided in the "Projects" directory. Ready-to-use projects are available for multiple IDEs.

In the DataLog application, real-time sensor data are transmitted via serial port to a PC using the HAL_UART_Transmit() system call.

Transmitted sensor data can be viewed through Unicleo-GUI, a PC-based application developed by STMicroelectronics, available on www.st.com, which can be used to read and show data from the sensors expansion board connected to a PC via the STM32 Nucleo board.

The firmware converts the sensor data into a readable format for the Unicleo-GUI utility.

Sending temperature sensor data via UART, for example, would require the following steps:

- Initialization: BSP_TEMPERATURE_Init(...);
- Sensor temperature reading: BSP_TEMPERATURE_Get_Temp(...)
- Data serialization: Serialize();
- Data transmission: HAL_UART_Transmit();

The Serialize() function converts the temperature data into a readable format for the Unicleo-GUI utility. Similarly, data from other sensors is also formatted and communicated to the utility. When connected via Tera Term, the user can use the blue button on the STM32 Nucleo expansion board to start and stop the data log.

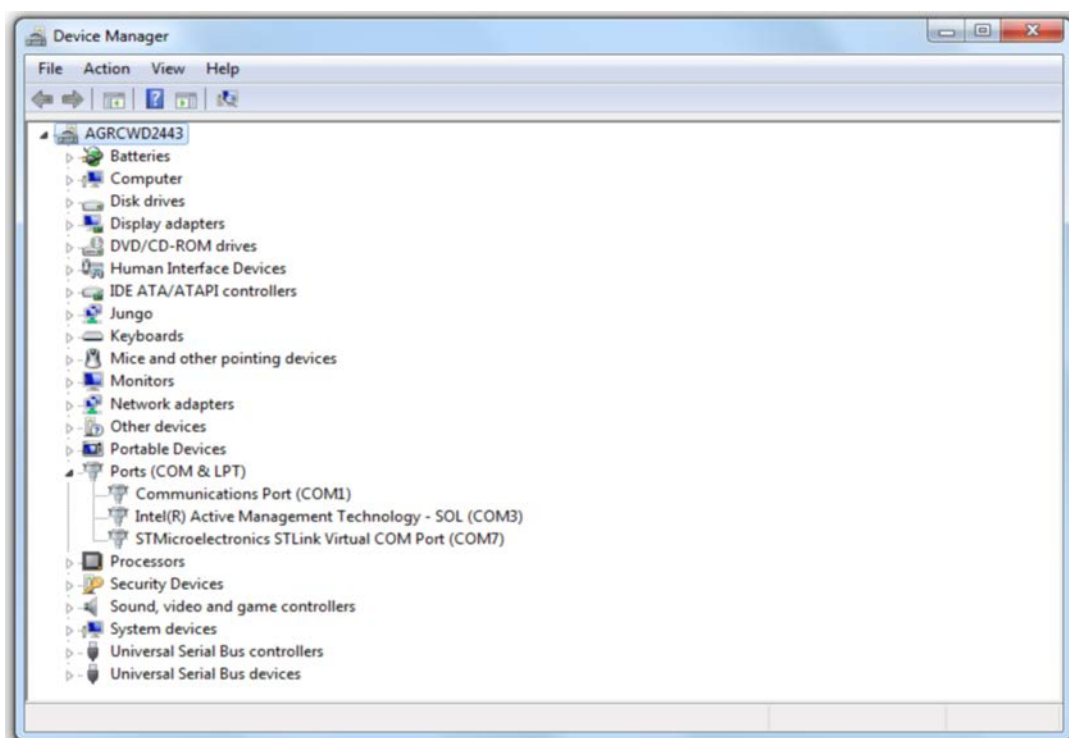
2.6 Unicleo-GUI data logging utility

The X-CUBE-MEMS1 expansion for STM32Cube contains a web link to download a utility for Windows PCs called "Unicleo-GUI", available on www.st.com.

Before using this utility, ensure that the STM32 Nucleo development board plus expansion board assembly is connected to the PC.

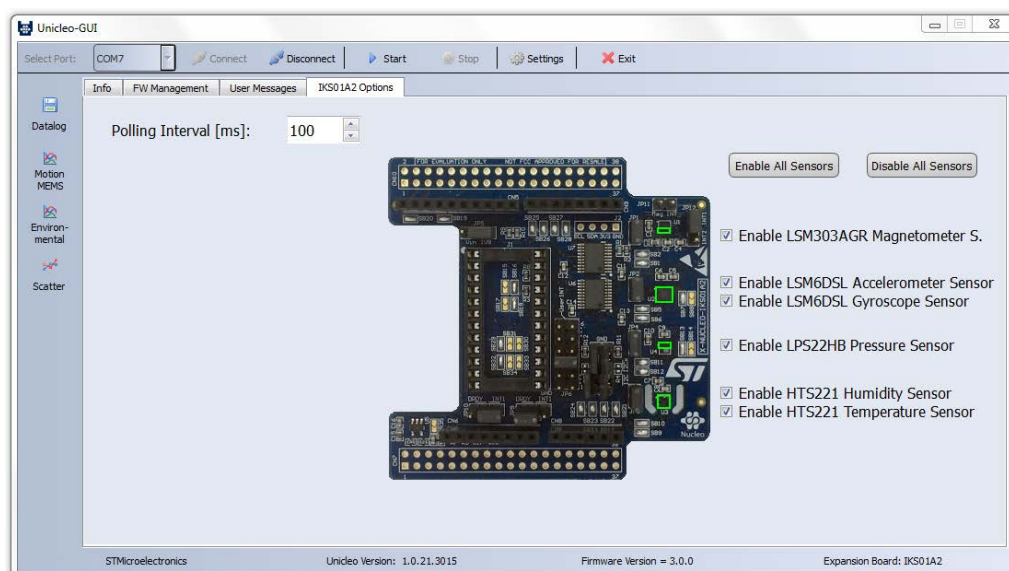
- Step 1.** Check the Windows Device Manager for the ST COM port number.
in the example below, it is COM7.

Figure 4. Windows Device Manager



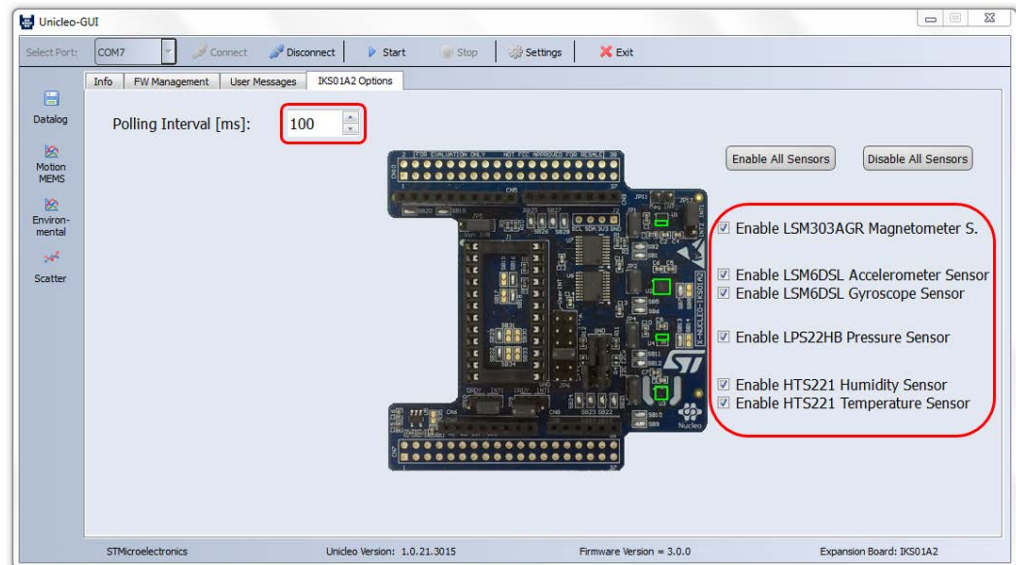
Step 2. Launch Unicleo-GUI application and ensure the COM port number for the current Nucleo board is correct.

Figure 5. Unicleo-GUI main page



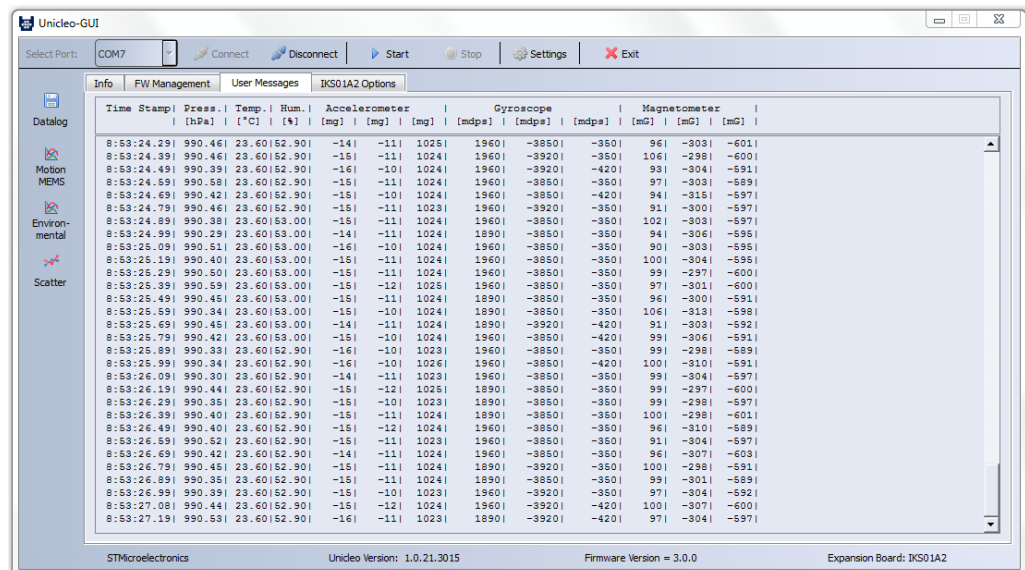
Step 3. Select between various sensors (e.g., pressure, temperature, humidity, accelerometer, gyroscope, magnetometer) available on the expansion board and set appropriate delay/interval in milliseconds between consecutive data points; the default is 100 ms.

Figure 6. Unicleo-GUI Utility sensor and interval selection



Step 4. Press "Start" to display the data.

Figure 7. Unicleo-GUI data plot



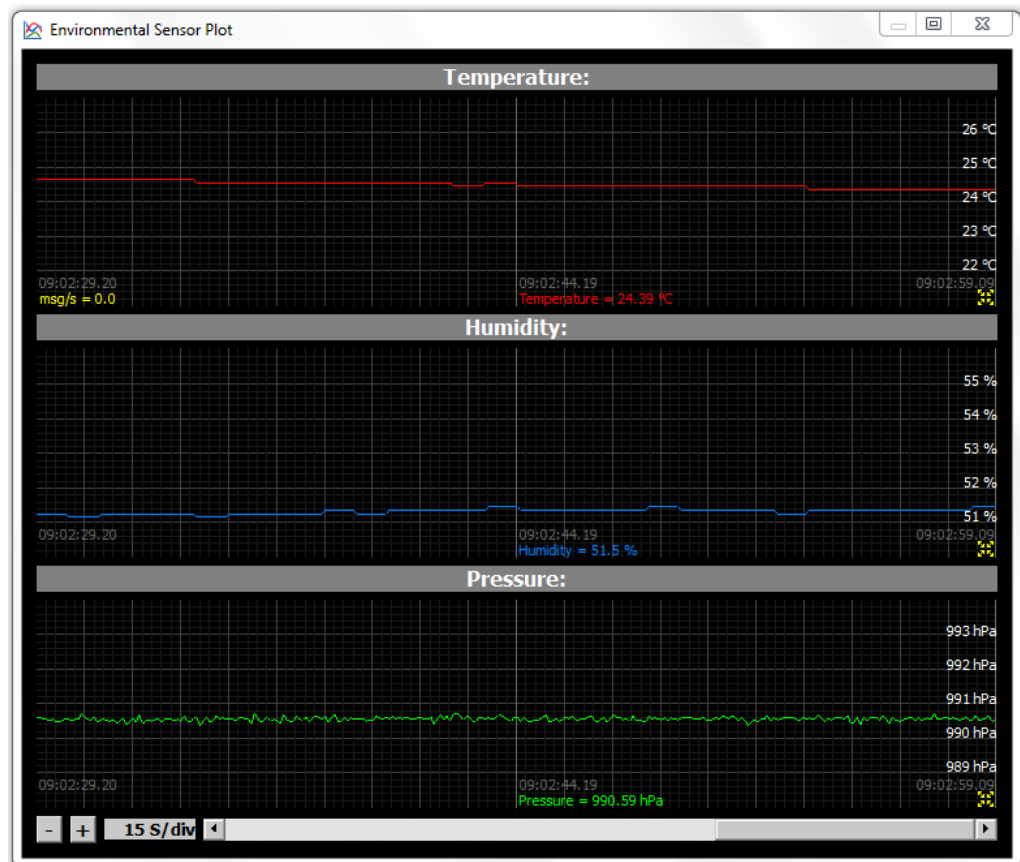
Step 5. Press "Motion MEMS" to display inertial sensor data.

Figure 8. Unicleo-GUI Motion Sensor Plot



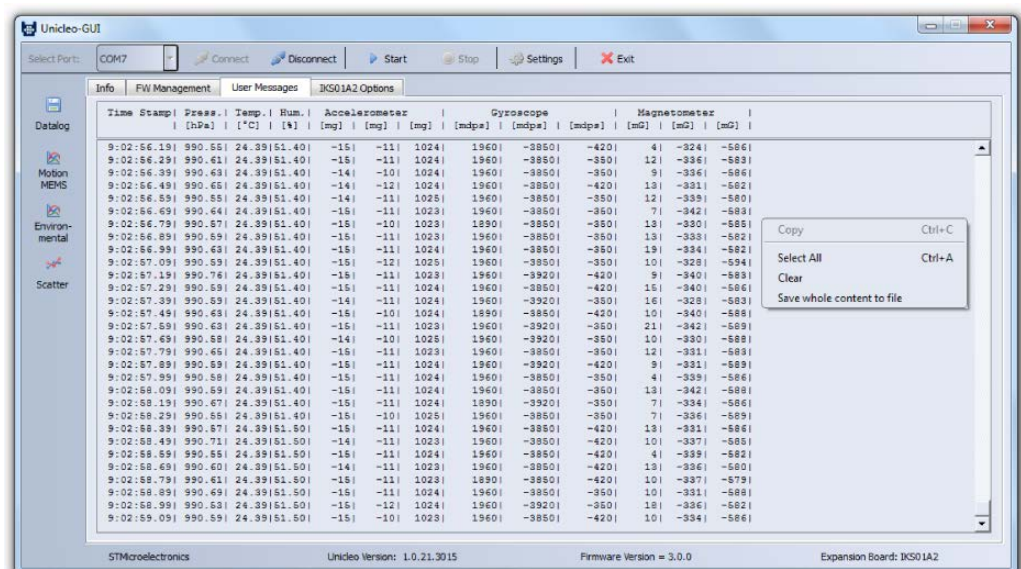
Step 6. Press "Environmental" to display environmental sensor data.

Figure 9. Unicleo-GUI Environmental Sensor Plot



Step 7. Press the right mouse button to choose between recording in a file or removing the data from the panel.

Figure 10. Unicleo-GUI right click Menu



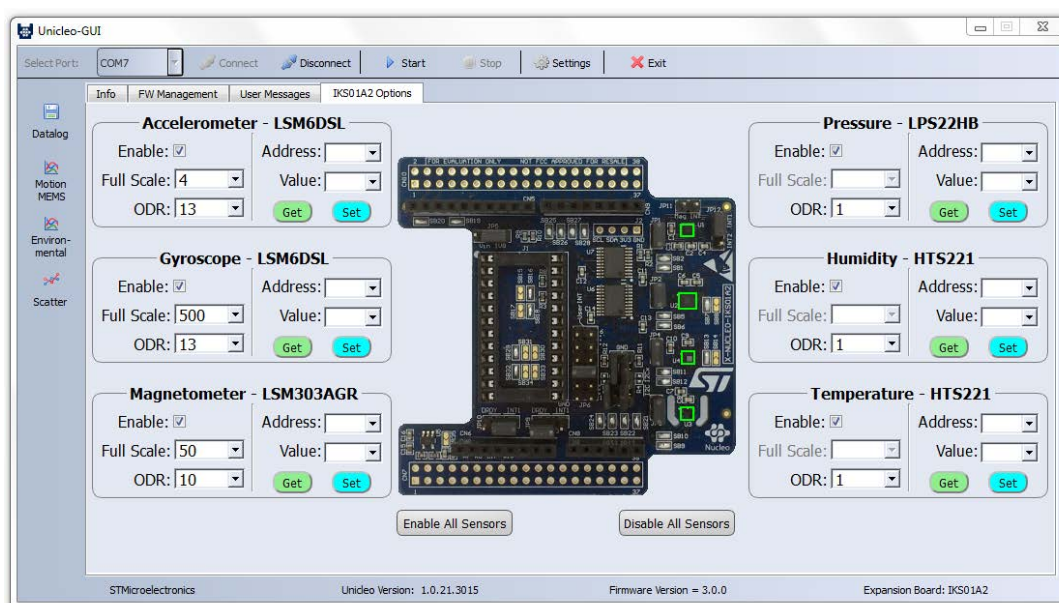
2.7 DataLogExtended application

This application shows how to use the X-NUCLEO-IKS01A1 or the X-NUCLEO-IKS01A2 expansion boards to send sensor data from an STM32 Nucleo board to a connected PC via UART and display it on Unicleo-GUI.

After connection has been established, the user can view data from all on-board environment sensors (temperature, humidity and pressure sensors) and all on-board inertial sensors (accelerometer, gyroscope and magnetometer sensors) and organize data in graphs (using Unicleo-GUI as seen for the DataLog application).

In addition, the user can change the sensor output data rate (ODR) and full scale (FS) settings using the Unicleo-GUI scroll-down menu without modifying the firmware and also get or set any sensor register value on a specific address. The application serial settings are: baud rate 921600 bps; 8 data bits; No parity; 1 stop bit; no hard flow control.

Figure 11. DataLogExtended application screenshot from Unicleo-GUI



2.8 DataLogTerminal application

This application shows how to use the X-NUCLEO-IKS01A1 or the X-NUCLEO-IKS01A2 to send sensor data from a STM32 Nucleo board using UART to a connected PC and display it on generic applications like Tera Term. After connection has been established, the user can view the data from all on-board environment sensors (temperature, humidity and pressure sensors) and all on-board inertial sensors (accelerometer, gyroscope and magnetometer sensors) using a hyper terminal. The application serial settings are: baud rate 115200 bps; 8 data bits; No parity; 1 stop bit; no hard flow control.

Figure 12. DataLogTerminal application screenshot

```

COM7:115200baud - Tera Term VT
File Edit Setup Control Window Help

TimeStamp: 00:00:37.82
ACC_X[0]: -10, ACC_Y[0]: -11, ACC_Z[0]: 1024
WHO_AM_I address[0]: 0x6A
ODR[0]: 104.000 Hz
FS[0]: 2.000 g

GYR_X[0]: 1960, GYR_Y[0]: -3920, GYR_Z[0]: -420
WHO_AM_I address[0]: 0x6A
ODR[0]: 104.000 Hz
FS[0]: 2000.000 dps

ACC_X[1]: 8, ACC_Y[1]: 8, ACC_Z[1]: 983
WHO_AM_I address[1]: 0x33
ODR[1]: 100.000 Hz
FS[1]: 2.000 g

MAG_X[0]: 141, MAG_Y[0]: -274, MAG_Z[0]: -609
WHO_AM_I address[0]: 0x40
ODR[0]: 100.000 Hz
FS[0]: 50.000 Gauss

HUM[0]: 50.50
WHO_AM_I address[0]: 0xBC
ODR[0]: 1.000 Hz

TEMP[0]: 24.29
WHO_AM_I address[0]: 0xBC
ODR[0]: 1.000 Hz

TEMP[1]: 24.89
WHO_AM_I address[1]: 0xB1
ODR[1]: 25.000 Hz

PRESS[0]: 986.30
WHO_AM_I address[0]: 0xB1
ODR[0]: 25.000 Hz
  
```

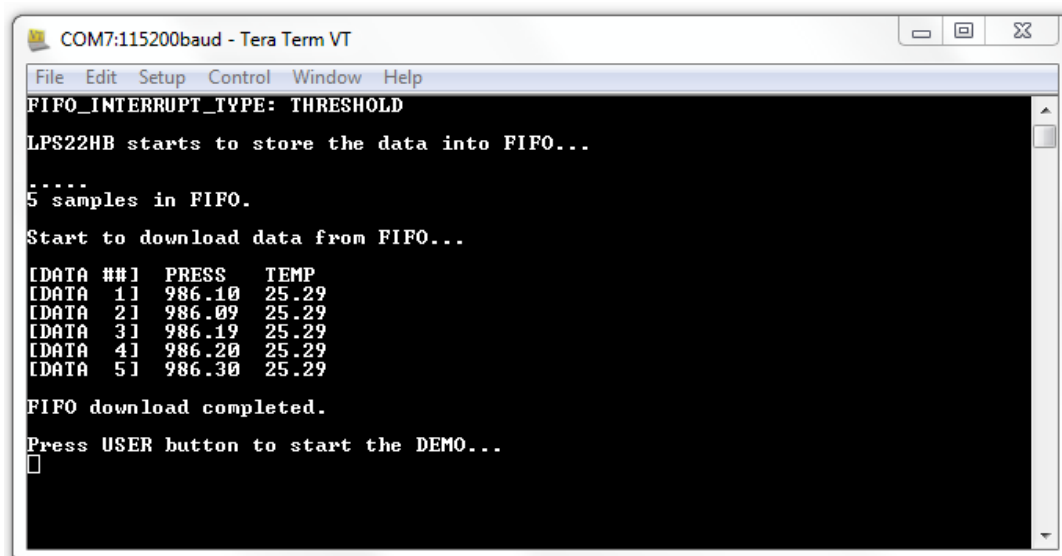
2.9 FIFO mode application for pressure sensor

This application shows how to use the X-NUCLEO-IKS01A1 with the STEVAL-MET001V1 or the X-NUCLEO-IKS01A2 to store pressure and temperature data in FIFO mode and send data from a STM32 Nucleo board via UART to a connected PC, displaying it on generic applications like Tera Term.

Note: *This feature is only available for LPS22HB.*

After connection has been established, press the user button to store pressure and temperature data in the FIFO mode and then view the data using a hyper terminal. The application serial settings are: baud rate 115200 bps; 8 data bits; No parity; 1 stop bit; no hard flow control.

Figure 13. FIFO mode application for pressure sensor screenshot



2.10 6D orientation application for accelerometer sensor

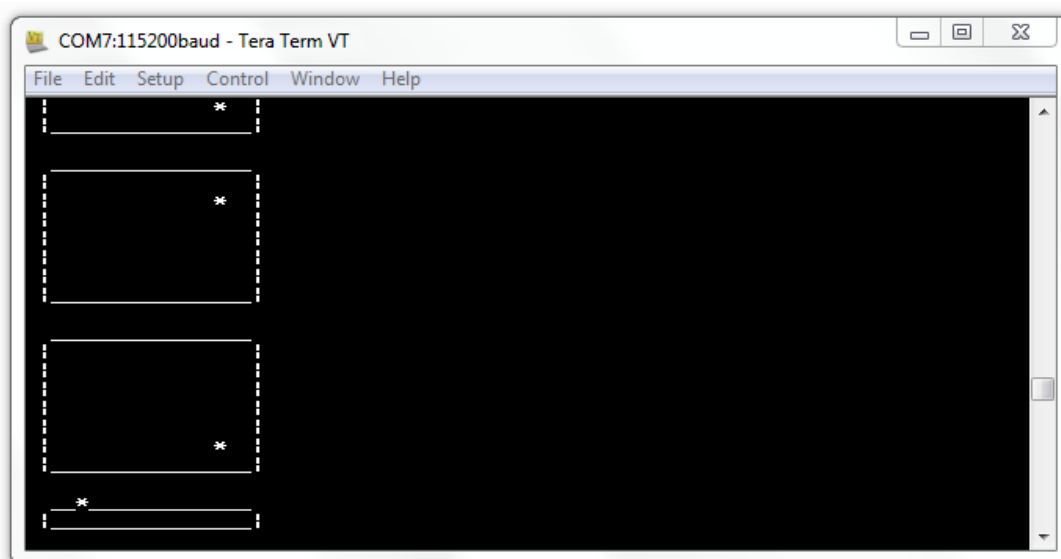
This application shows how to use the X-NUCLEO-IKS01A1 with the STEVAL-MKI160V1 or the X-NUCLEO-IKS01A2 expansion board to find out the 6D orientation and send data from an STM32 Nucleo board via UART to a connected PC, displaying it on generic applications like Tera Term.

Note: *This feature is only available for LSM6DS3 and LSM6DSL.*

After connection has been established, the user can rotate the board to change the 6D orientation and then view the data using a hyper terminal or just push the user button to display the current 6D orientation.

The application serial settings are: baud rate 115200 bps; 8 data bits; No parity; 1 stop bit; no hard flow control.

Figure 14. 6D orientation application for accelerometer sensor screenshot



2.11 FIFO continuous mode application for gyroscope sensor

This application shows how to use the X-NUCLEO-IKS01A1 with the STEVAL-MKI160V1 or the X-NUCLEO-IKS01A2 expansion board to store gyroscope data in FIFO continuous mode and send data from an STM32 Nucleo board via UART to a connected PC, displaying it on generic applications like Tera Term.

Note: *This feature is only available for LSM6DS3 and LSM6DSL.*

After connection has been established, the user can push the user button to launch the FIFO demo in continuous mode and then view the data using a hyper terminal. By pressing again the STM32 Nucleo board user button, FIFO continuous mode changes into FIFO bypass mode. If you press the user button once again, the FIFO demo restarts in continuous mode and so on.

The application serial settings are: baud rate 115200 bps; 8 data bits; No parity; 1 stop bit; no hard flow control.

Figure 15. FIFO continuous mode application for gyroscope sensor screenshot

```

COM7:115200baud - Tera Term VT
File Edit Setup Control Window Help

Press USER button to start the DEMO...
LSM6DSL starts to store the data into FIFO...
.....
30 samples in FIFO.
Started downloading data from FIFO...

[DATA ##]    GYR_X    GYR_Y    GYR_Z
[DATA 01]    1890    -3990    -1540
[DATA 02]    1890    -4060    -700
[DATA 03]    1890    -3990    -560
[DATA 04]    1890    -3990    -560
[DATA 05]    1890    -3990    -770
[DATA 06]    1960    -4060    -560
[DATA 07]    1960    -3990    -490
[DATA 08]    1960    -4060    -490
[DATA 09]    1960    -4060    -490
[DATA 10]    1960    -4060    -490

Sample list limited to: 10

.....
FIFO is stopped in Bypass mode.
Press USER button to start the DEMO...

```

2.12 FIFO low power mode application for accelerometer sensor

This application shows how to use the X-NUCLEO-IKS01A1 with the STEVAL-MKI160V1 or the X-NUCLEO-IKS01A2 expansion board to store accelerometer data in FIFO continuous mode and send data from an STM32 Nucleo board via UART to a connected PC, displaying it on generic applications like Tera Term.

Note: *This feature is only available for LSM6DS3 and LSM6DSL.*

After connection has been established, the user can push the user button to launch the FIFO low power demo and then view the data using a hyper terminal; afterwards, the component enters sleep mode. The user can press the user button to launch again the FIFO low power demo.

The application serial settings are: baud rate 115200 bps; 8 data bits; No parity; 1 stop bit; no hard flow control.

Figure 16. FIFO low power mode application for accelerometer sensor screenshot

```

COM7:115200baud - Tera Term VT
File Edit Setup Control Window Help

Received FIFO Threshold Interrupt on INT1 pin ...
Nucleo processor is waking up ...
300 samples in FIFO.
Started downloading data from FIFO ...

[DATA ##]  ACC_X  ACC_Y  ACC_Z  [mg]
[DATA 01]   -14   -12   1019
[DATA 02]   -15   -12   1019
[DATA 03]   -14   -12   1019
[DATA 04]   -14   -12   1019
[DATA 05]   -15   -12   1019
[DATA 06]   -14   -12   1019
[DATA 07]   -15   -12   1019
[DATA 08]   -15   -12   1019
[DATA 09]   -15   -12   1019
[DATA 10]   -14   -12   1020

Sample list limited to: 10
Nucleo processor is entering sleep mode while LSM6DSL is storing data into FIFO ...
Nucleo processor is waking up ...
Nucleo processor is entering sleep mode while LSM6DSL is storing data into FIFO ...

```

2.13 FIFO mode application for gyroscope sensor

This application shows how to use the X-NUCLEO-IKS01A1 with the STEVAL-MK160V1 or the X-NUCLEO-IKS01A2 expansion board to store gyroscope data in FIFO mode and send data from an STM32 Nucleo board via UART to a connected PC, displaying it on generic applications like Tera Term.

Note: *This feature is only available for LSM6DS3 and LSM6DSL.*

After connection has been established, the user can push the user button to launch the FIFO mode demo and then view the data using a hyper terminal; press the user button to launch again the FIFO mode demo.

The application serial settings are: baud rate 115200 bps; 8 data bits; No parity; 1 stop bit; no hard flow control.

Figure 17. FIFO mode application for gyroscope sensor screenshot

```

COM7:115200baud - Tera Term VT
File Edit Setup Control Window Help

LSM6DSL starts to store the data into FIFO...
.....
10 samples in FIFO.
Started downloading data from FIFO...

[DATA ##]  GYR_X  GYR_Y  GYR_Z
[DATA 01]  -432460  303660  420
[DATA 02]  -78890  -110180  -32340
[DATA 03]  -187320  -87640  -126070
[DATA 04]  -44380  407190  -35700
[DATA 05]  255080  277410  263550
[DATA 06]  335160  -123550  453460
[DATA 07]  149310  -428260  275940
[DATA 08]  -148400  -316540  9800
[DATA 09]  -620130  179060  -5320
[DATA 10]  -378770  363860  62160

FIFO download completed.
Press USER button to start the DEMO...

```

2.14 Free fall detection application for accelerometer sensor

This application shows how to detect the free fall event using the X-NUCLEO-IKS01A1 with the STEVAL-MKI160V1 or the X-NUCLEO-IKS01A2 expansion board and an STM32 Nucleo board.

Note: *This feature is only available for LSM6DS3 and LSM6DSL.*

After application starts, the user can try to let the STM32 Nucleo board falling; when the free fall event is detected, the Nucleo board LED is switched on for a while.

The Nucleo board user button can be used to enable/disable the free fall detection feature.

2.15 Multiple event application for accelerometer sensor

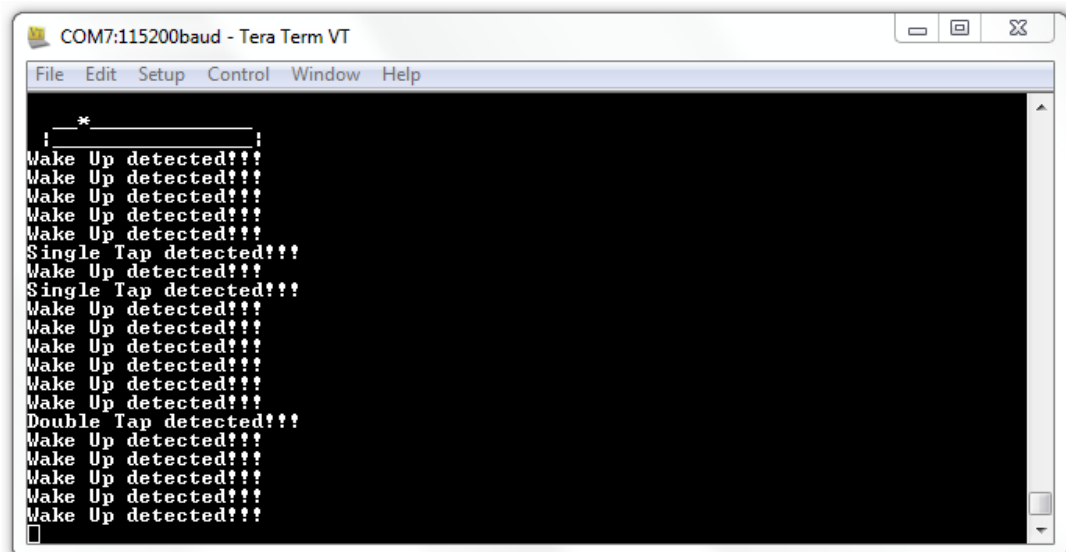
This application shows how to use the X-NUCLEO-IKS01A1 with the STEVAL-MKI160V1 or the X-NUCLEO-IKS01A2 expansion board to detect free fall, tap, double tap, tilt, wake up, 6D Orientation and step events and send data from an STM32 Nucleo board via UART to a connected PC, displaying it on generic applications like Tera Term.

Note: *This feature is only available for LSM6DS3 and LSM6DSL.*

After connection has been established, the user can simulate all the events and then view the data using a hyper terminal or can push the user button to enable/disable all hardware features.

The application serial settings are: baud rate 115200 bps; 8 data bits; No parity; 1 stop bit; no hard flow control.

Figure 18. Multiple event application for accelerometer sensor screenshot



2.16 Pedometer application for accelerometer sensor

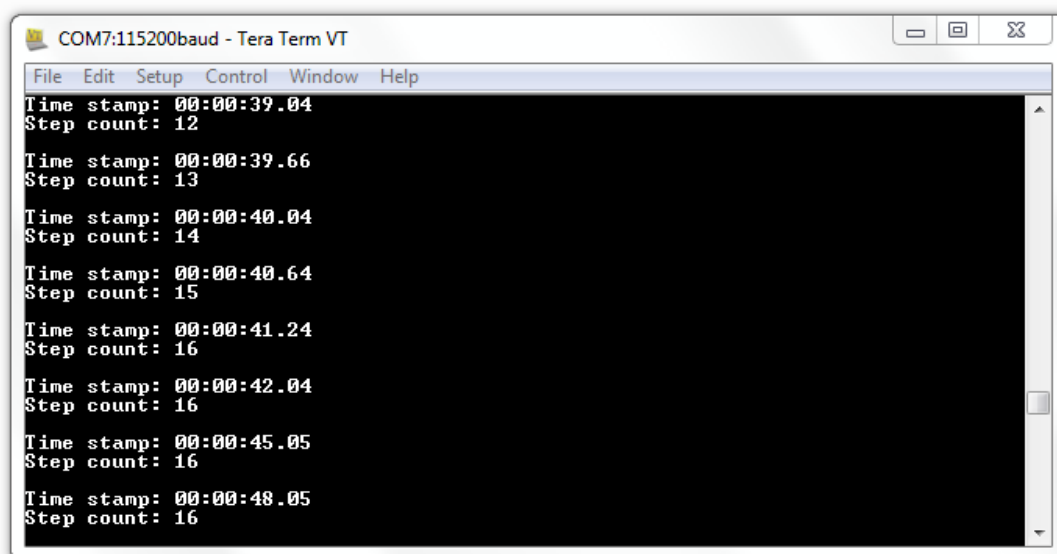
This application shows how to use the X-NUCLEO-IKS01A1 with the STEVAL-MKI160V1 or the X-NUCLEO-IKS01A2 expansion board to count steps and send data from an STM32 Nucleo board via UART to a connected PC, displaying it on generic applications like Tera Term.

Note: *This feature is only available for LSM6DS3 and LSM6DSL.*

After connection has been established, the user can shake the board to simulate the steps and then view the data using a hyper terminal or can push the user button to reset the step counter.

The application serial settings are: baud rate 115200 bps; 8 data bits; No parity; 1 stop bit; no hard flow control.

Figure 19. Pedometer application for accelerometer sensor screenshot



2.17 Self-test application for accelerometer and gyroscope sensors

This application shows how to use the X-NUCLEO-IKS01A1 with the STEVAL-MKI160V1 or the X-NUCLEO-IKS01A2 expansion board to test accelerometer and gyroscope operation mode and send data from an STM32 Nucleo board via UART to a connected PC, displaying it on generic applications like Tera Term.

Note: *This feature is only available for LSM6DS3 and LSM6DSL.*

After connection has been established, the user can push the user button to launch the self-test and then view the data using a hyper terminal.

The application serial settings are: baud rate 115200 bps; 8 data bits; No parity; 1 stop bit; no hard flow control.

Figure 20. Self-test application for accelerometer and gyroscope sensors screenshot

```

COM7:115200baud - Tera Term VT
File Edit Setup Control Window Help

Press USER button to start the DEMO ...
Starting LSM6DSL accelerometer self-test ...
Keep the device still!!!

Measured acceleration [mg]:
  AXIS      : PRE-SELFTEST : SELFTEST
  ---      : ---         : ---
  X         :      -15      :    407
  Y         :      -10      :    505
  Z         :    1024      :   1403

Test limits and data [mg]:
  LOW LIMIT : DIFFERENCE : HIGH LIMIT
  ---      : ---         : ---
  90        :    422      :   1700
  90        :    515      :   1700
  90        :    379      :   1700

LSM6DSL accelerometer self-test PASSED!

Starting LSM6DSL gyroscope self-test ...
Keep the device still!!!

Measured angular velocity [mdps]:
  AXIS      : PRE-SELFTEST : SELFTEST
  ---      : ---         : ---
  X         :    1974      : 369194
  Y         :   -3976      : 335734
  Z         :   -392       : 398958

Test limits and data [mdps]:
  LOW LIMIT : DIFFERENCE : HIGH LIMIT
  ---      : ---         : ---
  150000    :   367220    : 700000
  150000    :   339710    : 700000
  150000    :   399350    : 700000

LSM6DSL gyroscope self-test PASSED!

```

2.18 Single tap and double tap detection for accelerometer sensor

This application shows how to detect the single and double tap events using the X-NUCLEO-IKS01A1 with the STEVAL-MKI160V1 or the X-NUCLEO-IKS01A2 expansion board and an STM32 Nucleo board.

Note: This feature is only available for LSM6DS3 and LSM6DSL.

After application starts, the user can try to tap the STM32 Nucleo board; when the single tap event is detected, the Nucleo board LED is switched on for a while. The user can press the user button to pass from the single tap detection to the double tap detection feature; when the double tap event is detected, the LED is switched on twice for a while. The user can press again the Nucleo board user button to disable the single/double tap detection feature and so on.

2.19 Tilt detection for accelerometer sensor

This application shows how to detect the tilt event using the X-NUCLEO-IKS01A1 with the STEVAL-MKI160V1 or the X-NUCLEO-IKS01A2 expansion board and an STM32 Nucleo board.

Note: This feature is only available for LSM6DS3 and LSM6DSL.

After application starts, the user can try to tilt the STM32 Nucleo board; when the tilt event is detected, the Nucleo board LED is switched on for a while. The Nucleo board user button can be used to enable/disable the tilt detection feature.

2.20 Wake up detection for accelerometer sensor

This application shows how to detect the wake up event using the X-NUCLEO-IKS01A1 with the STEVAL-MKI160V1 or the X-NUCLEO-IKS01A2 expansion board and an STM32 Nucleo board.

Note: This feature is only available for LSM6DS3 and LSM6DSL.

After application starts, the user can try to touch the STM32 Nucleo board; when the wake up event is detected, the Nucleo board LED is switched on for a while. The Nucleo board user button can be used to enable/disable the wake up detection feature.

2.21 Sample applications for motion libraries

Every motion library is provided together with a sample application that shows the main features of the library using the X-NUCLEO-IKS01A1 or the X-NUCLEO-IKS01A2 expansion board and an STM32 Nucleo board. For more information, refer to each motion library user manual available on www.st.com.

3 System setup guide

3.1 Hardware description

This section describes the hardware components needed for developing a sensor-based application. The following sub-sections describe the individual components.

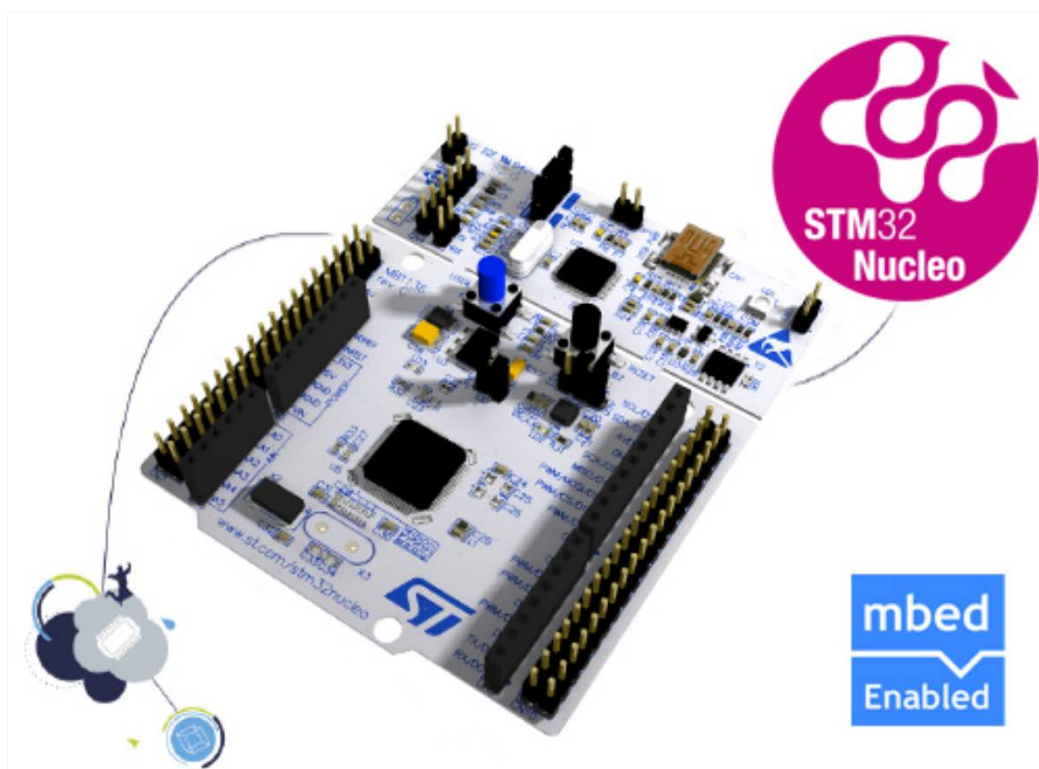
3.1.1 STM32 Nucleo platform

STM32 Nucleo development boards provide an affordable and flexible way for users to test solutions and build prototypes with any STM32 microcontroller line.

The Arduino™ connectivity support and ST morpho connectors make it easy to expand the functionality of the STM32 Nucleo open development platform with a wide range of specialized expansion boards to choose from. The STM32 Nucleo board does not require separate probes as it integrates the ST-LINK/V2-1 debugger/programmer.

The STM32 Nucleo board comes with the comprehensive STM32 software HAL library together with various packaged software examples.

Figure 21. STM32 Nucleo board



Information regarding the STM32 Nucleo board is available at www.st.com/stm32nucleo

3.1.2 X-NUCLEO-IKS01A1 expansion board

The X-NUCLEO-IKS01A1 is a sensor expansion board for the STM32 Nucleo board. It is also compatible with Arduino UNO R3 connector layout and is designed around humidity (HTS221), pressure (LPS25HB) and motion (LIS3MDL and LSM6DS0) sensing devices. The X-NUCLEO-IKS01A1 interfaces with the STM32 MCU via the I²C

pin, and the user can change the default I²C port and the device IRQ by changing a resistor on the evaluation board.

You can attach the LSM6DS3 DIL24 expansion component and use it instead of the one of the LSM6DS0 sensors.

Figure 22. X-NUCLEO-IKS01A1 expansion board



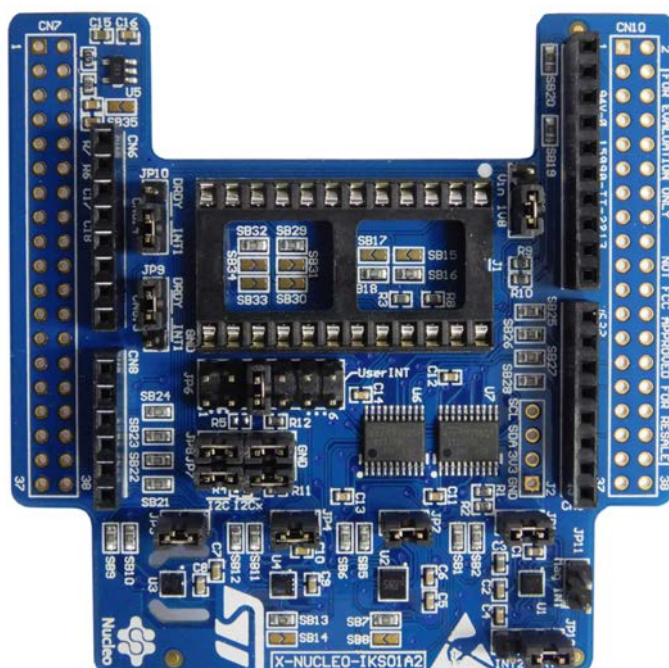
3.1.3 X-NUCLEO-IKS01A2 expansion board

The [X-NUCLEO-IKS01A2](#) is a motion MEMS and environmental sensor expansion board for STM32 Nucleo.

It is compatible with the Arduino UNO R3 connector layout, and is designed around the [LSM6DSL](#) 3D accelerometer and 3D gyroscope, the [LSM303AGR](#) 3D accelerometer and 3D magnetometer, the [HTS221](#) humidity and temperature sensor and the [LPS22HB](#) pressure sensor.

The X-NUCLEO-IKS01A2 interfaces with the STM32 microcontroller via the I²C pin, and it is possible to change the default I²C port.

Figure 23. X-NUCLEO-IKS01A2 MEMS and environmental sensor expansion board



3.1.4 Software description

The following software components are required in order to establish a suitable development environment for creating applications for the STM32 Nucleo equipped with the sensor expansion board:

- X-CUBE-MEMS1: an STM32Cube expansion for sensor application development. The X-CUBE-MEMS1 firmware and associated documentation is available on www.st.com.
- Development tool-chain and compiler: The STM32Cube expansion software supports the three following environments:
 - IAR Embedded Workbench for ARM® (EWARM) toolchain + ST-LINK
 - RealView Microcontroller Development Kit (MDK-ARM) toolchain + ST-LINK
 - System Workbench for STM32 + ST-LINK

3.2 Hardware and software setup

This section describes the hardware and software setup procedures. It also describes the system setup needed for the above.

3.2.1 Hardware setup

The following hardware components are required:

1. One STM32 Nucleo development platform (suggested order code: NUCLEO-F401RE or NUCLEO-L053R8 or NUCLEO-L152RE or NUCLEO-L476RG)
2. One sensor expansion board (order code: X-NUCLEO-IKS01A1 or X-NUCLEO-IKS01A2)
3. One USB type A to mini-B USB cable to connect the STM32 Nucleo to a PC

3.2.2 Software setup

To set up the SDK, run the sample testing scenario based on the GUI utility and customize applications, select one of the integrated development environments supported by the STM32Cube expansion software and follow the system requirements and setup information provided by the IDE provider.

For more information you can refer to Unicleo-GUI user manual available on www.st.com.

3.2.3 System setup guide

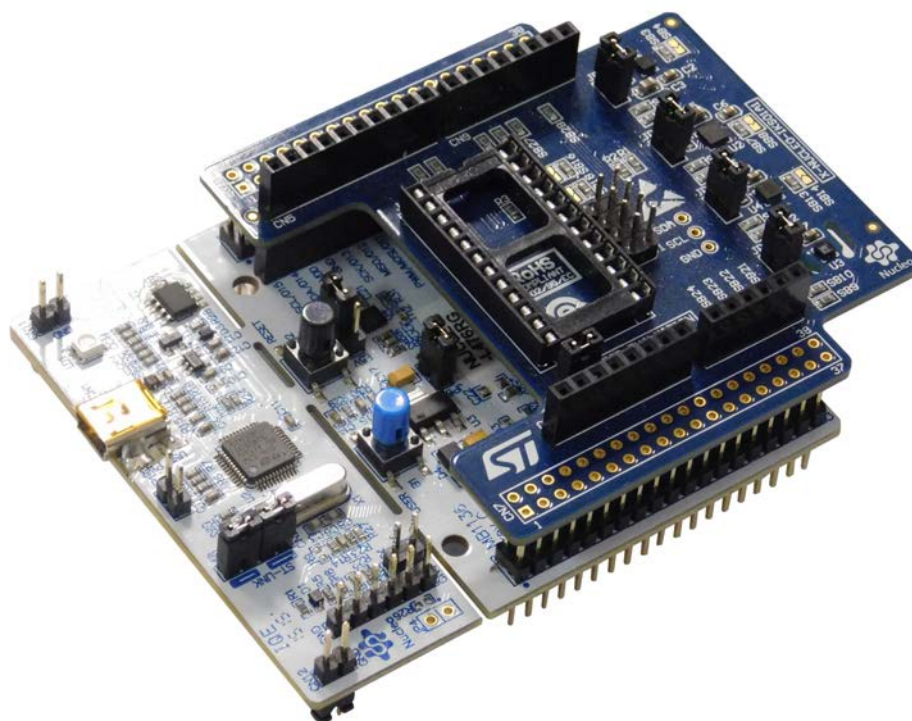
This section describes how to setup different hardware components before writing and executing an application on the STM32 Nucleo board with the sensor expansion board.

3.2.4 STM32 Nucleo and sensor expansion board setup

The STM32 Nucleo board integrates the ST-LINK/V2-1 debugger/programmer. Developers can download the relevant version of the ST-LINK/V2-1 USB driver by searching STSW-LINK008 or STSW-LINK009 (according to your version of Windows) on www.st.com.

The X-NUCLEO-IKS01A1 and X-NUCLEO-IKS01A2 sensor expansion boards can be easily connected to the STM32 Nucleo board through the Arduino UNO R3 extension connector and can interface with the external STM32 microcontroller on STM32 Nucleo via the Inter-Integrated Circuit (I²C) transport layer.

Figure 24. Sensor expansion board plugged to STM32 Nucleo board



3.2.5 Unicleo-GUI setup

The Unicleo-GUI retrieves sensor data from the connected STM32 Nucleo board and displays it in tables and graphs.

To use the Unicleo-GUI, ensure the relevant hardware and software has been correctly set up.

The Unicleo-GUI installer for a Windows PC can be downloaded from www.st.com. "Utilities\PC_Software" folder contains a link to the download page.

Revision history

Table 1. Document revision history

Date	Revision	Changes
24-Jul-2018	1	Initial release

Contents

1	What is STM32Cube?	2
1.1	STM32Cube overview	2
1.2	STM32Cube architecture	2
2	X-CUBE-MEMS1 software expansion for STM32Cube	4
2.1	Overview	4
2.2	Architecture	4
2.3	Folder structure	5
2.4	APIs	6
2.5	DataLog application	6
2.6	Unicleo-GUI data logging utility	6
2.7	DataLogExtended application	10
2.8	DataLogTerminal application	11
2.9	FIFO mode application for pressure sensor	12
2.10	6D orientation application for accelerometer sensor	13
2.11	FIFO continuous mode application for gyroscope sensor	13
2.12	FIFO low power mode application for accelerometer sensor	14
2.13	FIFO mode application for gyroscope sensor	15
2.14	Free fall detection application for accelerometer sensor	15
2.15	Multiple event application for accelerometer sensor	16
2.16	Pedometer application for accelerometer sensor	16
2.17	Self-test application for accelerometer and gyroscope sensors	17
2.18	Single tap and double tap detection for accelerometer sensor	18
2.19	Tilt detection for accelerometer sensor	18
2.20	Wake up detection for accelerometer sensor	18
2.21	Sample applications for motion libraries	19
3	System setup guide	20
3.1	Hardware description	20
3.1.1	STM32 Nucleo platform	20
3.1.2	X-NUCLEO-IKS01A1 expansion board	20

3.1.3	X-NUCLEO-IKS01A2 expansion board	21
3.1.4	Software description	22
3.2	Hardware and software setup	22
3.2.1	Hardware setup.	22
3.2.2	Software setup	22
3.2.3	System setup guide.	22
3.2.4	STM32 Nucleo and sensor expansion board setup.	23
3.2.5	Unicleo-GUI setup.	23
Revision history		24

List of tables

Table 1.	Document revision history	24
----------	-------------------------------------	----

List of figures

Figure 1.	Firmware architecture	2
Figure 2.	X-CUBE-MEMS1 software architecture	5
Figure 3.	X-CUBE-MEMS1 package folder structure	5
Figure 4.	Windows Device Manager	7
Figure 5.	Unicleo-GUI main page	7
Figure 6.	Unicleo-GUI Utility sensor and interval selection	8
Figure 7.	Unicleo-GUI data plot	8
Figure 8.	Unicleo-GUI Motion Sensor Plot	9
Figure 9.	Unicleo-GUI Environmental Sensor Plot	10
Figure 10.	Unicleo-GUI right click Menu	10
Figure 11.	DataLogExtended application screenshot from Unicleo-GUI	11
Figure 12.	DataLogTerminal application screenshot	12
Figure 13.	FIFO mode application for pressure sensor screenshot	13
Figure 14.	6D orientation application for accelerometer sensor screenshot	13
Figure 15.	FIFO continuous mode application for gyroscope sensor screenshot	14
Figure 16.	FIFO low power mode application for accelerometer sensor screenshot	15
Figure 17.	FIFO mode application for gyroscope sensor screenshot	15
Figure 18.	Multiple event application for accelerometer sensor screenshot	16
Figure 19.	Pedometer application for accelerometer sensor screenshot	17
Figure 20.	Self-test application for accelerometer and gyroscope sensors screenshot	18
Figure 21.	STM32 Nucleo board	20
Figure 22.	X-NUCLEO-IKS01A1 expansion board	21
Figure 23.	X-NUCLEO-IKS01A2 MEMS and environmental sensor expansion board	22
Figure 24.	Sensor expansion board plugged to STM32 Nucleo board	23

IMPORTANT NOTICE – PLEASE READ CAREFULLY

STMicroelectronics NV and its subsidiaries ("ST") reserve the right to make changes, corrections, enhancements, modifications, and improvements to ST products and/or to this document at any time without notice. Purchasers should obtain the latest relevant information on ST products before placing orders. ST products are sold pursuant to ST's terms and conditions of sale in place at the time of order acknowledgement.

Purchasers are solely responsible for the choice, selection, and use of ST products and ST assumes no liability for application assistance or the design of Purchasers' products.

No license, express or implied, to any intellectual property right is granted by ST herein.

Resale of ST products with provisions different from the information set forth herein shall void any warranty granted by ST for such product.

ST and the ST logo are trademarks of ST. All other product or service names are the property of their respective owners.

Information in this document supersedes and replaces information previously supplied in any prior versions of this document.

© 2018 STMicroelectronics – All rights reserved