Getting started with X-LINUX-MEMS1 package for developing MEMS Applications on Linux

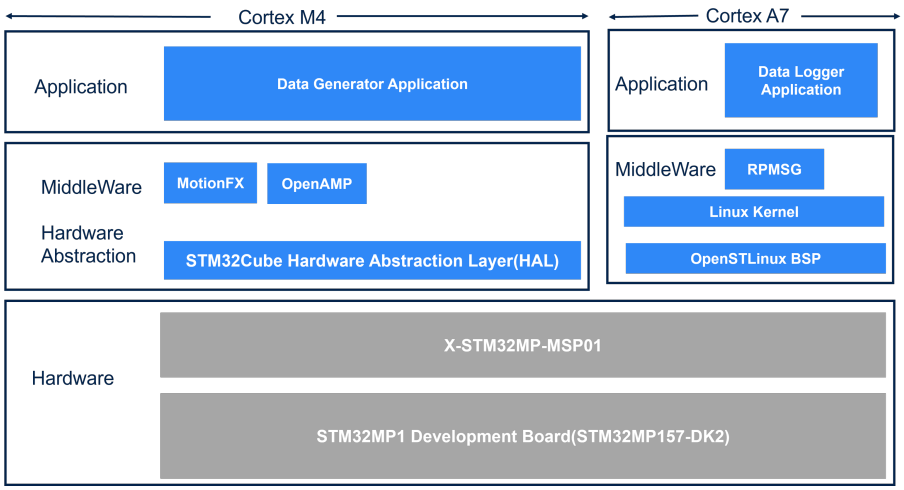
Introduction

The X-LINUX-MEMS1 is an STM32MPU OpenSTLinux software expansion package for the STM32MP157F-DK2 discovery kit, used to demonstrate sensor fusion (STM32_MotionFX_Library) running on the Cortex® M4, and sensor data logging application running on the Cortex® A7, of the STM32MP1.

The X-LINUX-MEMS1 software package is used with X-STM32MP-MSP01 multi-sensor board connected to a 40-pin GPIO header of the STM32MP1 DK2 board. The motion FX library running on the Cortex® M4 uses MEMS sensors data (ISM330DHCX: accelerometer and gyroscope. IIS2MDC: magnetometer) and sends data over RPMsg (remote processor messaging) to the Cortex® A7.

The firmware running on the Cortex® M4 is based on an X-CUBE-MEMS1 package.

Figure 1. X-LINUX software architecture diagram



1 X-LINUX-MEMS1 overview

The X-LINUX-MEMS1 software provides a user space application running on STM32MP157F-DK2 for the X-STM32MP-MSP01 expansion board with multiple motion sensors. The X-LINUX-MEMS1 software package is composed of 3 modules:

1. Data logger (C firmware running on Cortex® M4) containing firmware drivers for accelerometer, gyroscope and magnetometer.
2. Sensor fusion (STM32_MotionFX_Library – running on Cortex® M4).
3. User application based on RPMsg (C application based on RPMsg running on Cortex® A7 and receiving data from Cortex® M4).

1.1 Features

The main features of the X-LINUX-MEMS1 are as follows:

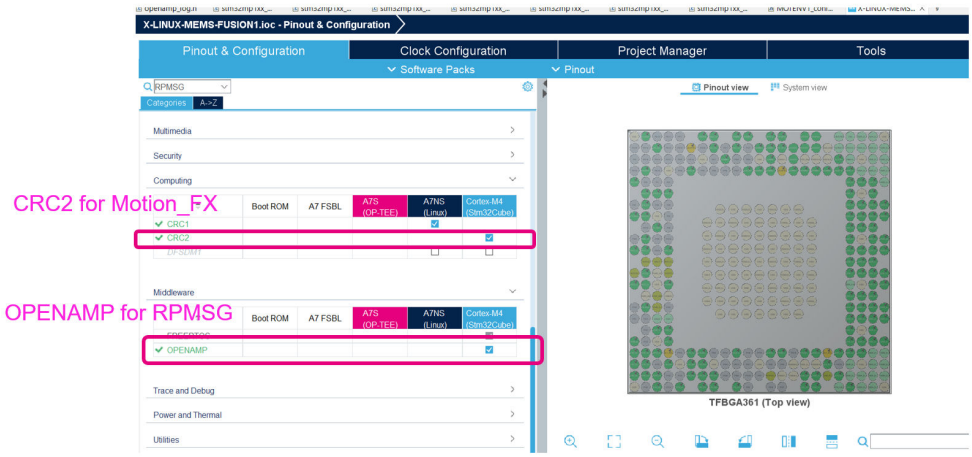
- Firmware for Cortex®M4 for running Motion FX
- C console application based on RPMsg running on Cortex A7 for data logging
- Compatible with STM32 ODE
- Environment sensors driver included
- Free, user-friendly license terms

1.2 Software configuration

Apart from other settings there are two main settings for the software configuration:

1. CRC2 enable for Motion_FX running on Cortex® M4
2. RPMSG for communication between Cortex® M4 and Cortex® A7

Figure 2. IOC File Settings



1.3 Software package structure

The folder structure of the software package is below:

Figure 3. Release package structure Top Level

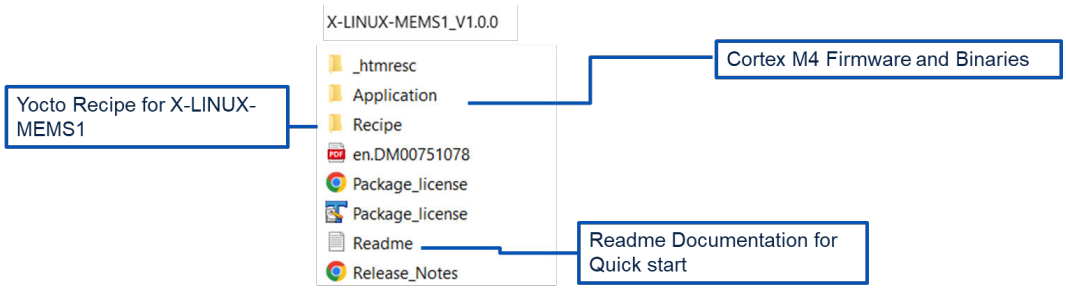
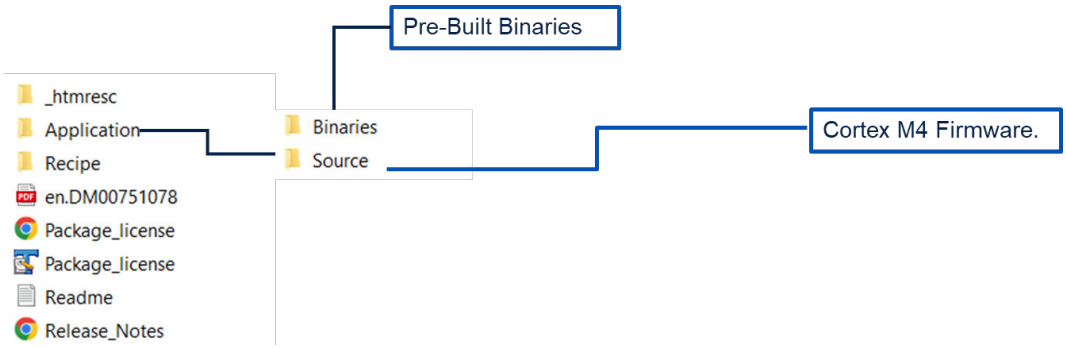


Figure 4. Folder content overview



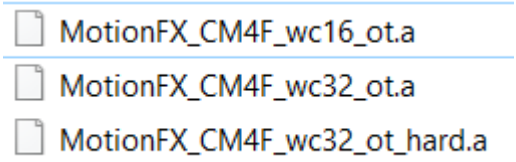
1.3.1 Cortex® M4 firmware

Cortex® M4 is firmware for MEMS data reading over I²C. The application is built for the below MEMS sensors:

1. ISM330DHCX: 3-axis accelerometer and 3-axis gyroscope.
2. IIS2MDC: 3-axis digital magnetometer.
3. IIS2DLPC: 3-axis accelerometer for industrial applications.

It uses the motion_FX sensor fusion library to show the sensor fusion data such as heading and quaternion on the console C – application

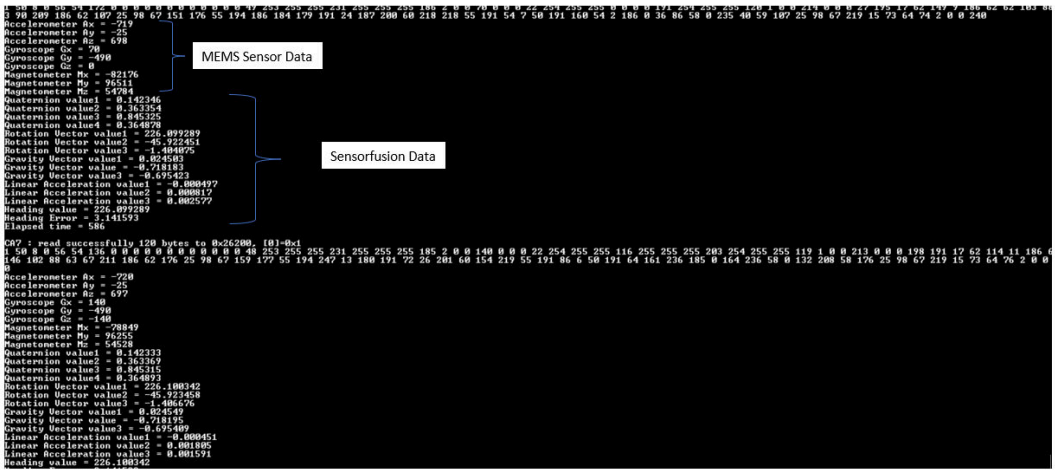
Figure 5. MotionFX Library for Cortex M4



1.3.2 Cortex® A7 application

The RPMsg is a console C application based on the RPMsg framework used to receive the data from the Cortex® M4 at regular intervals. A high level application (QT, GTK or Python) can be made on top of this data, as shown below, and is sent at regular intervals.

Figure 6. Sensor data logging application



2 Hardware setup

The X-LINUX-MEMS1 software works with the X-STM32MP-MSP01 board, which is plugged on the 40-pin GPIO connector present on the STM32MP157F-DK2 platform.

Figure 7. X-STM32MP-MSP01 expansion board

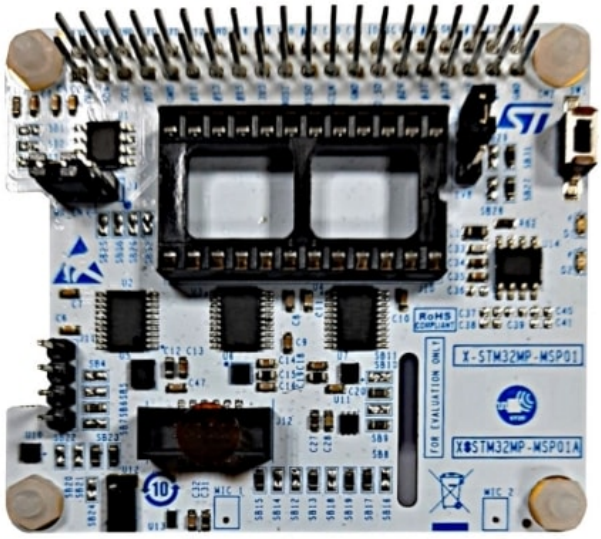
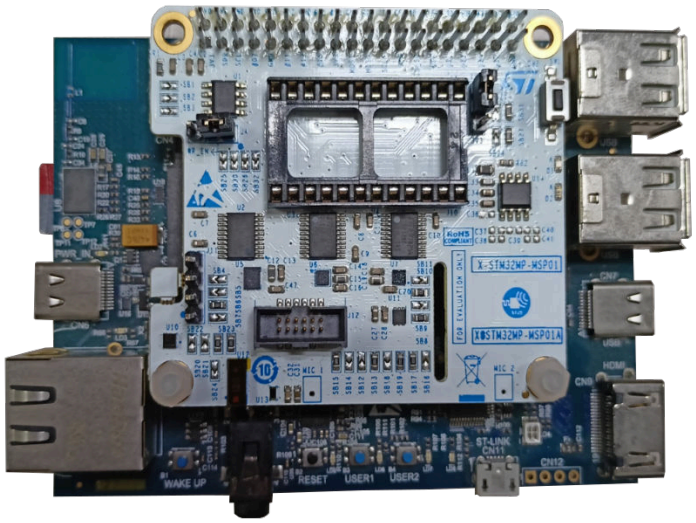


Figure 8. X-STM32MP-MSP01 expansion board on STM32MP1 board



3 Software setup

This section describes the software setup, which is required for building, flashing, transferring, and running the MEMS application.

3.1 Recommended PC prerequisites

A Linux® PC running under Ubuntu® 20.04 is to be used. The developer can follow the link below:

https://wiki.st.com/stm32mpu/wiki/PC_prerequisites

3.2 Installing the SDK

This software package is built for the STM32 MPU ecosystem 4.1. This is required to build the application package. The package contains the binaries which can be transferred using the scp command or zmodem. In case customization is needed in the application, installing the SDK helps in building it. The developer can follow the link below:

STM32MPU SDK Installation.

Once the SDK is installed, export the tool chain using the below command to build any Cortex® A7 application:

```
$source . /<path to SDK Installation Directory>/environment-setup-cortexa7t2hf-neon-vfpv4-ostl-linux-gnueabi
```

3.3 Downloading and running the package

This is required to build the X-LINUX-MEMS1 Yocto recipe for the distribution package and for creating the STM32MP1 SD card flashable images, which has the MEMS application (elf, rpmsg, Python) embedded.

The developer can follow the given link to download the Distribution Package:

3.4 Connecting to the board and transferring files

This is required to transfer the built binaries (application, elf, Python) to the STM32MP157F-DK2 board from the development PC. The developer can transfer the binaries either by a:

1. a hotspot method
2. or setting up a Wi-Fi connection in the Board: How to setup a WLAN connection - stm32mpu
3. or using any serial protocol (like zmodem from Tera Term)

4 Building the application

The Cortex® M4 firmware is built using STM32CubeIDE, while the rmpsg application is built using the tool chain provided in the STM32MP1 SDK.

4.1 Starter Packages

Download or clone the package (X-LINUX-MEMS1_V1.0.0.tar.xz) from www.st.com and extract it.

```
$tar xvf X-LINUX-MEMS1_V1.0.0.tar.xz
```

You get the X-LINUX-MEMS1_V1.0.0 folder as shown in Figure 4. Folder content overview.

4.2 Cortex® M4 firmware

The firmware workspace is built using STM32CubeIDE:

Figure 9. X-LINUX-MEMS1 Cortex® M4 folder structure

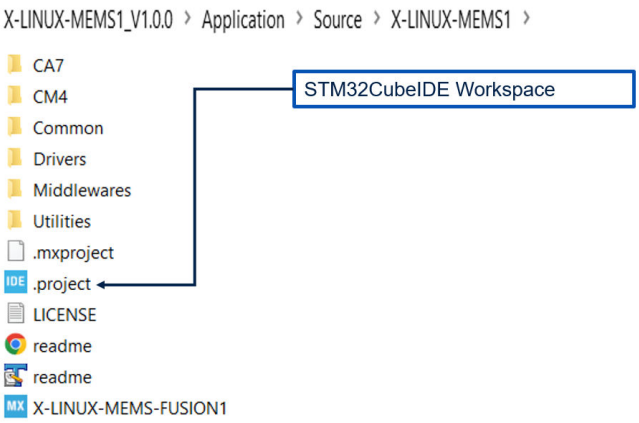
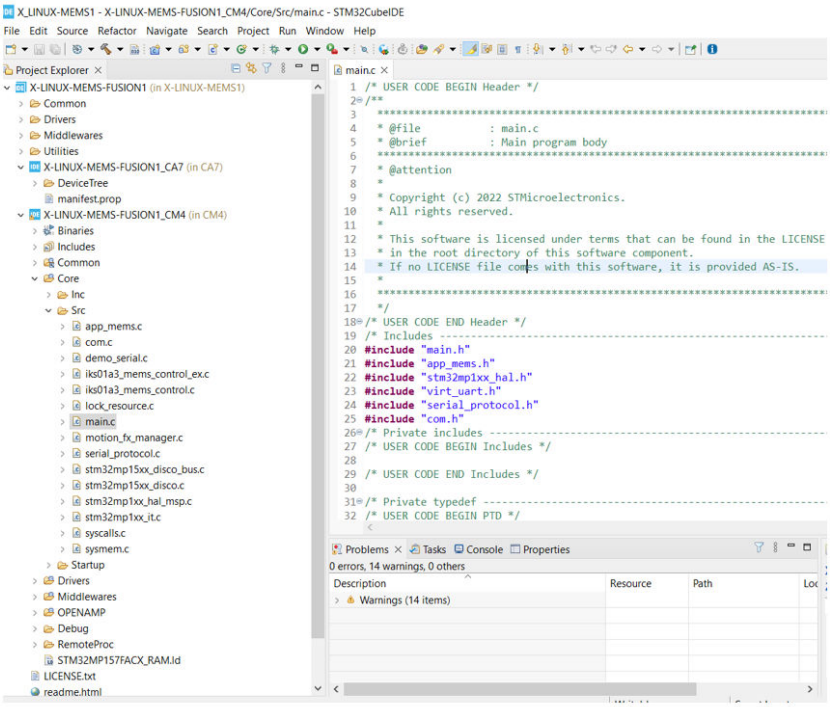


Figure 10. **STM32CubeIDE Cortex® M4 workspace**



After building the application, X-LINUX-MEMS-FUSION1_CM4.elf is formed at X-LINUX-MEMS1\X-LINUX-MEMS\CM4\Debug.

4.3 Cortex® A7 application

The rpmsg can be built using the makefile provided via the make command. Before building using the make command, tool chain for STM32MP1SDK needs to be exported using source command mentioned in Section 3.2 Installing the SDK.

Makefile and the rpmsg source are present at: X-LINUX-MEMS1_V1.0.0\Application\Source\X-LINUX-MEMS1\Utilities\C\rpmsg.

4.4 Distribution package

This is required to build the Yocto recipes and create STM32MP1 images which has x-linux-mems1 application embedded in them.

Step 1. Create a directory for the distribution package and initialize repo in the current directory

```
PC $> repo init -u https://github.com/STMicroelectronics/oe-manifest.git -b refs/tags/openstlinux-5.15-yocto-kirkstone-mp1-v22.11.23
```

```
PC $> repo sync
```

Step 2. Initializing the OpenEmbedded build environment for STM32MP1

```
PC $> DISTRO=openstlinux-weston MACHINE=stm32mp1 source layers/meta-st/scripts/envsetup.sh
```

Step 3. Download the X-LINUX-MEMS1 application package

```
PC $> cp -rf X-LINUX-MEMS1_V1.0.0/Recipe/meta-st-mems1/ ../layers/meta-st/
```

copy it into the layers/meta-st folder inside the build directory

Step 4. Add meta-st-mems1 layer

```
PC $> bitbake-layers add-layer ../layers/meta-st/meta-st-mems1
```

Step 5. Update the configuration to add new components in the image

```
PC $> echo 'IMAGE_INSTALL:append = "mems1"' >> ../layers/meta-st/meta-st-openstlinux
/conf/layer.conf
```

or

```
PC $>vi ../layers/meta-st/meta-st-openstlinux/conf/layer.conf
```

```
IMAGE_INSTALL: append = "mems1"
```

Step 6. Build the image

```
PC $> bitbake st-image-weston
```

New Images are formed in the tmp-glibc/deploy/images/stm32mp1/ directory

```
PC $> ls -l tmp-glibc/deploy/images/stm32mp1/FlashLayout_sdcard_stm32mp157f-dk2-trus
ted.tsv
```

and FlashLayout_sdcard_stm32mp157f-dk2-trusted are created besides other images.
Follow the "link" to flash the binary.

Step 7. Check if the file below is present on the discovery kit

```
$ ls -l /lib/firmware
```

Elf file and rpmsg utility will be present.

4.5 Running the application

4.5.1 Using rpmsg utility

4.5.1.1 Starter package

The .elf and rpmsg can be built as explained in the above section. There are prebuilt binaries which can be pushed to the discovery kit at /lib/firmware.

Change the permission of rpmsg and run the application

```
$chmod a+x rpmsg
```

```
$./rpmsg
```

4.5.2 Using Python utility

Transfer X-LINUX-MEMS1_V1.0.0\Application\Source\X-LINUX-MEMS1\Utilities\sensor.py utility to /lib/firmware

Run the below command in the terminal of the STM32MPU and Python GUI will be launched on the STM32MPU LCD Screen.

```
PC $python3 sensor.py
```

Figure 11. **Running Python GUI**

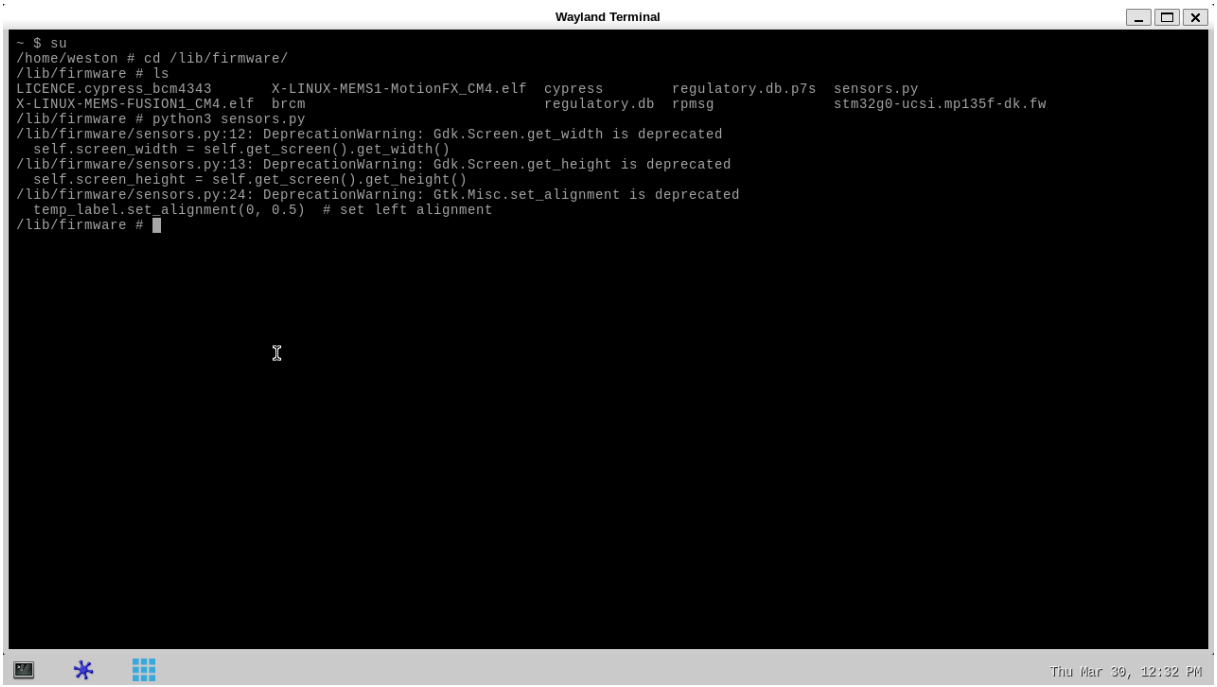


Figure 12. **Sensor.py Python GUI**

4.5.3 Distribution package

Once flashed using STM32CubeProgrammer, these files (.elf, rpmsg, sensor.py) can be found at the '/lib/firmware' location.

Revision history

Table 1. **Document revision history**

Date	Revision	Changes
05-May-2023	1	Initial release.
08-Jun-2023	2	Watermark has been removed.

Contents

List of tables

List of figures