LAB#1 GUIDE

Rapid Wireless Sensing enabled by NXP’s latest MCX W23 wireless MCU and Low-Power Motion Wakeup Sensors

Hands-on Lab#1 Guide

Contents

Hands-On Lab#1 Overview:

Tamper detection using low-power motion wakeup sensors:
Securing Your Assets with MCXW23 Wireless MCU

Brief Description

This example uses **FRDM-MCXW23** and on-board **FXLS8974CF** accelerometer sensor to demonstrate autonomous detection of tampering/theft/abuse on device using low-power motion wakeup feature and transmit ALERT message via BLE wireless UART.

Details

The core idea is to leverage advanced sensor technology to protect high-value or secure assets. For example, smart meters can monitor for tampering, enhancing home security by detecting unauthorized access to safes or lockers. Personal medical devices can be safeguarded against misuse, and laptops or tablets can be protected from theft. In industrial settings, warehouse theft detection and machine tampering alerts can significantly reduce losses and improve security. This technology can benefit even simple applications like door open/close detection.

Solution

This example demonstrates ease-of-enablement using NXP's FRDM-MCXW23 and sensors development ecosystem to accelerate prototyping for your multiple such applications.

The **Lab#1** solution comprises of:

- **MCX W23** for transmitting tamper detection alerts via BLE.
- 3-axis accelerometer **FXLS8974CF** for low-power motion wakeup.

FXLS8974CF: 3-Axis Accelerometer:

The **FXLS8974CF** is a **3-axis accelerometer** targeted for application requiring **low-power motion wake up**. This sensor has **SDCD (sensor data change detection) embedded block which implements an efficient and flexible inertial event detection function** to detect various inertial events like no-motion/motion detecting tamper/theft/abuse on an asset. This ultra-low power wake-up on motion can trigger host MCU to wake-up or go back to deep sleep mode when no motion detected autonomously.

Key Features:

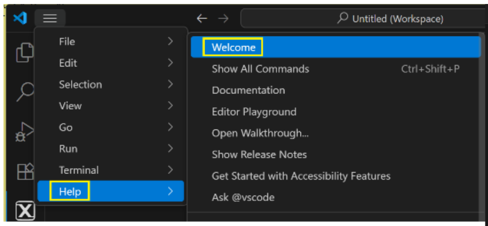
- **Ultra Low power**: < 1 µA in low power wakeup mode (0.78 Hz to 6.25 Hz ODR)
- **Sensor Data Change Detection (SDCD) function**: highly configurable digital window comparator for easy / efficient implementation of low-power motion detection
- **Self-Test Diagnostic**: Can be run in field to assess device health (unaffected by device orientation or motion)
- **±2 to ±16 g** (user selectable) full scale range
- **12-bit** Sensor Data Output Resolution
- **I²C / SPI** (pin configurable) digital interfaces
- **2 x 2 mm DFN Package**, 0.4 mm pitch with wettable flanks
- **-40 to 105 °C** operating temperature
- **EMC Class III** Compliant

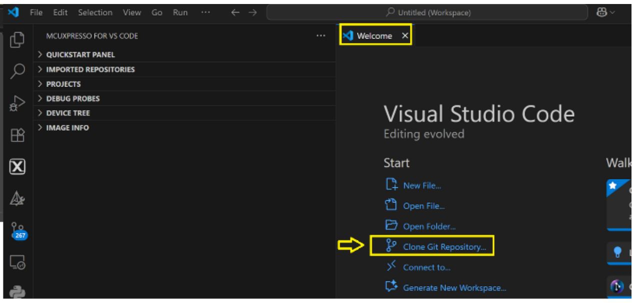
Target Applications:

- Asset tracking/Inventory management
- Patient activity monitoring
- Metering anti-tampering
- Drug delivery.
- Medical wearables
- Home Security
- Equipment monitoring
- Vibration Sensing
- Camera Stabilization

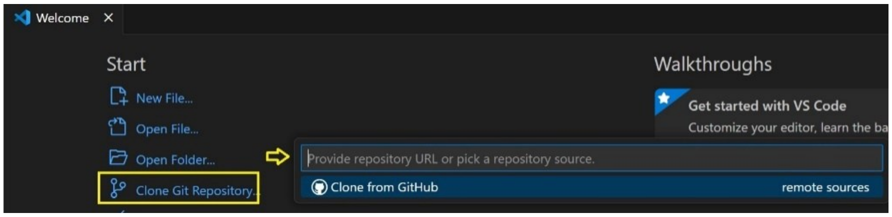
Get Hands-on Workshop Lab Examples from ACH

1) Open VS Code and select "Clone Git Repository" option on the “Welcome” page. Find the “Welcome” page under “Help” tab.

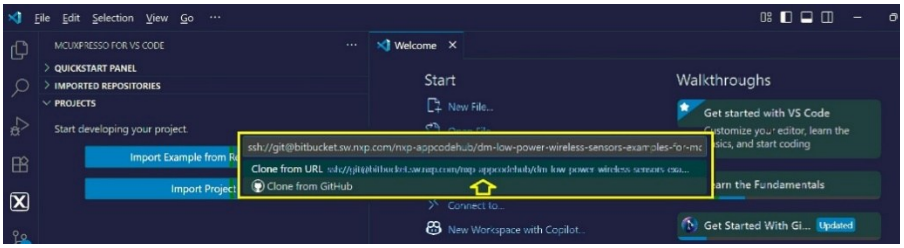




2) VS Code will open a pop-up to allow you to enter the Git repository URL.



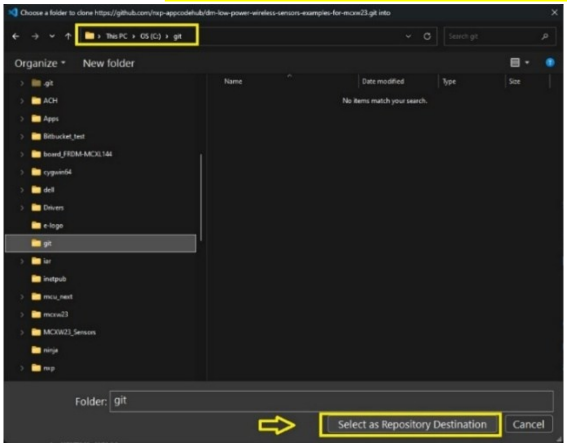
3) Copy the ACH gihub URL:"https://github.com/nxp-appcodehub/dm-low-power-wireless-sensors-examples-for-mcxw23.git" and select the the "Clone from URL" option.



ssh://git@bitbucket.sw.nxp.com/nxp-appcodehub/dm-low-power-wireless-sensors-examples-for-mc

Clone from URL ssh://git@bitbucket.sw.nxp.com/nxp-appcodehub/dm-low-power-wireless-sensors-exa...

4) It will ask for local destination directory where you would like to save the cloned repository, <u>create a "git" folder under C: drive and select that folder</u>.

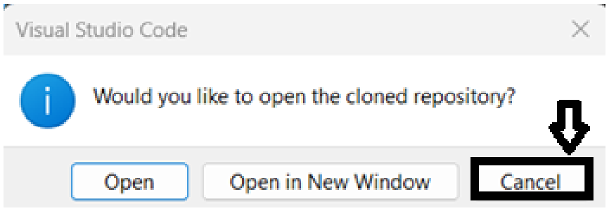


Choose a folder to clone https://github.com/nxp-appcodehub/dm-low-power-wireless-sensors-examples-for-mcxw23.git into

This PC › OS (C:) › git

Folder: git

5) VS Code will ask whether you would like to open the cloned repository. Click on Cancel.

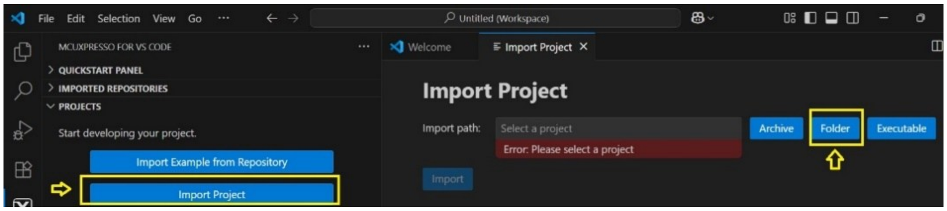


Visual Studio Code

Would you like to open the cloned repository?

6) VS Code will clone the repository into the destination folder i.e. C:\git directory.

7) Click on "Import Project(s)" to start importing the chosen ACH project(s).



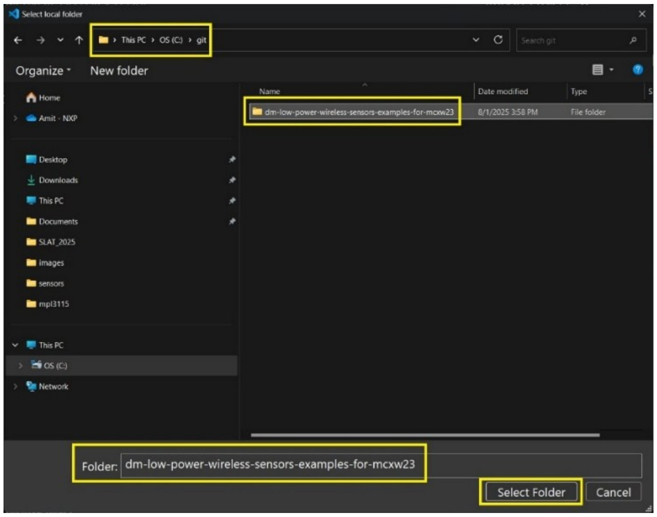
Start developing your project.

Import Project

Import path: Select a project

Error: Please select a project

8) Select the cloned repository destination folder i.e. "C:/git/dm-low-power-wireless-sensors-examples-for-mcxw23".



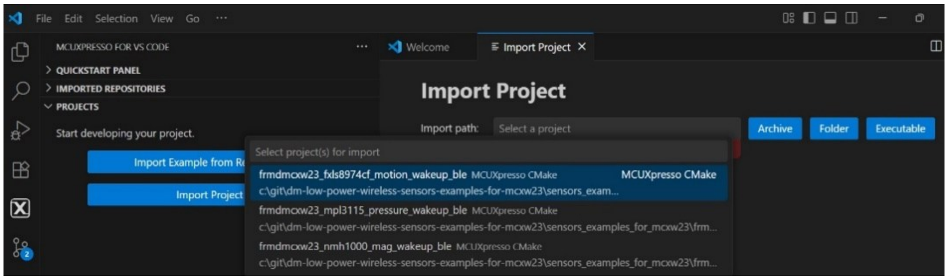
Select local folder

This PC › OS (C:) › git

Name	Date modified	Type
dm-low-power-wireless-sensors-examples-for-mcxw23	8/1/2025 3:58 PM	File folder

Folder: dm-low-power-wireless-sensors-examples-for-mcxw23

9) Import Lab#1 "frmdmcxw23_fxls8974cf_motion_wakeup_ble" project into VS code workspace:



Start developing your project.

Import Project

Import path: Select a project

Select project(s) for import

frmdmcxw23_fxls8974cf_motion_wakeup_ble MCUXpresso CMake MCUXpresso CMake
c:\git\dm-low-power-wireless-sensors-examples-for-mcxw23\sensors_exam...

frmdmcxw23_mpl3115_pressure_wakeup_ble MCUXpresso CMake
c:\git\dm-low-power-wireless-sensors-examples-for-mcxw23\sensors_examples_for_mcxw23\frm...

frmdmcxw23_nmh1000_mag_wakeup_ble MCUXpresso CMake
c:\git\dm-low-power-wireless-sensors-examples-for-mcxw23\sensors_examples_for_mcxw23\frm...

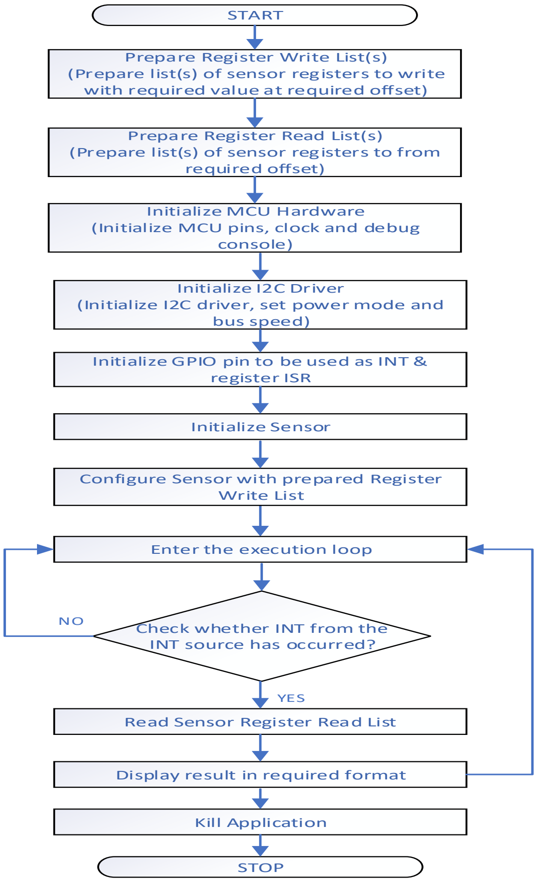
10) Select the toolchain version: ARM GNU Toolchain.

11) The selected "frmdmcxw23_fxls8974cf_motion_wakeup_ble" project is now imported on the VS Code workspace.

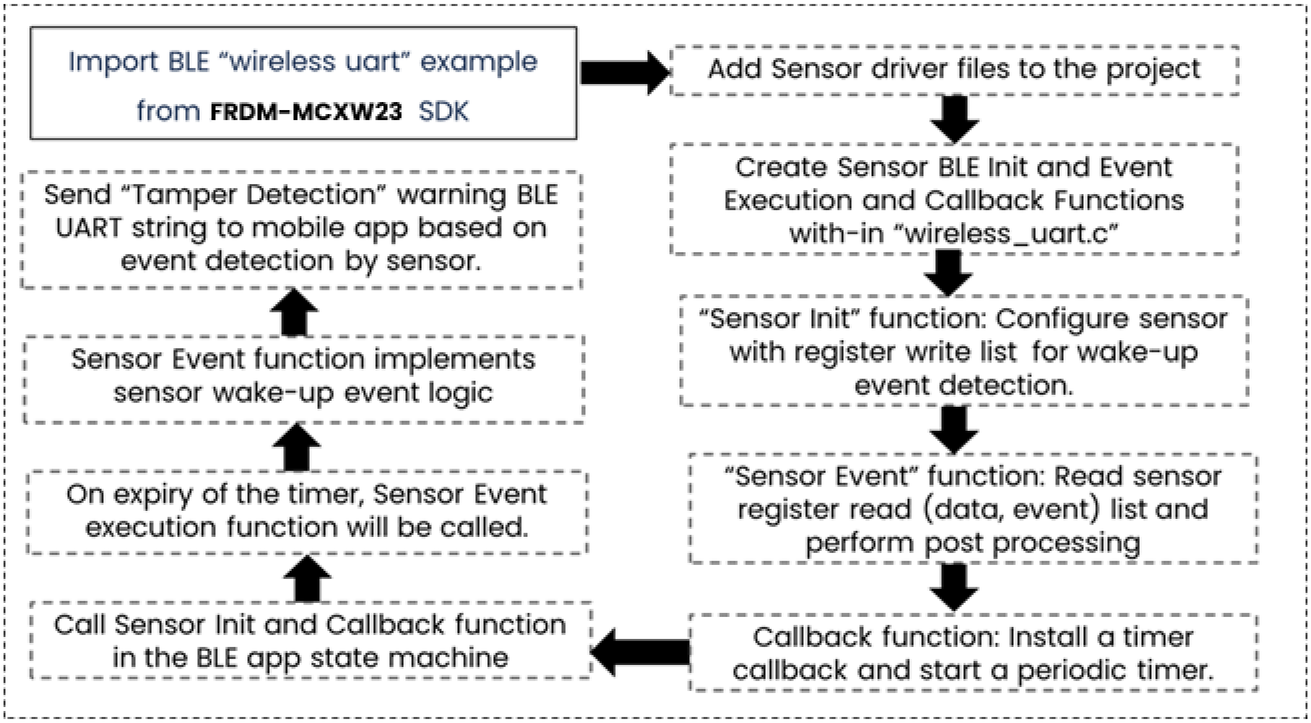
Code Walkthrough

Typical ISSDK example code flow:

1) Prepare register write list.
2) Prepare register read list.
3) Initialize MCU Hardware (Pins, Clock etc.)
4) Initialize COMM (I2C, SPI) driver
5) Initialize GPIO pin to be user as INT and register ISR.
6) Initialize Sensor, read WHOAMI
7) Configure Sensor with prepared register write list
8) Enter execution loop:
   i. Check whether interrupt source has occurred.
   ii. If yes, then read register read list
   iii. Display result or upload into TSA table
   iv. Execute post processing or other functions.


START
Prepare Register Write List(s)
(Prepare list(s) of sensor registers to write with required value at required offset)
Prepare Register Read List(s)
(Prepare list(s) of sensor registers to from required offset)
Initialize MCU Hardware
(Initialize MCU pins, clock and debug console)
Initialize I2C Driver
(Initialize I2C driver, set power mode and bus speed)
Initialize GPIO pin to be used as INT & register ISR
Initialize Sensor
Configure Sensor with prepared Register Write List
Enter the execution loop
NO
Check whether INT from the INT source has occurred?
YES
Read Sensor Register Read List
Display result in required format
Kill Application
STOP

Learn how to convert SDK wireless example to wireless sensing example:



Import BLE “wireless uart” example from **FRDM-MCXW23** SDK

Add Sensor driver files to the project

Create Sensor BLE Init and Event Execution and Callback Functions with-in “wireless_uart.c”

“Sensor Init” function: Configure sensor with register write list for wake-up event detection.

“Sensor Event” function: Read sensor register read (data, event) list and perform post processing

Callback function: Install a timer callback and start a periodic timer.

Call Sensor Init and Callback function in the BLE app state machine

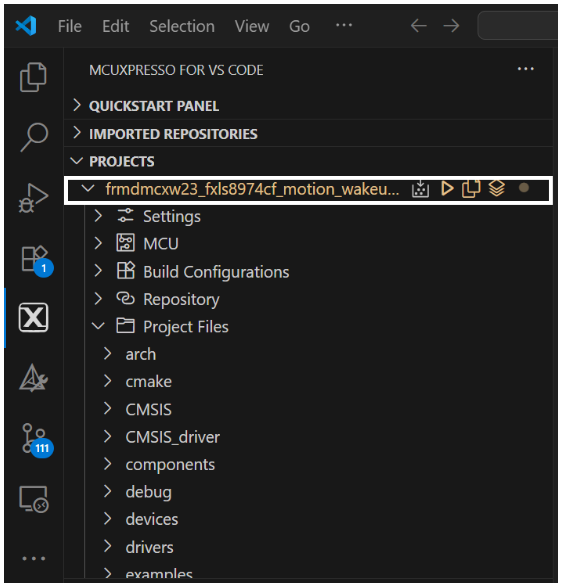
On expiry of the timer, Sensor Event execution function will be called.

Sensor Event function implements sensor wake-up event logic

Send “Tamper Detection” warning BLE UART string to mobile app based on event detection by sensor.

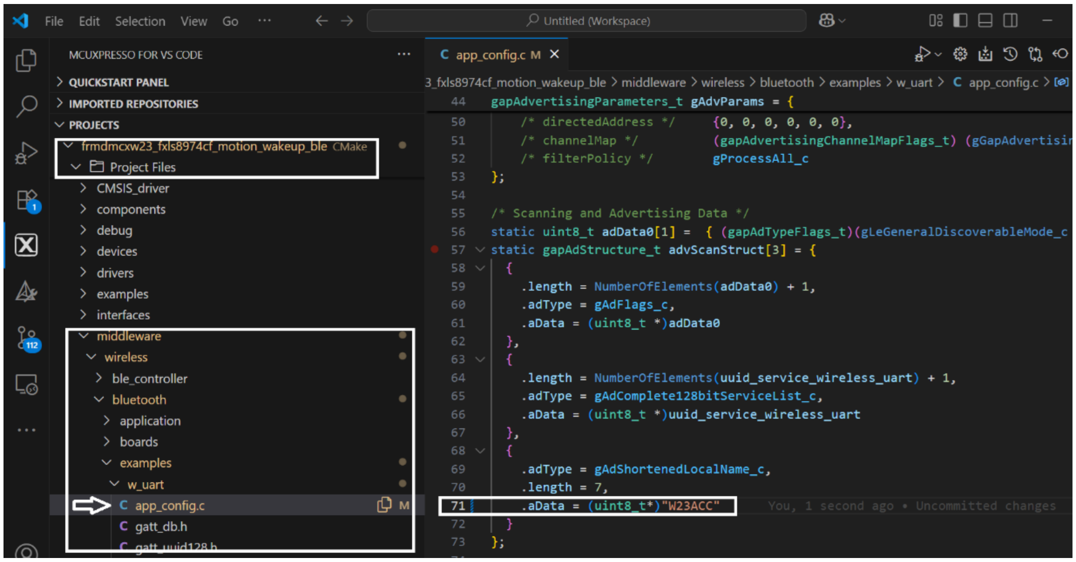
Compile Project:

1) Chose “frmdmcxw23_fxls8974cf_motion_wakeup_ble” project” on your VS Code workspace:



2) Before compiling the project go to Explorer view and open app_config.c file (available under “Project Files->middleware->wireless->Bluetooth->examples->w_uart” folder).

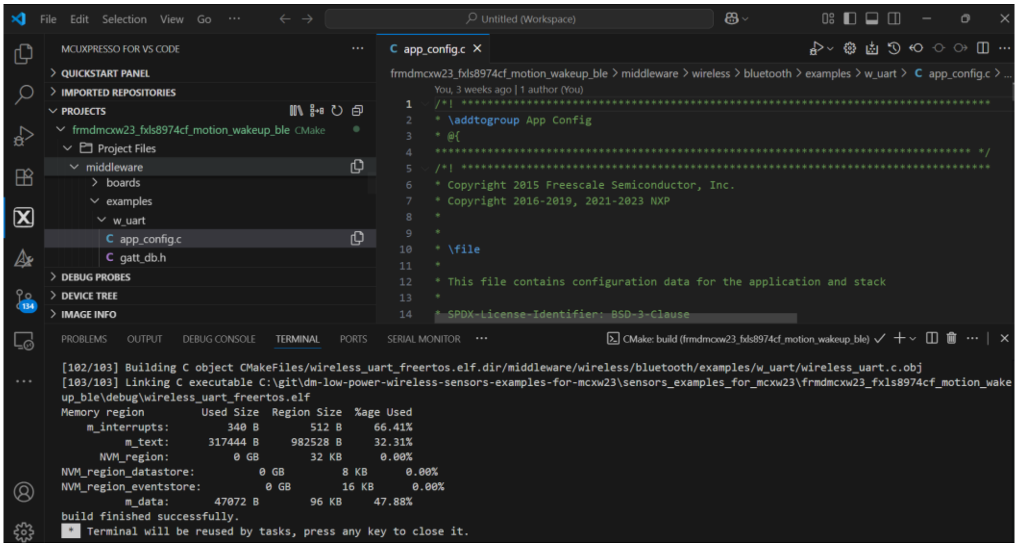
3) On line 71, make sure to update “aData” field with a unique name (this will help to identify your board so that it doesn’t clash with any other nearby board). Let me change to “NXP_A0” (try using NXPA01 onwards) but you can select any name you want (max length is 6 characters).



```
gapAdvertisingParameters_t gAdvParams = {
    /* directedAddress */     {0, 0, 0, 0, 0, 0},
    /* channelMap */          (gapAdvertisingChannelMapFlags_t) (gGapAdvertisi
    /* filterPolicy */        gProcessAll_c
};

/* Scanning and Advertising Data */
static uint8_t adData0[1] =  { (gapAdTypeFlags_t)(gLeGeneralDiscoverableMode_c
static gapAdStructure_t advScanStruct[3] = {
  {
    .length = NumberOfElements(adData0) + 1,
    .adType = gAdFlags_c,
    .aData = (uint8_t *)adData0
  },
  {
    .length = NumberOfElements(uuid_service_wireless_uart) + 1,
    .adType = gAdComplete128bitServiceList_c,
    .aData = (uint8_t *)uuid_service_wireless_uart
  },
  {
    .adType = gAdShortenedLocalName_c,
    .length = 7,
    .aData = (uint8_t*)"W23ACC"
  }
};
```

4) Right click on chosen project and select "Pristine Build/Rebuild Project" to start clean build the project.

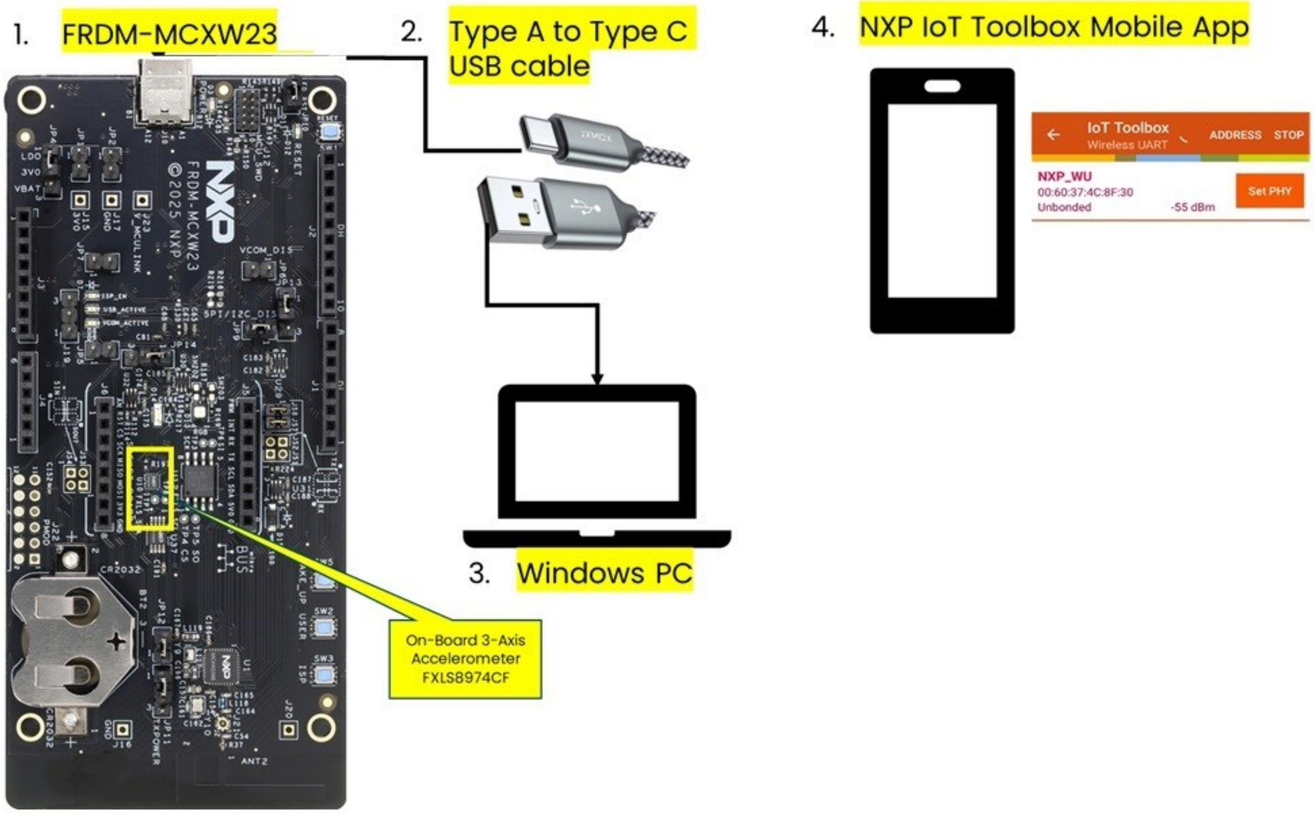
5) Confirm successful compilation of “frmdmcxw23_fxls8974cf_motion_wakeup_ble” project.



```
/*! *********************************************************************************
* \addtogroup App Config
* @{
********************************************************************************** */
/*! *********************************************************************************
* Copyright 2015 Freescale Semiconductor, Inc.
* Copyright 2016-2019, 2021-2023 NXP
*
*

* \file
*
* This file contains configuration data for the application and stack
*
* SPDX-License-Identifier: BSD-3-Clause
```

```
[102/103] Building C object CMakeFiles/wireless_uart_freertos.elf.dir/middleware/wireless/bluetooth/examples/w_uart/wireless_uart.c.obj
[103/103] Linking C executable C:\git\dm-low-power-wireless-sensors-examples-for-mcxw23\sensors_examples_for_mcxw23\frmdmcxw23_fxls8974cf_motion_wake
up_ble\debug\wireless_uart_freertos.elf
Memory region         Used Size  Region Size  %age Used
    m_interrupts:         340 B        512 B     66.41%
          m_text:      317444 B     982528 B     32.31%
      NVM_region:          0 GB        32 KB      0.00%
NVM_region_datastore:          0 GB         8 KB      0.00%
NVM_region_eventstore:          0 GB        16 KB      0.00%
          m_data:       47072 B        96 KB     47.88%
build finished successfully.
 *  Terminal will be reused by tasks, press any key to close it.
```

Connect HW:



1. FRDM-MCXW23

2. Type A to Type C USB cable

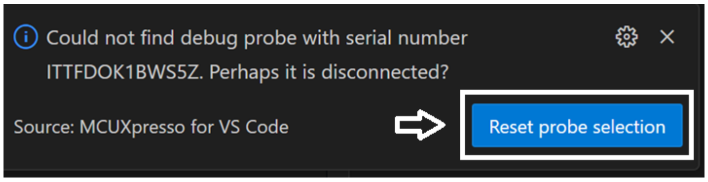
3. Windows PC

4. NXP IoT Toolbox Mobile App

On-Board 3-Axis Accelerometer FXLS8974CF

Program the target Board:

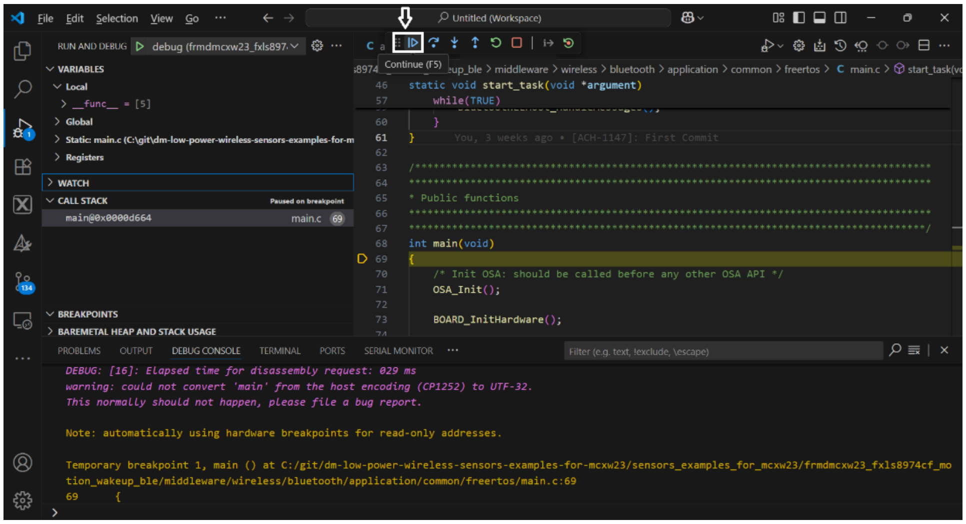
1) Right click on the "frdmmcxw23_fxls8974cf_motion_wakeup_ble" project and select "Debug".
2) In case VS code ask to reset debug probe, then click on “Reset probe selection” to proceed.



Could not find debug probe with serial number ITTFDOK1BWS5Z. Perhaps it is disconnected?

Source: MCUXpresso for VS Code

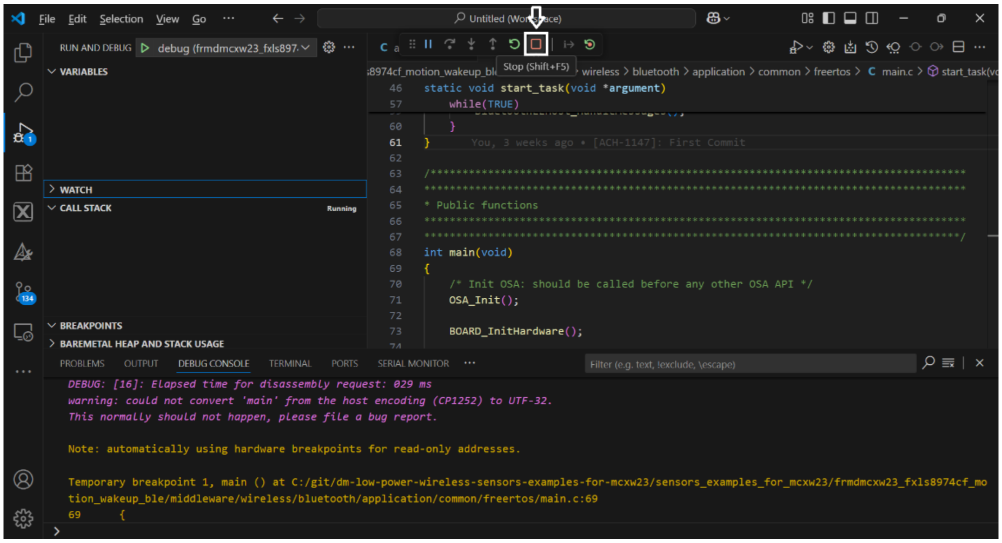
3) Debugger will start downloading the program to device. Once downloaded, you will see program curser in the main () function.



```
static void start_task(void *argument)
    while(TRUE)
    }
}

/*****************************************************************************
 * Public functions
 *****************************************************************************/
int main(void)
{
    /* Init OSA: should be called before any other OSA API */
    OSA_Init();

    BOARD_InitHardware();
```

```
DEBUG: [16]: Elapsed time for disassembly request: 029 ms
warning: could not convert 'main' from the host encoding (CP1252) to UTF-32.
This normally should not happen, please file a bug report.

Note: automatically using hardware breakpoints for read-only addresses.

Temporary breakpoint 1, main () at C:/git/dm-low-power-wireless-sensors-examples-for-mcxw23/sensors_examples_for_mcxw23/frdmmcxw23_fxls8974cf_mo
tion_wakeup_ble/middleware/wireless/bluetooth/application/common/freertos/main.c:69
69      {
```

4) Click on “Continue” button or press "F5" from your keyboard to resume running the downloaded program on device.
5) Now the program is downloaded on the device. you should see “white/bluish” LED blinking.
6) Click on “Terminate” button or press “Shift + F5” to terminate the debug session.



File
Edit
Selection
View
Go
Untitled (Workspace)
RUN AND DEBUG
debug (frmdmcxw23_fxls897
VARIABLES
WATCH
CALL STACK
Running
BREAKPOINTS
BAREMETAL HEAP AND STACK USAGE
Stop (Shift+F5)
s8974cf_motion_wakeup_bl › wireless › bluetooth › application › common › freertos › main.c › start_task(vo
PROBLEMS
OUTPUT
DEBUG CONSOLE
TERMINAL
PORTS
SERIAL MONITOR
Filter (e.g. text, !exclude, \escape)

```
static void start_task(void *argument)
    while(TRUE)
    }
}        You, 3 weeks ago • [ACH-1147]: First Commit

/*******************************************************************************
********************************************************************************
* Public functions
********************************************************************************
*******************************************************************************/
int main(void)
{
    /* Init OSA: should be called before any other OSA API */
    OSA_Init();

    BOARD_InitHardware();
```

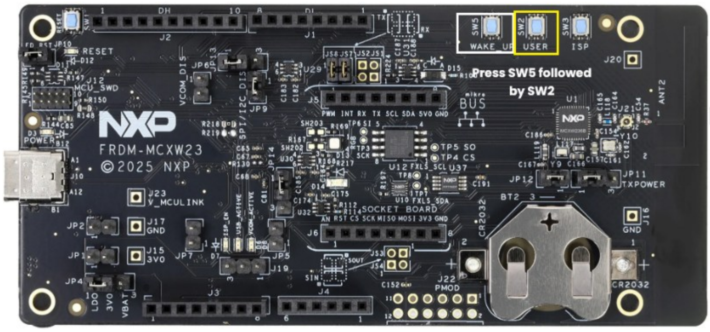
```
DEBUG: [16]: Elapsed time for disassembly request: 029 ms
warning: could not convert 'main' from the host encoding (CP1252) to UTF-32.
This normally should not happen, please file a bug report.

Note: automatically using hardware breakpoints for read-only addresses.

Temporary breakpoint 1, main () at C:/git/dm-low-power-wireless-sensors-examples-for-mcxw23/sensors_examples_for_mcxw23/frmdmcxw23_fxls8974cf_mo
tion_wakeup_ble/middleware/wireless/bluetooth/application/common/freertos/main.c:69
69      {
```

7) Disconnect the USB-C cable connected to FRDM-MCXW23 and reconnect. You should see “white/bluish” LED blinking

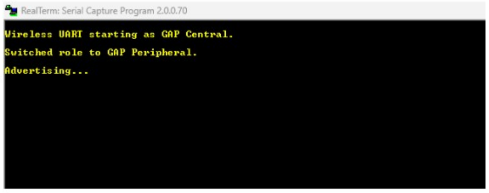
Start Advertising:

1) After that you should see white/bluish LED blinking and when you open a serial terminal (with baud rate 115200). You will see W UART starting as GAP central:

2) On the FRDM-MCXW23 board, press SW5 followed by SW2, then you will see the profile shift to GAP Peripheral and now advertising.



Press SW5 followed by SW2



```
Wireless UART starting as GAP Central.
Switched role to GAP Peripheral.
Advertising...
```

Run NXP IoT Toolbox App on your mobile:

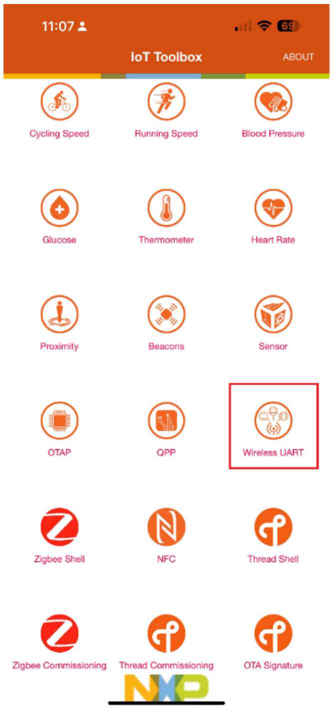
1) Open the installed NXP IoT Toolbox (available from Play Store and App Store) on your cell phone.

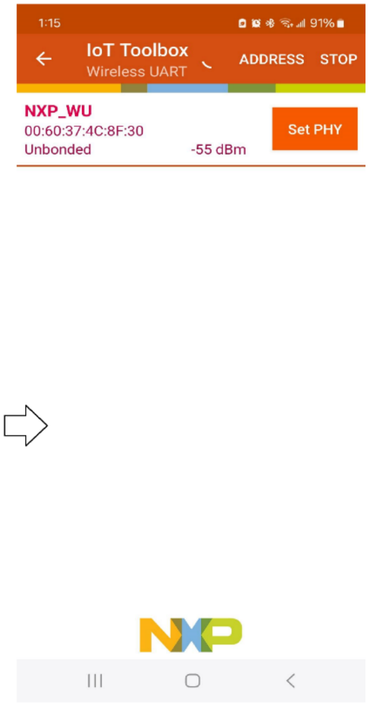
2) **<u>Make sure on your mobile phone following setting is set:</u>**

   <u>Bluetooth connection is ON, and the location is ON.</u>

3) Inside the application, click on the Wireless UART widget. Scan should start automatically.

4) When a device called NXP_WU or <your_id> appears, click on it. Your phone should now be connecting to the board.



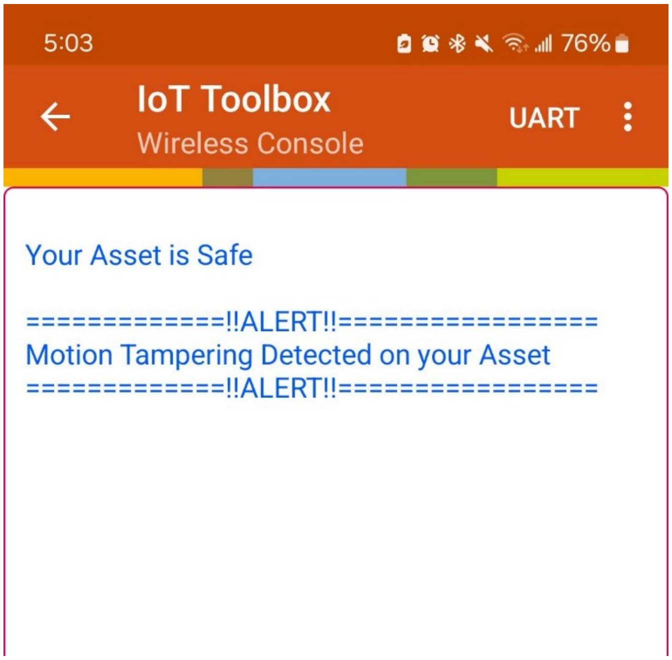


NXP_WU
00:60:37:4C:8F:30
Unbonded -55 dBm

5) With no tampering/motion shown on the FRDM-MCXW23 board, the Wireless UART application on IoT Toolbox mobile app will show status as: "Your Asset is Safe “.

6) When you show tampering/movement on the FRDM-MCXW23, the on-board FXLS8974CF accelerometer detects the motion and wakeup.

7) At that point, you will see Wireless UART app showing ALERT message as shown below:



```
Your Asset is Safe

=============!!ALERT!!=================
Motion Tampering Detected on your Asset
=============!!ALERT!!=================
```

8) FRDM-MCXW23 board will also show "RED" LED status. The "RED" LED status will continuously remain ON till tampering/motion detected.

9) If there is no further tampering/motion detected for continuous ~5 sec, the on-board FXLS8974CF accelerometer will detect no-motion and update the status message on wireless UART app. The "RED" LED status on FRDM-MCXW23 board will also go OFF.

Congratulation on successfully completing Hands-On Lab1

Congratulations!
You successfully
completed the
Hands-On Lab#1

Appendix

Revision History

Revision	Date	Description	Author
1.0	08/19/25	Creation	Amit Purohit