COINES Documentation

Bosch Sensortec

None

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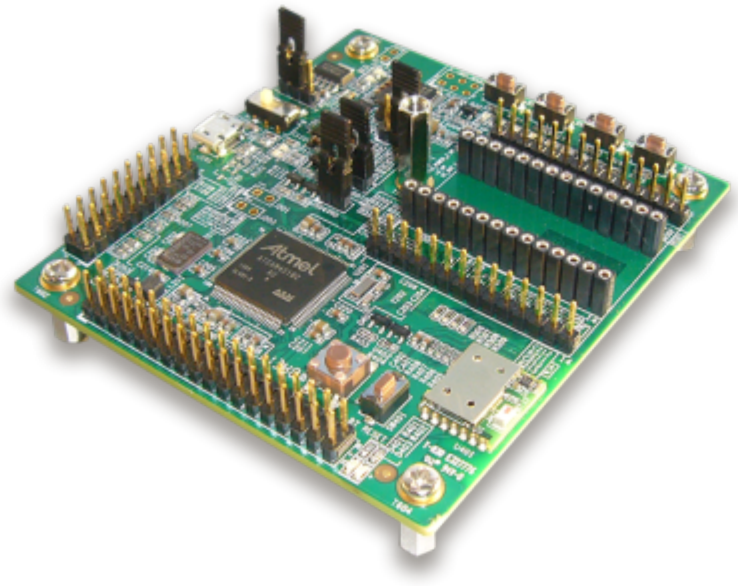
1. Introduction

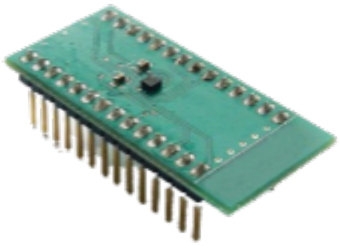
Bosch Sensortec offers a toolkit for evaluation of it's sensor products.The toolkit consists of 3 elements:

1. **Engineering board**: Application Board named APP2.0 and APP3.x in this document, serves as interface translator from the sensor interface (I^2C or SPI) to a USB interface, allowing PC software to communicate with the sensor on the shuttle board. Nicla Sense ME board combines four state-of-the-art sensors from Bosch Sensortec (BHI260AP, BMP390, BMM150 and BME688) in the Arduino ecosystem.



Application Board 2.0/3.0/3.1/Nicla Sense ME

2. **Sensor Shuttle board**: A sensor specific shuttle board also known as breakout board is a PCB with the sensor mounted on it. The shuttle board allows easy access to the sensor pins via a simple socket and can be directly plugged into the Bosch Sensortec's Application boards. APP3.x shuttle boards also known as mini shuttle boards has smaller form factor when compared with APP2.0 shuttle board.



APP2.0/3.x sensor shuttle board

3. **COINES**: COINES provides a low-level interface for communication with Bosch Sensortec's Engineering boards enabling access to their MEMS sensors through sample applications and SensorAPI. For detailed description, refer to sections below.

2. Introduction to COINES

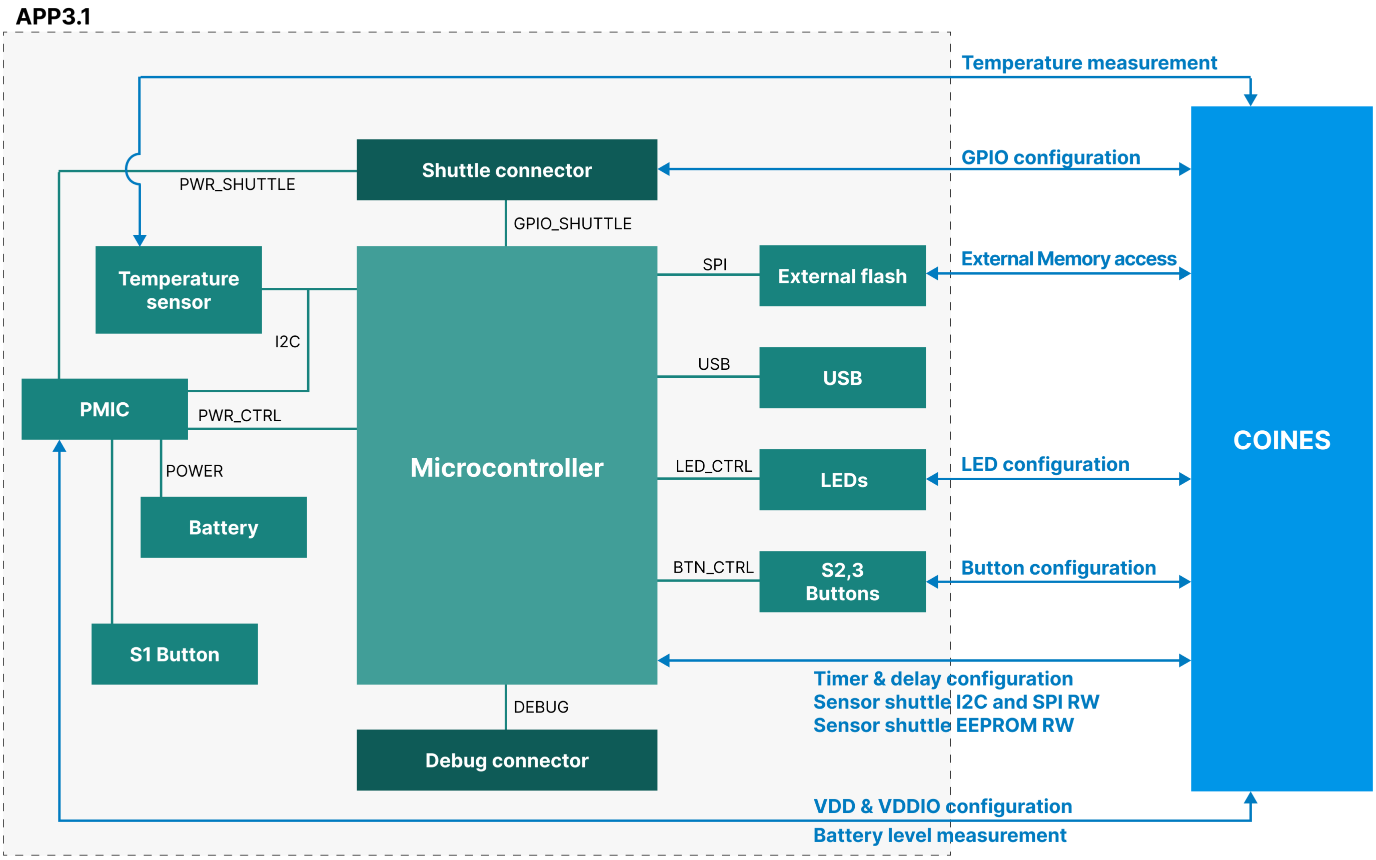
COINES (\"**CO**mmunication with **IN**ertial and **E**nvironmental **S**ensors\") is an SDK (Software Development Kit), implemented in C as a programming language that provides a low-level interface to Bosch Sensortec's Engineering Boards. The user can access Bosch Sensortec's MEMS sensors through this C interface. COINES can be used with the SensorAPI of the sensor which is available at https://github.com/BoschSensortec. The user can modify, compile and run the sample applications in COINES SDK and SensorAPI.

The full working environment consists of:

- A Bosch Sensortec MEMS sensor on a shuttle board mounted on the socket of Bosch Sensortec's Application board APP2.0/APP3.x
- Windows, Linux or Mac PC to which the Engineering Board is connected via USB or BLE.
- The release of the COINES software is available at https://www.bosch-sensortec.com/software-tools/tools/coines/
- C compiler is also required (for details, see sections below)

3. COINES usage

The following diagram represents COINES usage.



COINES usage with APP3.1

4. Installation

COINES should be usable on any recent PC or laptop system which has at least a performance as an "office PC". The hardware should provide a USB interface.

COINES runs on recent versions of Windows, Linux and Mac Operating systems.

4.1 Installation (Windows)

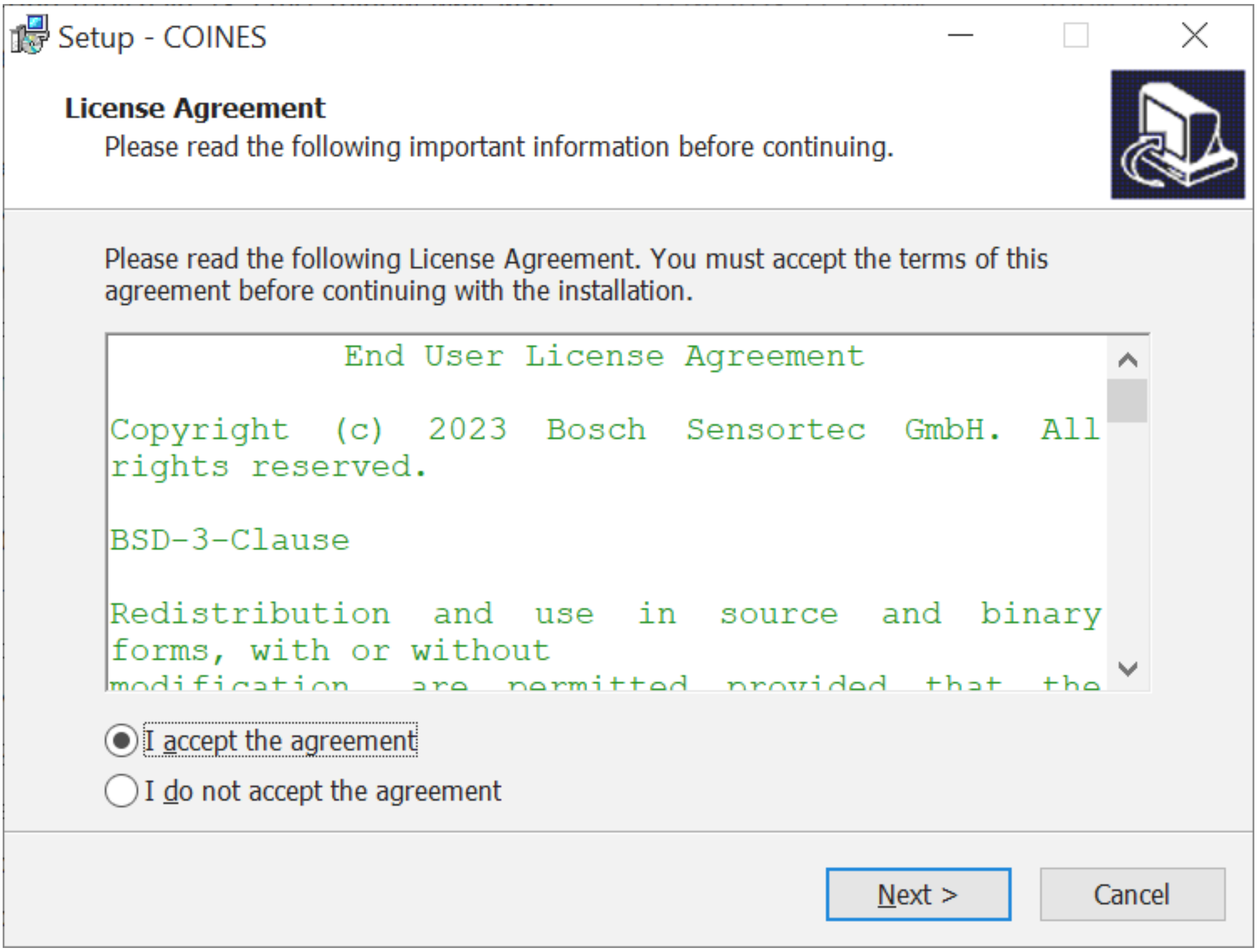
4.1.1 System requirements

The supported OS versions are Windows 10 and 11.

4.1.2 Installation of COINES

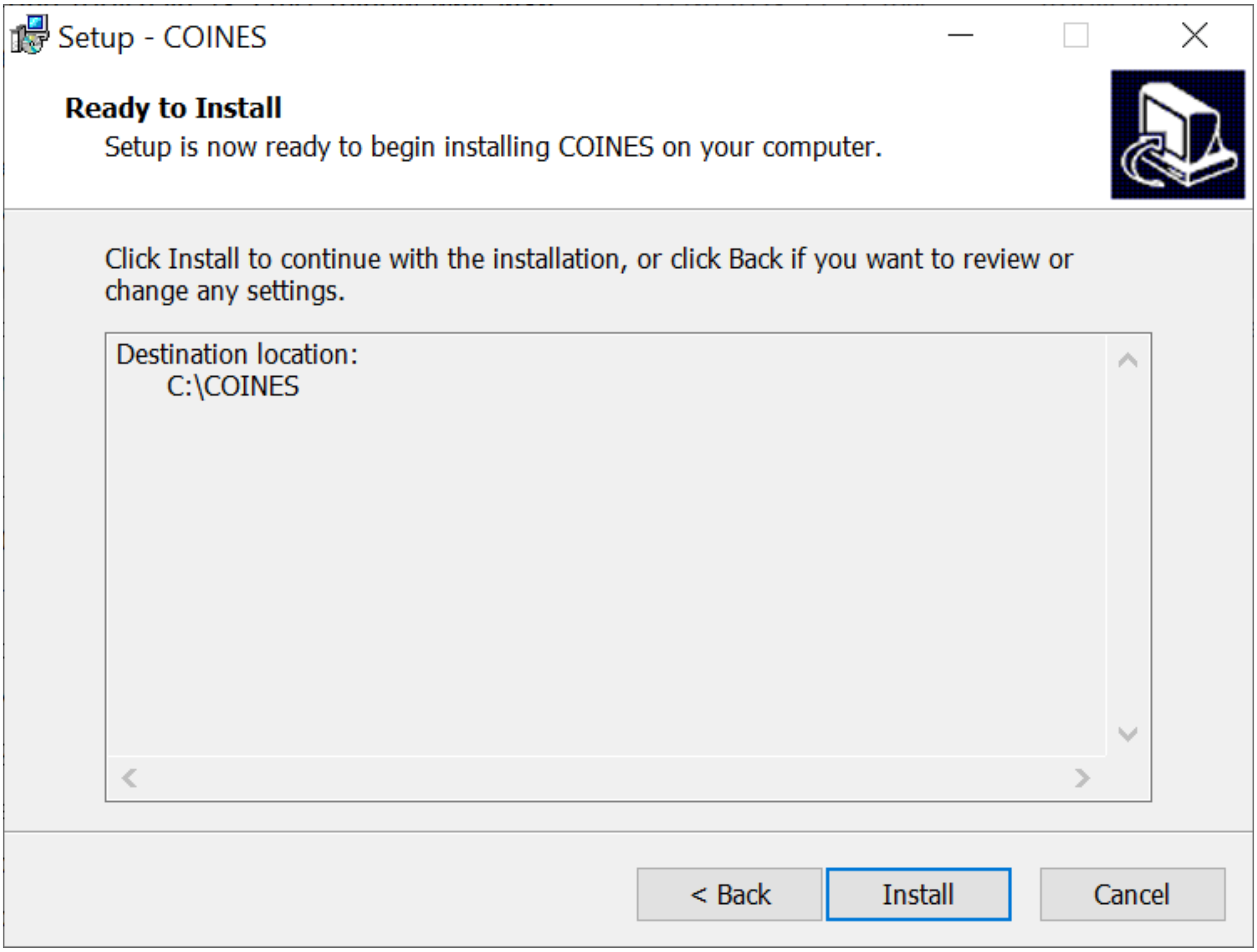
The steps below need to be followed in order to install COINES SDK:

1. Download the latest version of COINES from Bosch Sensortec website
2. Run the Installer
3. Accept the End User License Agreement and click Next



Windows installer end user agreement dialog

4. Click Install to start Installation



Windows install dialog

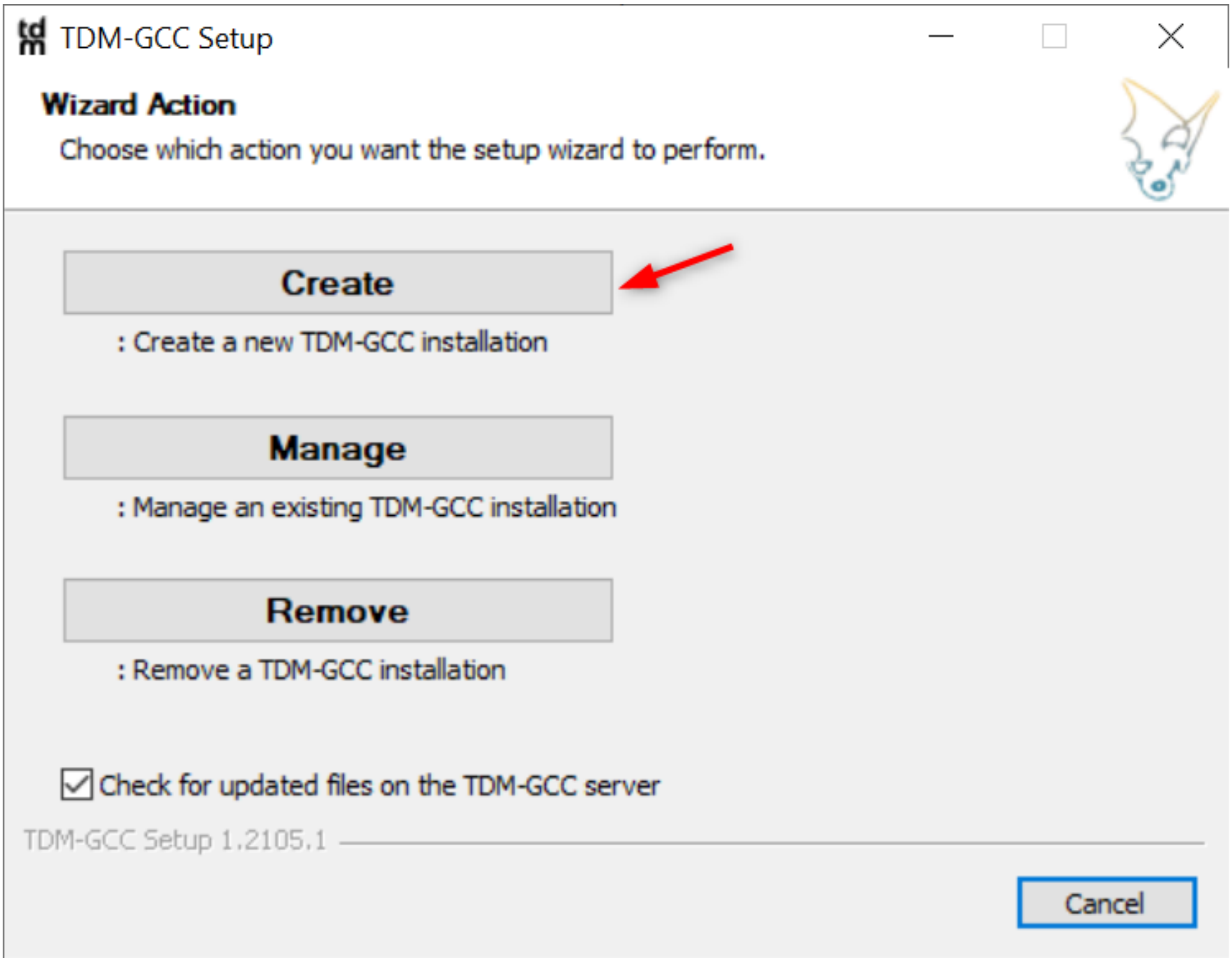
4.1.3 Installation of compiler environment

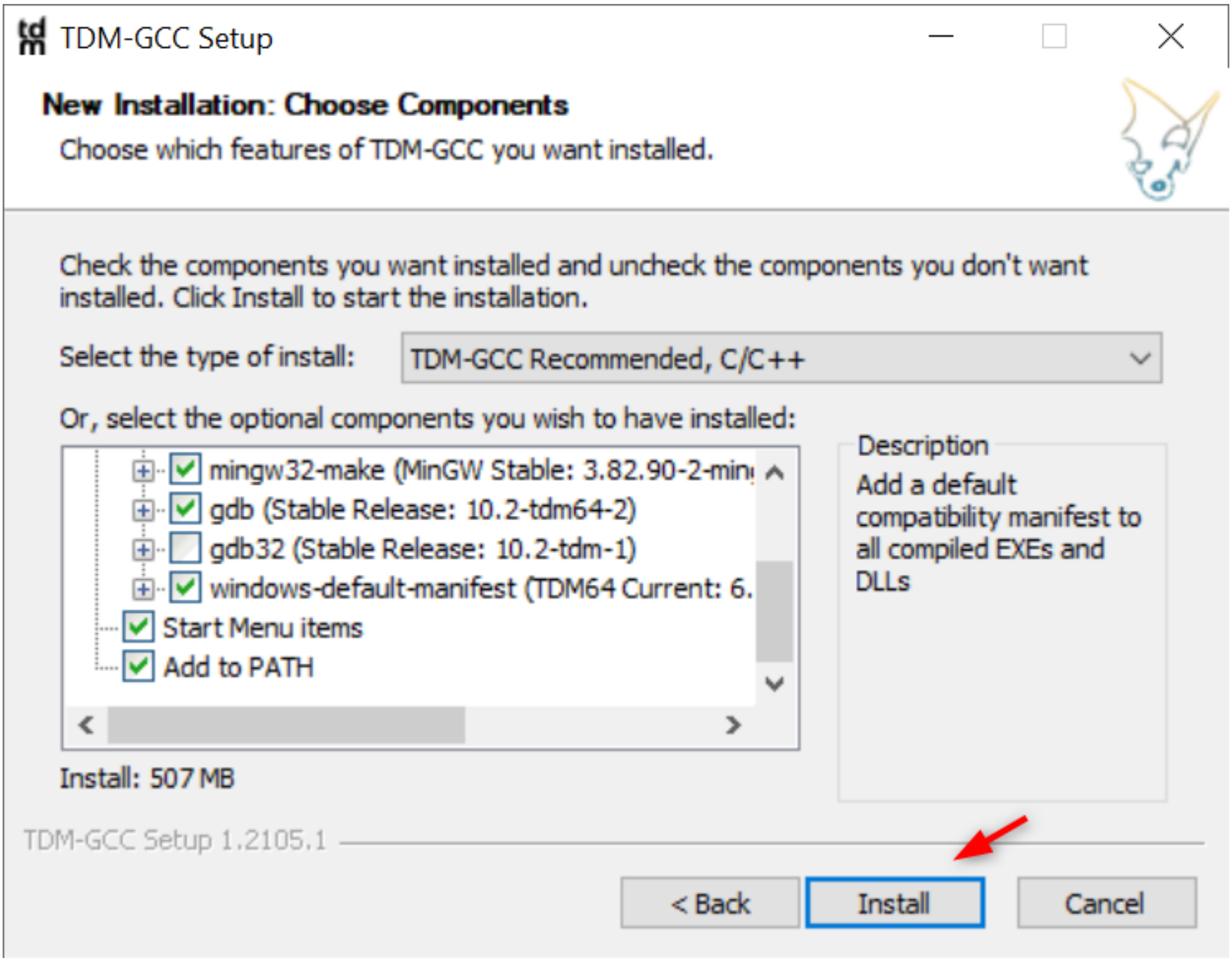
COINES examples can be built using GNU C compiler (GCC). There are various distributions of GCC. TDM-GCC is easy to install and hence preferred for COINES. TDM GCC is based on MinGW GCC.

If you have already installed GCC (MinGW/Cygwin/MSYS2 GCC) and added to 'PATH' environmental variable, you can skip compiler installation.

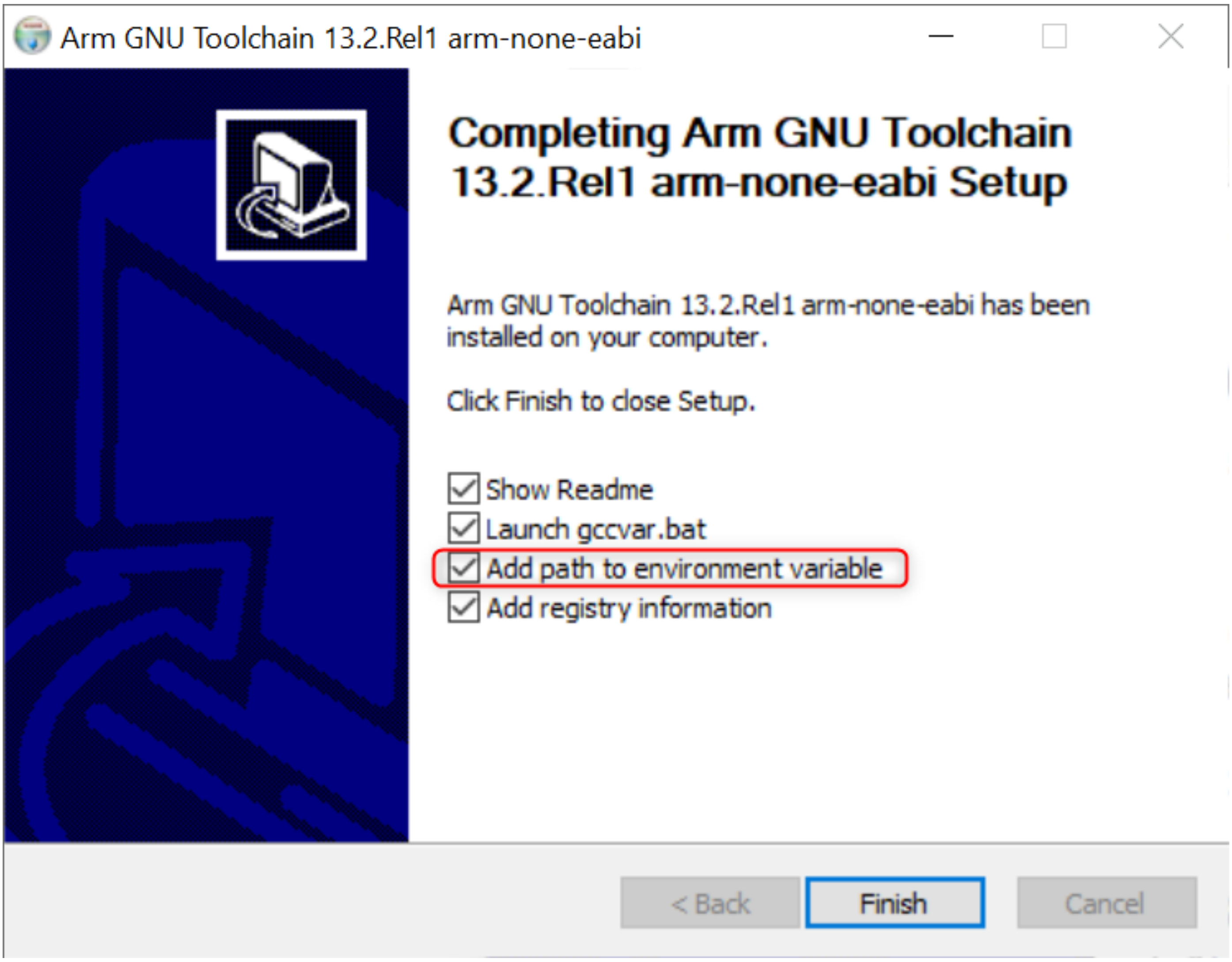
The steps to install compiler environment are as follows:

1. Download the TDM32/TDM64 bundle (link). **Use TDM32 bundle if your Windows OS is 32-bit and TDM64 bundle if 64-bit.**
2. Start the Installer. Ensure that the option Check for updated files on the TDM GCC server is unchecked. Click Create and proceed with the installation
3. If you intend to do run the COINES example on Application Board's microcontroller, install the latest version of GNU Embedded Toolchain for ARM for Windows. Make sure you have checked 'Add to PATH'.


TDM-GCC Setup
Wizard Action
Choose which action you want the setup wizard to perform.
Create
: Create a new TDM-GCC installation
Manage
: Manage an existing TDM-GCC installation
Remove
: Remove a TDM-GCC installation
Check for updated files on the TDM-GCC server
TDM-GCC Setup 1.2105.1
Cancel



TDM-GCC installation dialog



GNU ARM Toolchain installation

4.2 Installation (Linux/MacOS)

4.2.1 System requirements

- The supported Linux OS versions are Debian based - Ubuntu 18.04 and 22.04.
- The supported macOS versions are MacOS Ventura 13.4.1 and 13.5.2.

4.2.2 Installation of COINES

The steps below need to be followed in order to install COINES SDK:

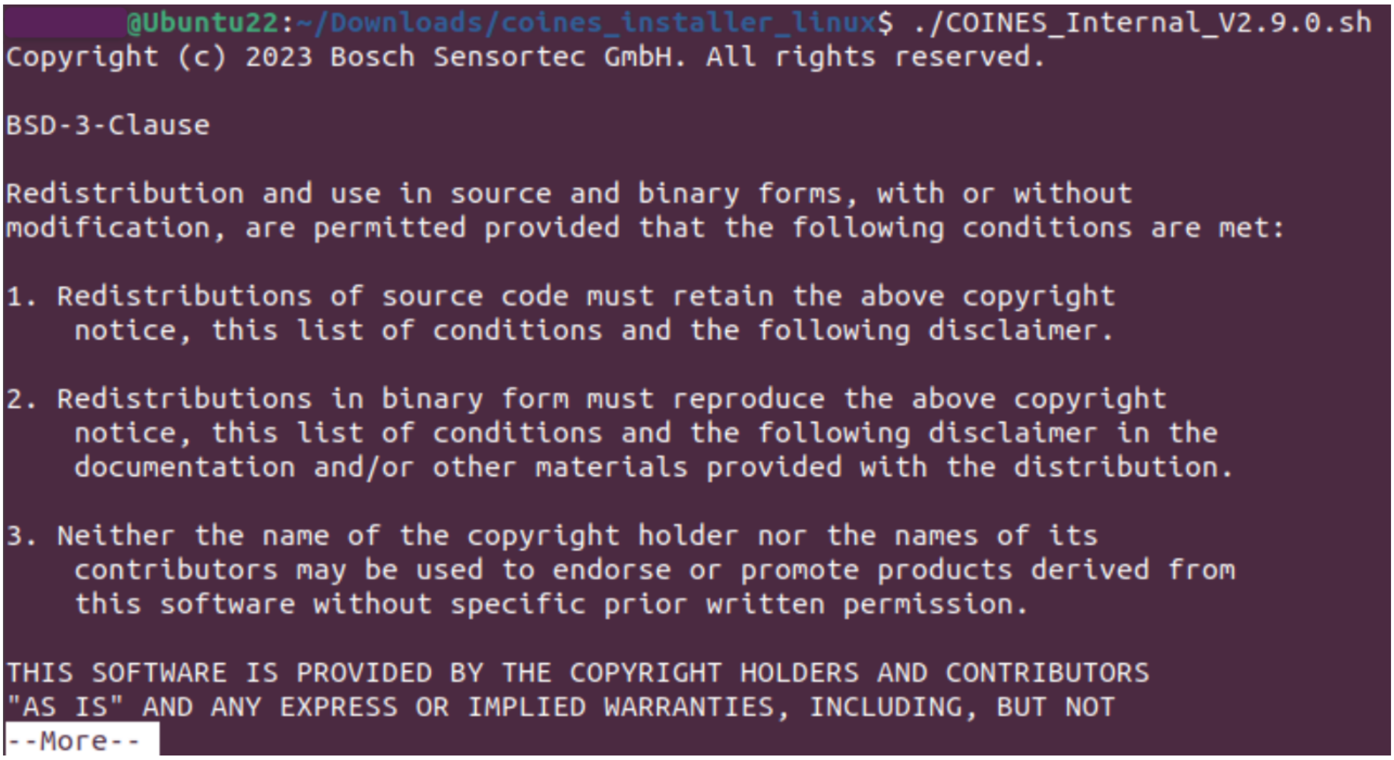
1. Download the installer.
2. Use the command `cd` to go to the directory where the installer is located and make the installer executable:

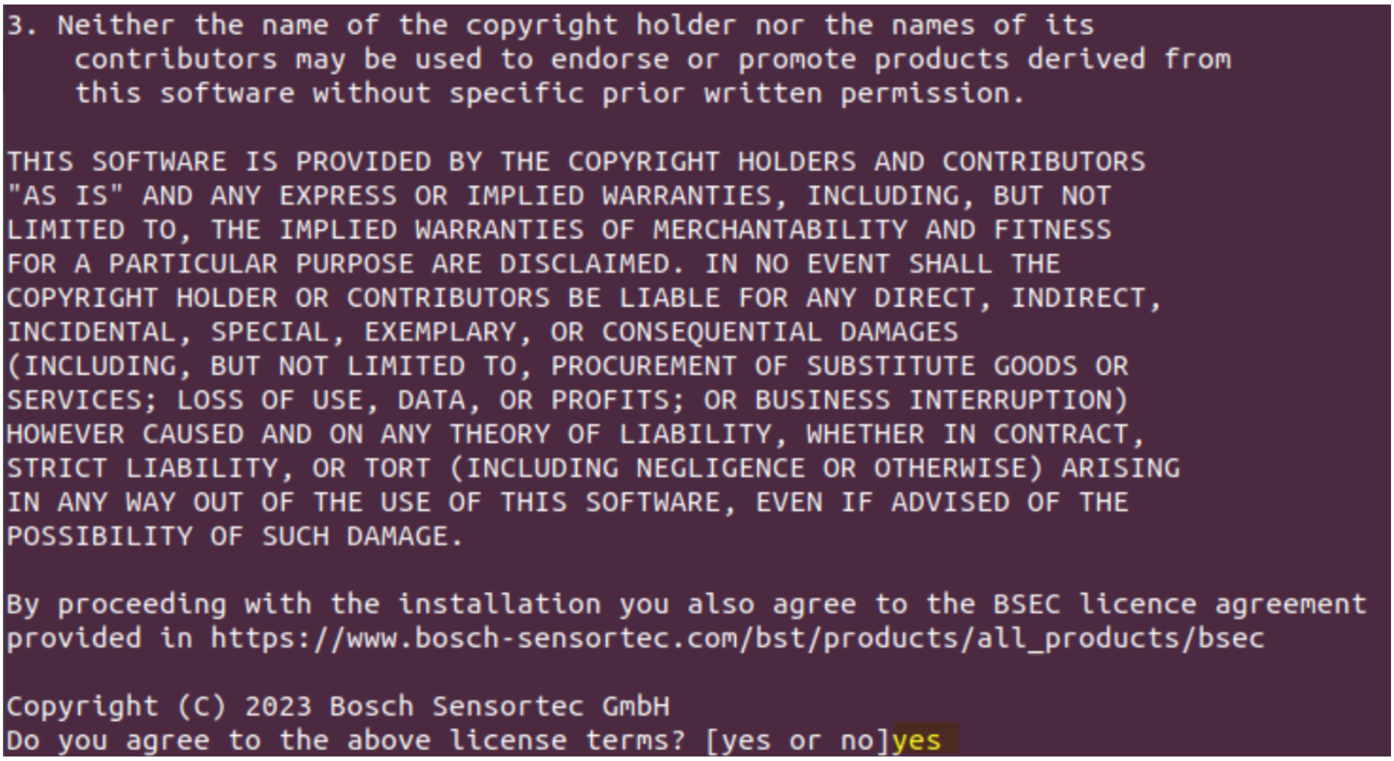
- `chmod +x coines_vX.Y.sh`

3. Ensure that you are connected to the Internet before running the installer, which is executed like this:

- `./coines_vX.Y.sh`

4. Accept the End User License agreement





Linux installer end user agreement

5. The installer will prompt you if the required dependencies/packages are not installed. (This step requires root privileges.)

4.2.3 Installation of compiler environment

On a Debian or Redhat based Linux distro, the installer prompts for installation of missing dependencies, `gcc`, `make` and `libusb-dev` packages.If due to some reason installation fails, the user can manually install the dependencies.

- Debian based distros - `gcc`, `make`, `libusb-1.0-0-dev`, `dfu-util`, `libdbus-1-dev`
- Redhat based distros - `gcc`, `make`, `libusbx-devel`, `dfu-util`, `dbus-devel`
- MacOS - `libusb`, `dfu-util`

If you intend to run the COINES example on Application Board's microcontroller, download the latest version of GNU Embedded Toolchain for ARM for Linux and extract the package. Add the compiler to PATH variable by editing `$HOME/.bashrc` or similar file like `/etc/profile or /etc/environment`.

5. Using COINES to access the sensor on Engineering Board

5.1 Running examples on the MCU of the Application board

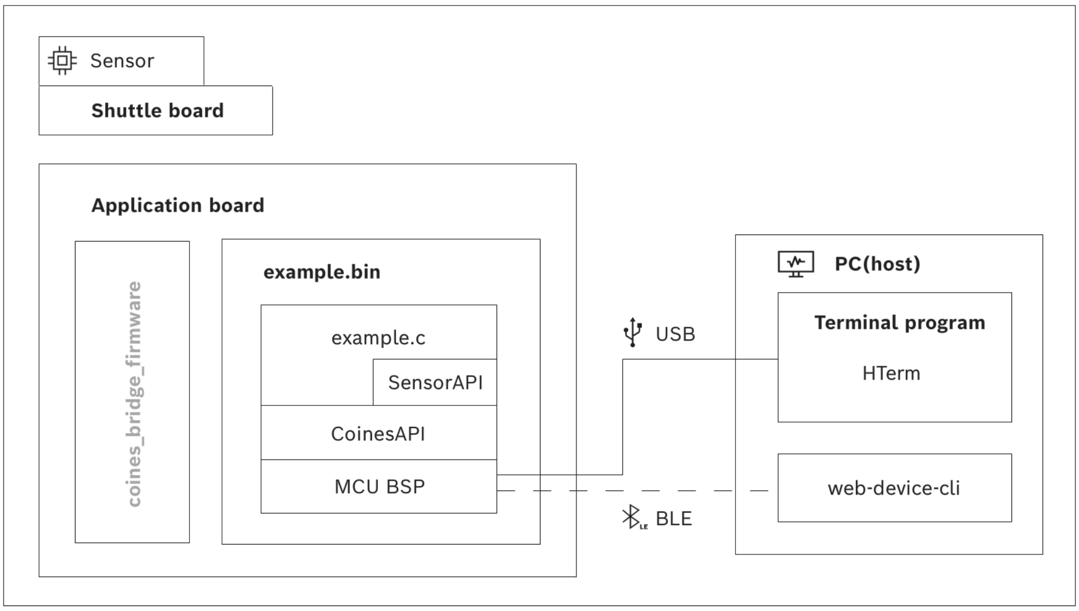
5.1.1 Working principle

The COINES SDK can be cross-compiled on PC side and downloaded into the memory of the Application board and executed there. The user can choose to download the created binary into the flash memory or into the RAM (if the binary is within the RAM memory capacity e.g., APP3.x's RAM is 256 KB).

Downloading COINES SDK example to APP3.x Flash memory will overwrite default firmware. To update the firmware again, refer to section 13.

In this configuration, the COINES layer provides a simple abstraction on top of the MCU BSP (i.e. board level support layer of the microcontroller). Any `printf` command will now not output to the console, but rather to the USB connection, which appears as virtual COM port on PC side.

This mode facilitates the execution of many time-critical operations on the sensor, such as fast reading of FIFO content at high data rates.



Working principle: Running example on the MCU of the Application board

5.1.2 Getting started

To get started with example execution, follow these steps:

1. Make sure that GNU Embedded Toolchain for ARM is installed on your PC and added to environmental variable `PATH`.
2. Connect the Application board via USB, with the sensor shuttle board mounted.
3. Open the command prompt or the terminal.
4. Use the command `cd` to go to the directory where the example that is to be built is located.

5.1.3 Interfacing via BLE

The procedure to interface via BLE involves these steps:

1. Open the script to be executed (in case of SensorAPI - common.c file in the selected example folder) in your IDE
2. Change COINES_COMM_INTF_USB to COINES_COMM_INTF_BLE
3. Change all print statments

```
printf(...) to fprintf(bt_w,...)
```

4. Now follow the steps from 1 - 4 in the above section

5.1.4 Cross compiling

To compile and download an example to Engineering Board's microcontroller, type any of the build commands below based on available Engineering board type and target memory location. Use '`mingw32-make`' (TDM-GCC/MinGW) or '`make`' (Linux/Cygwin/MSYS2/MacOS) for compilation.

Note: Nicla board programs can only be executed as PC target at this moment.

5.1.5 Viewing the results

The ways to view the execution results are outlined as follows:

1. Use a Serial Terminal application to view output.

- Windows - PuTTY, HTerm,etc.,
- Linux - `cat` command. Eg: `cat /dev/ttyACM0`
- macOS - `screen` command. Eg: `screen /dev/tty.usbmodem9F31`

Note: The binary on the MCU will be executed once the serial port is opened. The port must be opened including DTR signal set, otherwise the binary will not be executed. Some terminal programs such as HTerm allow explicit setting of the DTR signal.

2. For bluetooth communication, connect the Application board to another power source and keep it within the BLE range. And use any of the below tools to view the output.

- Android app - Serial Bluetooth terminal
- Website - Web Device CLI
- Python script -

5.1.6 Data logging

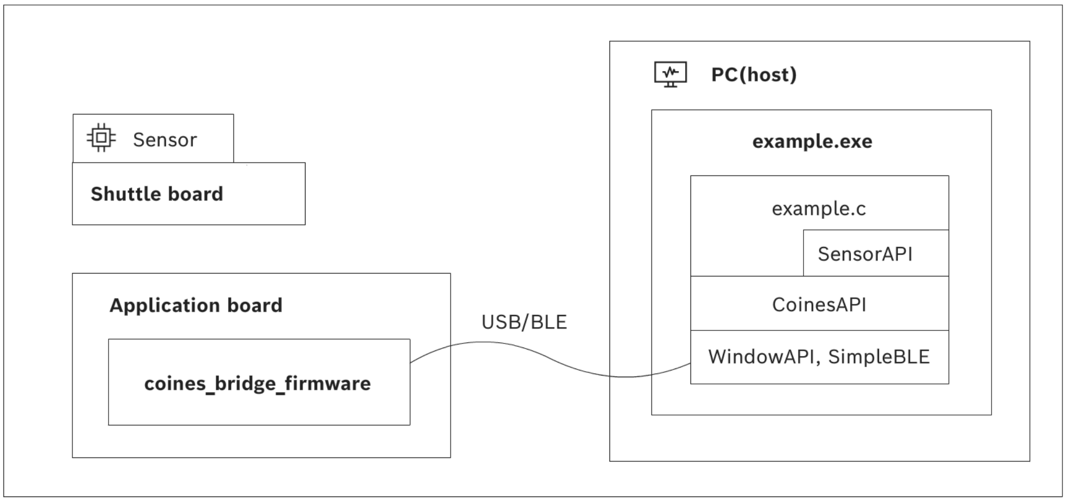
The user can use any serial terminal program to access and store the data provided via virtual COM port e.g HTerm has \"Save output\" option to store log.

5.2 Running examples on PC side

5.2.1 Working principle

When compiling the COINES SDK for PC side, the COINES layer provides an abstraction of the embedded environment on the host side. COINES library provides read and write functions for I^2C and SPI on PC side. These functions receive the arguments of the user input (i.e. what register address to read from) and tunnel them through the USB connection to the Application Board, where they are fed into the embedded I^2C and SPI functions and are executed to access the sensor. Any result or response from those functions is tunneled back to the PC side and provided to the example application.

This approach allows easy and flexible programming and offers the possibility to integrate the example code into other applications or add advanced logging options. The drawback is that in this mode the code is not executed in real time, as it runs on a multi-tasking operating system. To overcome this drawback, the examples can also be run on the MCU side (see section 5.1{reference-type="ref" reference="ExampleOnMCU"}).



Working principle: Running example on PC side

5.2.2 PC side implementation

This setup has the challenge of lacking the real-time capabilities known from a pure microcontroller environment. To overcome this, the coinesAPI offers streaming functions, which allow the user to schedule data readout directly on the microcontroller, either based on a data interrupt coming from the sensors or based on the timer of the microcontroller. The scheduler waits for the configured interrupt (sensor interrupt or timer interrupt) and reads out areas of the register map, which can be configured by the user.

As an example, the user could choose to read out the 6 bytes from the register map of a certain inertial sensor, containing the sensor data of three axis (2 bytes per axis). If the user would configure e.g a readout once per milliseconds, the result would be a data stream of three-axis sensor data at a rate of 1 kHz.

5.2.3 Getting started

To get started with example execution, follow these steps:

1. Connect the Application board via USB, with the sensor shuttle board mounted.
2. Refer to section 13{reference-type="ref" reference="firmwareUpdate"} and update the Coines Bridge firmware to the board.
3. Open the command prompt or the terminal.
4. Use the command `cd` to go to the directory where the example that is to be built is located.

Note: Some examples may not compile for both PC and MCU target. Please refer to the example documentation or simply the example name (e.g. examples that can only be compiled for the PC are named with a following '_pc').

5.2.4 Interfacing via BLE

The procedure to interface via BLE involves these steps:

1. Open the script to be executed (in case of SensorAPI - common.c file in the selected example folder) in your IDE
2. Change COINES_COMM_INTF_USB to COINES_COMM_INTF_BLE
3. Now follow the steps from 1 - 4 in the above section

5.2.5 Compiling

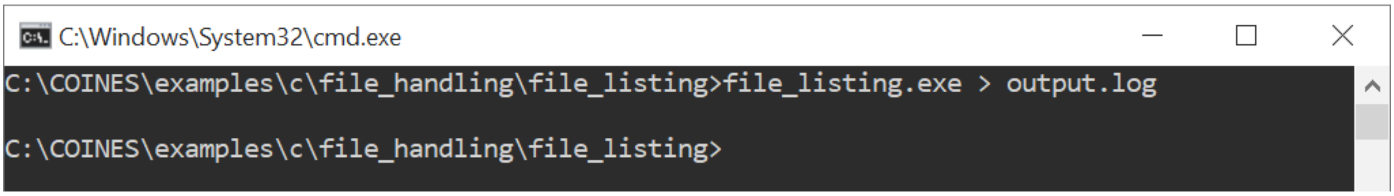
To run an example in PC side, execute below command \"mingw32-make TARGET=PC\". Use '`mingw32-make`' (TDM-GCC/MinGW) or '`make`' (Linux/Cygwin/MSYS2/MacOS) for compilation.

5.2.6 Viewing the results

Running the output executable in the command prompt of the PC will display the results. To view ouput via BLE, connect the Application board to another power source and keep it within the BLE range and run the executable in the PC.

5.2.7 Data logging

The user can utilize the terminal's output redirection command to store the result of a command/executable in a file, as demonstrated below.



5.3 Project Cleanup

The commands to clean build files are listed below:

- `mingw32-make clean` - Use this command to remove the object files and other intermediate files created during the compilation process.
- `mingw32-make clean-all` - Use this command to remove all build artifacts, including the final executable or library, and start the build process from scratch

6. Using COINESPY to access the sensor on Engineering Board

6.1 Introduction to `COINESPY` library

The `COINESPY` library provides a Python interface for interacting with the Bosch Sensortec's Engineering Boards. The library offers the following range of functionalities:

- Control VDD and VDDIO of sensor
- Configure SPI and I^2C bus parameters
- Read and write into registers of sensors from Bosch Sensortec via SPI and I^2C
- Read and write digital pins of the Application Board

6.2 Installation

The `COINESPY` module can be installed using pip:

```
pip install coinespy
```

The module can be found on https://pypi.org/project/coinespy/. It is highly recommended to test the following script `examples\python\coinespy_test.py` in the COINES installation or Refer to 8.2.1{reference-type="ref" reference="GettingBoardInfo"} to check if the installation was successful.

7. Using Sensor API with COINES

7.1 SensorAPI

Bosch Sensortec recommends using the SensorAPI in order to communicate with the sensors. The SensorAPI, an abstraction layer written in C makes it much more convenient for the user to access the register map of the sensor, in order to configure certain functionality and obtain certain information from it.

For making use of the SensorAPI, some function pointers must be set to the appropriate read/write functions of the selected bus on the system (either I^2C or SPI), as well as one function pointer to a system's function causing delays in milliseconds.

In order to execute C code using SensorAPI, the COINES API provides the mentioned read, write, delay functions. These functions are wrapper functions, embedding the actual SensorAPI payloads into a transport package, sending this via USB or BLE to the Engineering board, where the payload is translated into corresponding SPI or I^2C messages and sent to the sensor on the shuttle board.The mapping would look similar to the one below.

```
#include "coines.h"
#include "bst_sensor.h"

struct bst_sensor_dev sensordev;
....
....
sensordev.intf = BST_SENSOR_I2C_INTF;  // SPI - BST_SENSOR_SPI_INTF
sensordev.read = coines_read_i2c;   // coines_read_spi
sensordev.write = coines_write_i2c; // coines_write_spi
sensordev.delay_ms = coines_delay_usec;
```

For the description of COINES functions used, refer to 15.2{reference-type="ref" reference="CoinesCFunctions"}.

7.2 Downloading Sensor API

In order to download SensorAPI, the steps below need to be followed:

- Download SensorAPI repo using Download zip option for selected sensors from boschsensortec github https://github.com/BoschSensortec.
- Unzip the downloaded SensorAPI repo to .
- Rename the unzipped folder to sensor name e.g and change directory to an example folder to execute it.

7.3 Running example on MCU side

Here are the step-by-step instructions to run examples on MCU side:

- Selected Platform: Windows
- Board: APP3.1
- Sensor shuttle: BMI270
- Example:
- Connect the Application Board board via USB, with the sensor shuttle board mounted.
- Open the command prompt or the terminal.
- Use the command `cd` to go to the directory where the example that is to be built is located.

```
Command Prompt

C:\>cd C:\COINES\examples\bmi270\bmi270_examples\accel_gyro

C:\COINES\examples\bmi270\bmi270_examples\accel_gyro>
```

- Execute command \"mingw32-make TARGET=MCU_APP31 download\"

```
C:\Windows\System32\cmd.exe - mingw32-make  TARGET=MCU_APP31 download

C:\COINES\examples\bmi270\bmi270_examples\accel_gyro>mingw32-make TARGET=MCU_APP31
download
Platform: Windows
cc:  "C:\Program Files (x86)\Arm GNU Toolchain arm-none-eabi\13.2 Rel1\bin\arm-none
-eabi-gcc.exe C:\Program Files (x86)\Arm GNU Toolchain arm-none-eabi\12.2 mpacbti-r
el1\bin\arm-none-eabi-gcc.exe".
[ CC ] ../../bmi2.c
[ CC ] ../../bmi270.c
[ CC ] ../common/common.c
[ CC ] accel_gyro.c
[ MAKE ] coines-api
[ MKDIR ] build/MCU_APP31
```

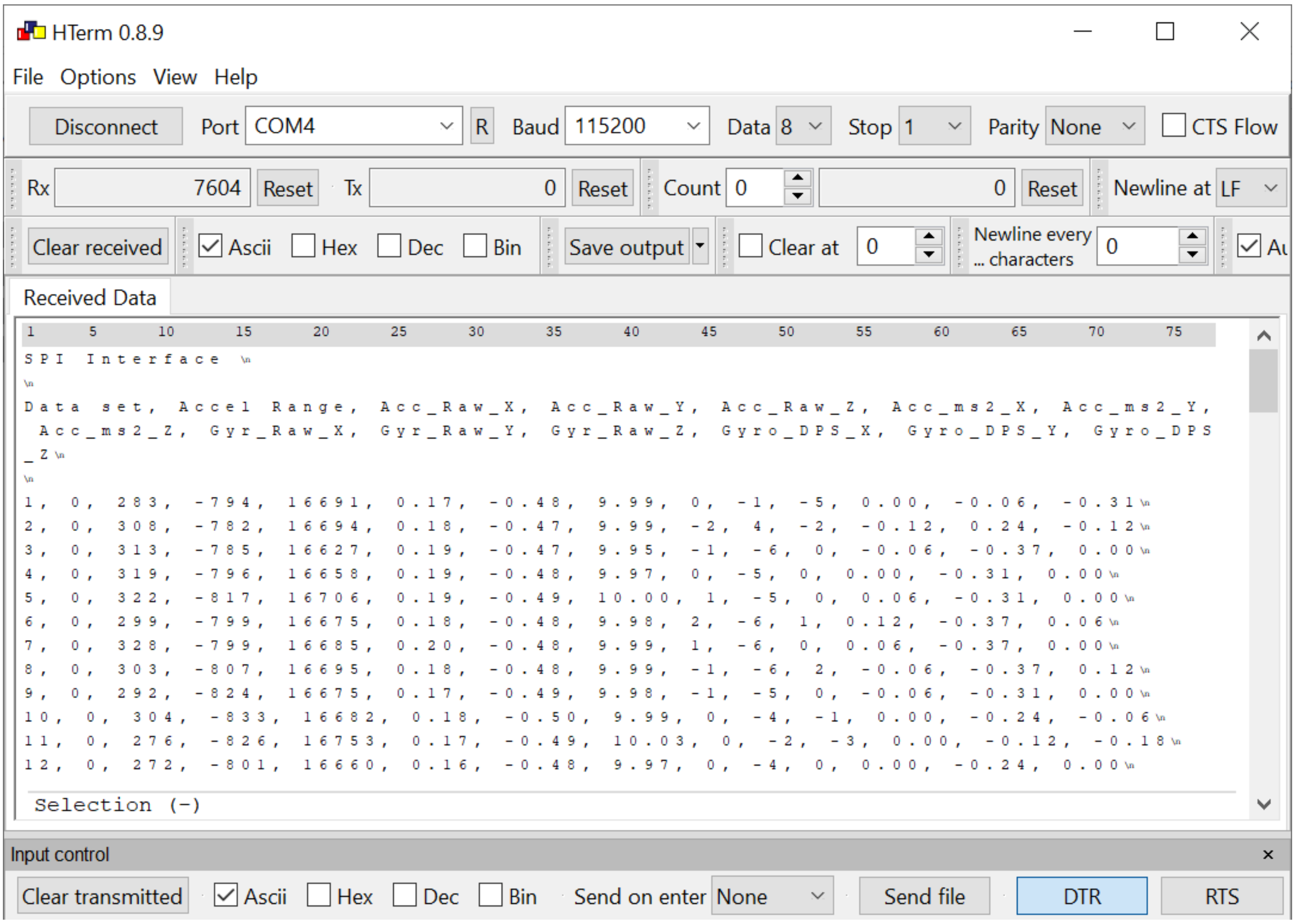
```
[ BIN ] accel_gyro.bin
[ DFU ] appswitch
dfu-util 0.9

Copyright 2005-2009 Weston Schmidt, Harald Welte and OpenMoko Inc.
Copyright 2010-2019 Tormod Volden and Stefan Schmidt
This program is Free Software and has ABSOLUTELY NO WARRANTY
Please report bugs to http://sourceforge.net/p/dfu-util/tickets/

Invalid DFU suffix signature
A valid DFU suffix will be required in a future dfu-util release!!!
Opening DFU capable USB device...
ID 108c:ab3d
Run-time device DFU version 0110
Claiming USB DFU Interface...
Setting Alternate Setting #0 ...
Determining device status: state = dfuIDLE, status = 0
dfuIDLE, continuing
DFU mode device DFU version 0110
Device returned transfer size 64
Copying data from PC to DFU device
Download        [=========================] 100%        85200 bytes
Download done.
state(5) = dfuDNLOAD-IDLE, status(0) = No error condition is present
Done!
can't detach
Resetting USB to switch back to runtime mode

C:\COINES\examples\bmi270\bmi270_examples\accel_gyro>
```

• View the output in a serial terminal application like HTerm


HTerm 0.8.9
File Options View Help
Disconnect Port COM4 R Baud 115200 Data 8 Stop 1 Parity None CTS Flow
Rx 7604 Reset Tx 0 Reset Count 0 0 Reset Newline at LF
Clear received Ascii Hex Dec Bin Save output Clear at 0 Newline every ... characters 0
Received Data
1 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75
SPI Interface \n
\n
Data set, Accel Range, Acc_Raw_X, Acc_Raw_Y, Acc_Raw_Z, Acc_ms2_X, Acc_ms2_Y, Acc_ms2_Z, Gyr_Raw_X, Gyr_Raw_Y, Gyr_Raw_Z, Gyro_DPS_X, Gyro_DPS_Y, Gyro_DPS_Z \n
\n
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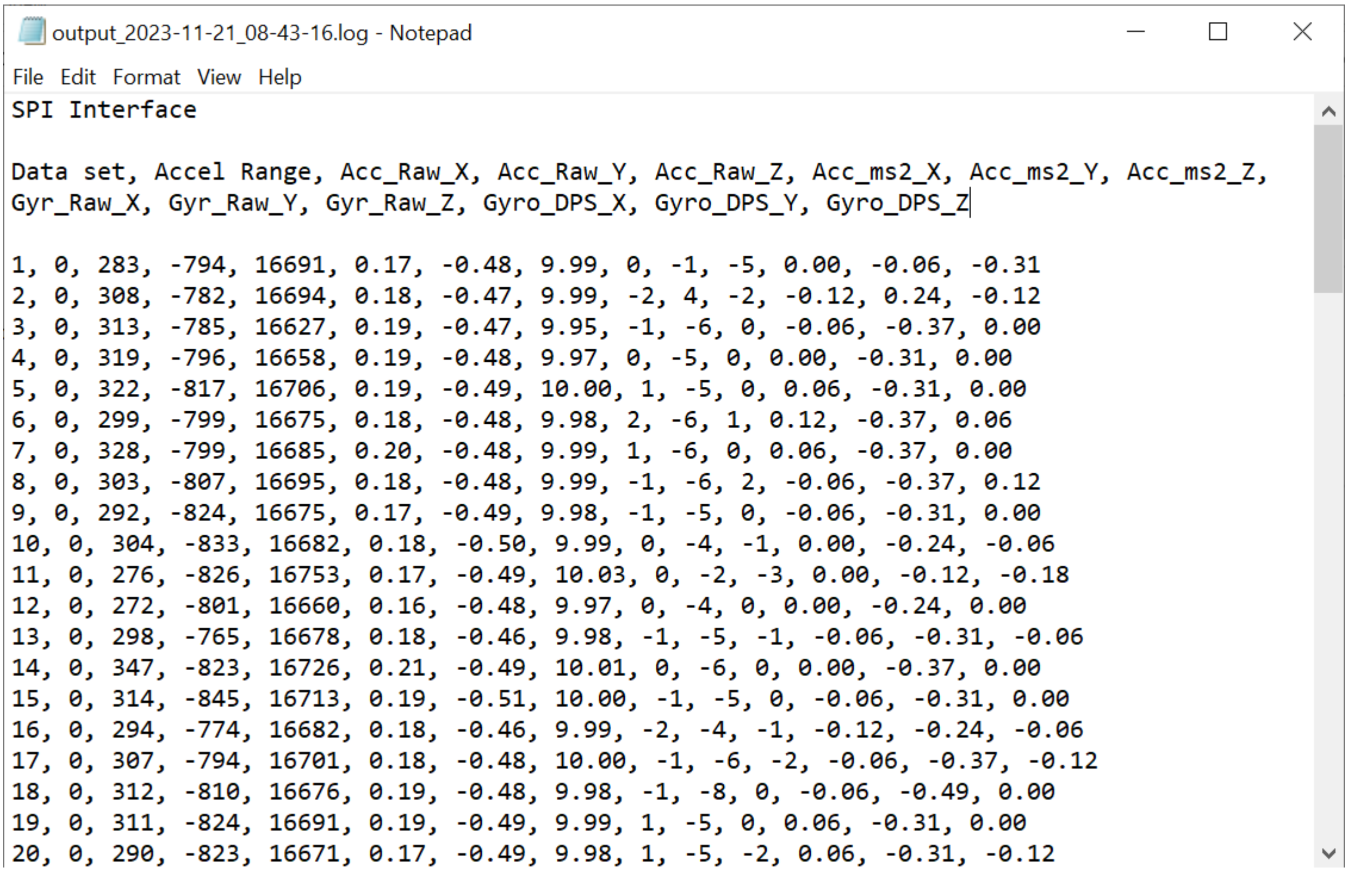
11, 0, 276, -826, 16753, 0.17, -0.49, 10.03, 0, -2, -3, 0.00, -0.12, -0.18\n
12, 0, 272, -801, 16660, 0.16, -0.48, 9.97, 0, -4, 0, 0.00, -0.24, 0.00\n
Selection (-)
Input control
Clear transmitted Ascii Hex Dec Bin Send on enter None Send file DTR RTS


output_2023-11-21_08-43-16.log - Notepad
File Edit Format View Help
SPI Interface
Data set, Accel Range, Acc_Raw_X, Acc_Raw_Y, Acc_Raw_Z, Acc_ms2_X, Acc_ms2_Y, Acc_ms2_Z, Gyr_Raw_X, Gyr_Raw_Y, Gyr_Raw_Z, Gyro_DPS_X, Gyro_DPS_Y, Gyro_DPS_Z
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13, 0, 298, -765, 16678, 0.18, -0.46, 9.98, -1, -5, -1, -0.06, -0.31, -0.06
14, 0, 347, -823, 16726, 0.21, -0.49, 10.01, 0, -6, 0, 0.00, -0.37, 0.00
15, 0, 314, -845, 16713, 0.19, -0.51, 10.00, -1, -5, 0, -0.06, -0.31, 0.00
16, 0, 294, -774, 16682, 0.18, -0.46, 9.99, -2, -4, -1, -0.12, -0.24, -0.06
17, 0, 307, -794, 16701, 0.18, -0.48, 10.00, -1, -6, -2, -0.06, -0.37, -0.12
18, 0, 312, -810, 16676, 0.19, -0.48, 9.98, -1, -8, 0, -0.06, -0.49, 0.00
19, 0, 311, -824, 16691, 0.19, -0.49, 9.99, 1, -5, 0, 0.06, -0.31, 0.00
20, 0, 290, -823, 16671, 0.17, -0.49, 9.98, 1, -5, -2, 0.06, -0.31, -0.12

7.4 Running example on MCU side via BLE

The sequence of actions required for interfacing via BLE includes the steps below:

1. Go to the folder in file explorer
2. Open the common.c file in the selected example folder in your IDE
3. Change COINES_COMM_INTF_USB to COINES_COMM_INTF_BLE

C common.c ×

examples > bmi270 > bmi270_examples > common > C common.c > bmi2_interface_init(bmi2_dev *, uint8_t)

```
int8_t bmi2_interface_init(struct bmi2_dev *bmi, uint8_t intf)
{
    int8_t rslt = BMI2_OK;

    if (bmi != NULL)
    {
        int16_t result = coines_board_init(COINES_COMM_INTF_BLE, true);
```

4. Open example script and change the

```
printf(...) to fprintf(bt_w,...)
```

C accel_gyro.c 1 ×

examples > bmi270 > bmi270_examples > accel_gyro > C accel_gyro.c > main(void)

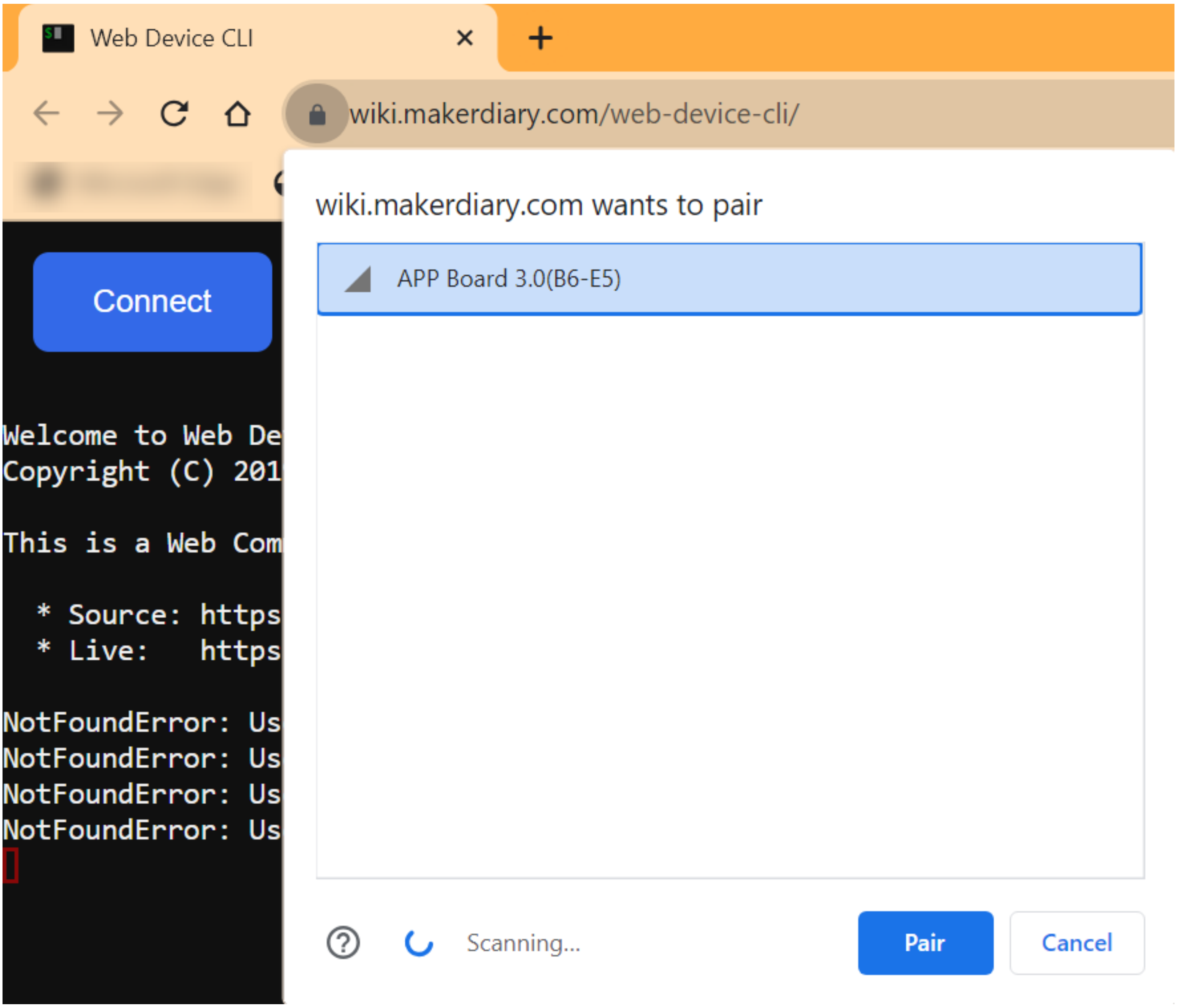
printf(— ? of 2

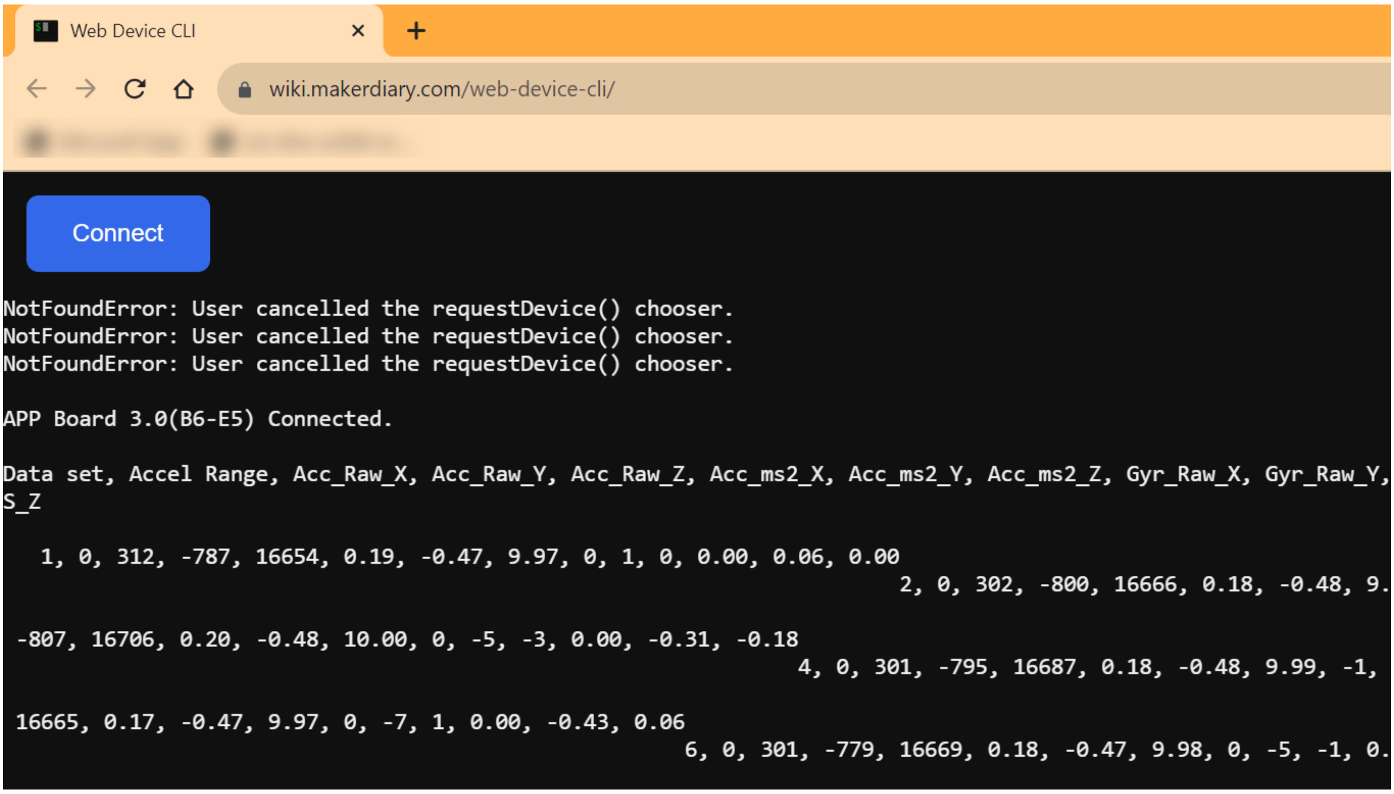
fprintf(bt_w,

```
range. */
gyr_x = lsb_to_
gyr_y = lsb_to_
gyr_z = lsb_to_dps(sensor_data.gyr.z, (float)2000, bmi.resolut

fprintf(bt_w, "%d, %d, %d, %d, %d, %4.2f, %4.2f, %4.2f, %d, %d
%4.2f, %4.2f, %4.2f\n",
        indx,
        config.cfg.acc.range,
        sensor_data.acc.x,
        sensor_data.acc.y,
        sensor_data.acc.z,
```

5. Now follow the same steps from 1 - 4 in the above section.
6. Connect the Application board to another power source and keep it within the BLE range.
7. View the output in the Web Device CLI site in your browser by connecting to board via BLE.


Web Device CLI
wiki.makerdiary.com/web-device-cli/
wiki.makerdiary.com wants to pair
APP Board 3.0(B6-E5)
Connect
Welcome to Web De
Copyright (C) 201
This is a Web Com
* Source: https
* Live: https
NotFoundError: Us
NotFoundError: Us
NotFoundError: Us
NotFoundError: Us
Scanning...
Pair
Cancel


Web Device CLI
wiki.makerdiary.com/web-device-cli/
Connect
NotFoundError: User cancelled the requestDevice() chooser.
NotFoundError: User cancelled the requestDevice() chooser.
NotFoundError: User cancelled the requestDevice() chooser.
APP Board 3.0(B6-E5) Connected.
Data set, Accel Range, Acc_Raw_X, Acc_Raw_Y, Acc_Raw_Z, Acc_ms2_X, Acc_ms2_Y, Acc_ms2_Z, Gyr_Raw_X, Gyr_Raw_Y,
S_Z
1, 0, 312, -787, 16654, 0.19, -0.47, 9.97, 0, 1, 0, 0.00, 0.06, 0.00
2, 0, 302, -800, 16666, 0.18, -0.48, 9.
-807, 16706, 0.20, -0.48, 10.00, 0, -5, -3, 0.00, -0.31, -0.18
4, 0, 301, -795, 16687, 0.18, -0.48, 9.99, -1,
16665, 0.17, -0.47, 9.97, 0, -7, 1, 0.00, -0.43, 0.06
6, 0, 301, -779, 16669, 0.18, -0.47, 9.98, 0, -5, -1, 0.

7.5 Running example on PC side

Here are the step-by-step instructions to run examples on PC side:

- Selected Platform: Windows
- Board: APP3.1
- Sensor shuttle: BMI270
- Example:
- Connect the Application Board board via USB, with the sensor shuttle board mounted.
- Refer to section 13{reference-type="ref" reference="firmwareUpdate"} and update the Coines Bridge firmware to the board.
- Open the command prompt or the terminal.
- Use the command `cd` to go to the directory where the example that is to be built is located.

```
C:\Windows\System32\cmd.exe

C:\>cd C:\COINES\examples\bmi270\bmi270_examples\step_counter

C:\COINES\examples\bmi270\bmi270_examples\step_counter>
```

- Execute command \"mingw32-make TARGET=PC COINES_BACKEND=COINES_BRIDGE\"

```
C:\Windows\System32\cmd.exe
C:\COINES\examples\bmi270\bmi270_examples\step_counter>mingw32-make TARGET=PC COINES_BACKEND
=COINES_BRIDGE
Platform: Windows
cc:  "C:\TDM-GCC-64\bin\gcc.exe".
"Cleaning pc..."
Deleted file - C:\COINES\coines-api\libcoines-pc.a
Deleted file - C:\COINES\coines-api\build\PC\ble_com.c.d
Deleted file - C:\COINES\coines-api\build\PC\ble_com.c.o
Deleted file - C:\COINES\coines-api\build\PC\cflags.save
Deleted file - C:\COINES\coines-api\build\PC\coines_bridge.c.d
Deleted file - C:\COINES\coines-api\build\PC\coines_bridge.c.o
Deleted file - C:\COINES\coines-api\build\PC\coines_common.c.d
Deleted file - C:\COINES\coines-api\build\PC\coines_common.c.o
Deleted file - C:\COINES\coines-api\build\PC\serial_com.c.d
Deleted file - C:\COINES\coines-api\build\PC\serial_com.c.o
Deleted file - C:\COINES\coines-api\build\PC\simpleble_lib_loader.c.d
Deleted file - C:\COINES\coines-api\build\PC\simpleble_lib_loader.c.o
[ MAKE ] coines-api
[ CC ] pc/coines_bridge.c
[ CC ] coines_common.c
[ CC ] pc/serial_com/serial_com.c
[ CC ] pc/ble_com/ble_com.c
[ CC ] pc/ble_com/simpleble_lib_loader.c
[ AR ] libcoines-pc.a
[ LD ] step_counter

C:\COINES\examples\bmi270\bmi270_examples\step_counter>
```

- View the output in the command prompt by running the example executable.

```
C:\Windows\System32\cmd.exe
[ LD ] step_counter

C:\COINES\examples\bmi270\bmi270_examples\step_counter>step_counter.exe
I2C Interface
Step counter watermark level set to 1 (20 steps)
Move the board in steps
Step counter interrupt occurred when watermark level (20 steps) is reached
No of steps counted  = 20
C:\COINES\examples\bmi270\bmi270_examples\step_counter>
```

7.6 Running example on PC side via BLE

The sequence of actions required for interfacing via BLE includes the steps below:

1. Go to the examples folder in file explorer.
2. Open the common.c file in the selected example folder in your IDE.
3. Change COINES_COMM_INTF_USB to COINES_COMM_INTF_BLE.
4. Connect the Application board to another power source and keep it within the BLE range.
5. Now follow the same steps from 3 - 6 in the above section.

```
C:\Windows\System32\cmd.exe
C:\COINES\examples\bmi270\bmi270_examples\step_counter>step_counter.exe

Adapter COB-C-008YH started scanning.

Adapter COB-C-008YH stopped scanning.

The following BLE devices were found:
[0] APP Board 3.0(B6-E5) [dd:fc:ab:af:b6:e5] [-44 dBm]

BLE connection status: Connecting to APP Board 3.0(B6-E5) [dd:fc:ab:af:b6:e5]

BLE connection status: Connected
I2C Interface
Step counter watermark level set to 1 (20 steps)
Move the board in steps
Step counter interrupt occurred when watermark level (20 steps) is reached
No of steps counted  = 20
C:\COINES\examples\bmi270\bmi270_examples\step_counter>
```

8. Examples on how to use COINES

8.1 COINES C examples

8.1.1 Establishing communication

The following code snippet shows how to set up a connection with the board.

```
#include <stdio.h>
    #include <stdlib.h>

    #include "coines.h"
```

```
    int main(void)
    {
        int8_t error_code;
        enum coines_comm_intf comm_intf = COINES_COMM_INTF_USB;

        error_code = coines_open_comm_intf(comm_intf, NULL);
        if (error_code == COINES_SUCCESS)
        {
            printf("\nSuccessfully connected to board!\n");
        }
        else
        {
            printf("\nUnable to connect with board!\n");
            exit(error_code);
        }

        coines_close_comm_intf(comm_intf, NULL);

        return 0;
    }
```

The APIs below can be used for board interface.

- `coines_open_comm_intf`
- `coines_close_comm_intf`

8.1.2 Getting board info

The following code snippet shows how to get board information.

```
#include <stdio.h>
    #include <stdlib.h>

    #include "coines.h"

    int main(void)
    {
        int8_t error_code;
        struct coines_board_info board_info;
        enum coines_comm_intf comm_intf = COINES_COMM_INTF_USB;

        error_code = coines_open_comm_intf(comm_intf, NULL);
        if (error_code < COINES_SUCCESS)
        {
            printf("\nUnable to connect with board!\n");
            exit(error_code);
        }

        error_code = coines_get_board_info(&board_info);
        if (error_code == COINES_SUCCESS)
        {
            printf("\nBoard Info:");
            printf("\n\tboard_info.board:0x%02X", board_info.board);
            printf("\n\tboard_info.hardware_id:0x%02X", board_info.hardware_id);
            printf("\n\tboard_info.shuttle_id:0x%02X", board_info.shuttle_id);
            printf("\n\tboard_info.software_id:0x%02X", board_info.software_id);
        }

        coines_close_comm_intf(comm_intf, NULL);

        return 0;
    }
```

8.1.3 I2C config and read

This basic program shows how to configure and perform I2C read. Sensor: BMI270

```
#include <stdio.h>
    #include <stdlib.h>

    #include "coines.h"

    #define BMI2_I2C_PRIM_ADDR  0x68

    int main(void)
    {
        int8_t error_code;
        uint8_t chip_id;
        uint8_t reg_addr = 0x0;
        enum coines_comm_intf comm_intf = COINES_COMM_INTF_USB;

        error_code = coines_open_comm_intf(comm_intf, NULL);
        if (error_code == COINES_SUCCESS)
```

```
        {
            printf("\nSuccessfully connected to board!\n");
        }
        else
        {
            printf("\nUnable to connect with board!\n");
            exit(error_code);
        }

        /* Power up the board */
        (void)coines_set_shuttleboard_vdd_vddio_config(3300, 3300);
        coines_delay_usec(200);

        /* SDO to Ground */
        coines_set_pin_config(COINES_SHUTTLE_PIN_22, COINES_PIN_DIRECTION_OUT, COINES_PIN_VALUE_LOW);

        /* Make CSB pin HIGH */
        coines_set_pin_config(COINES_SHUTTLE_PIN_21, COINES_PIN_DIRECTION_OUT, COINES_PIN_VALUE_HIGH);
        coines_delay_msec(100);

        /* SDO pin is made low */
        coines_set_pin_config(COINES_SHUTTLE_PIN_SDO, COINES_PIN_DIRECTION_OUT, COINES_PIN_VALUE_LOW);

        /* I2C config */
        coines_config_i2c_bus(COINES_I2C_BUS_0, COINES_I2C_STANDARD_MODE);

        /* I2C read */
        (void)coines_read_i2c(COINES_I2C_BUS_0, BMI2_I2C_PRIM_ADDR, reg_addr, &chip_id, 1);

        printf("I2C read: Sensor chip ID - 0x%x\n", chip_id);

        (void)coines_set_shuttleboard_vdd_vddio_config(0, 0);
        coines_delay_msec(100);

        /* Coines interface reset */
        coines_soft_reset();
        coines_delay_msec(100);

        coines_close_comm_intf(comm_intf, NULL);

        return 0;
    }
```

The user shall pass GPIO pin numbers, read register address and I2C device address for sensors based on the selected sensor shuttle board. I2C communication require the proper setting of VDD and VDDIO using `coines_set_shuttleboard_vdd_vddio_config`. The APIs below can be used for I2C configure/read/write.

- `coines_config_i2c_bus`
- `coines_read_i2c`
- `coines_write_i2c`

8.1.4 SPI config and read

This basic program shows how to configure and perform SPI read. Sensor: BMI270

```
#include <stdio.h>
    #include <stdlib.h>

    #include "coines.h"

    #define BMI2_SPI_RD_MASK  0x80

    int main(void)
    {
        int8_t error_code;
        uint8_t chip_id[2], dummy_byte;

        /* An extra dummy byte is read during SPI read */
        uint8_t dummy_byte_len = 1;
        uint8_t reg_addr = 0x0;
        enum coines_comm_intf comm_intf = COINES_COMM_INTF_USB;

        error_code = coines_open_comm_intf(comm_intf, NULL);
        if (error_code == COINES_SUCCESS)
        {
            printf("\nSuccessfully connected to board!\n");
        }
        else
        {
            printf("\nUnable to connect with board!\n");
            exit(error_code);
        }

        /* Power up the board */
        coines_set_shuttleboard_vdd_vddio_config(3300, 3300);
        coines_delay_msec(200);
```

```
    /* SPI config */
    (void)coines_config_spi_bus(COINES_SPI_BUS_0, COINES_SPI_SPEED_5_MHZ, COINES_SPI_MODE3);

    /* Pin config */
    coines_set_pin_config(COINES_SHUTTLE_PIN_21, COINES_PIN_DIRECTION_OUT, COINES_PIN_VALUE_HIGH);

    /* Mask read register address for SPI */
    reg_addr = (reg_addr | BMI2_SPI_RD_MASK);

    /* Dummy read for SPI init*/
    (void)coines_read_spi(COINES_SPI_BUS_0, COINES_MINI_SHUTTLE_PIN_2_1, reg_addr, &dummy_byte, 1);
    coines_delay_usec(450);

    /* SPI read */
    (void)coines_read_spi(COINES_SPI_BUS_0, COINES_MINI_SHUTTLE_PIN_2_1, reg_addr, chip_id, 1 + dummy_byte_len);
    coines_delay_usec(450);

    printf("SPI read: Sensor chip ID - 0x%x\n", chip_id[dummy_byte_len]);

    (void)coines_set_shuttleboard_vdd_vddio_config(0, 0);
    coines_delay_msec(100);

    /* Coines interface reset */
    coines_soft_reset();
    coines_delay_msec(100);

    coines_close_comm_intf(comm_intf, NULL);

    return 0;
}
```

The user shall pass GPIO pin numbers, read register address and SPI CS pins for sensors based on the selected sensor shuttle board. SPI communication require the proper setting of VDD and VDDIO using `coines_set_shuttleboard_vdd_vddio_config`. The APIs below can be used for SPI configure/read/write.

- `coines_config_spi_bus`
- `coines_read_spi`
- `coines_write_spi`

8.1.5 Led and button control

The example program below is to control LEDs and buttons on the board. Target: MCU

```
#include <stdio.h>
#include <stdbool.h>
#include "coines.h"

/* Callback for button 1 interrupt */
static void button1CB(uint32_t param1, uint32_t param2);

/*Callback for button 1 event */
void button1CB(uint32_t param1, uint32_t param2)
{
    (void)param1;
    (void)param2;

    coines_set_led(COINES_LED_RED, COINES_LED_STATE_ON);
    coines_set_led(COINES_LED_GREEN, COINES_LED_STATE_OFF);
    coines_set_led(COINES_LED_BLUE, COINES_LED_STATE_ON);
}

int main(void)
{
    coines_open_comm_intf(COINES_COMM_INTF_USB, NULL);

    coines_set_pin_config(COINES_APP30_BUTTON_1, COINES_PIN_DIRECTION_IN, COINES_PIN_VALUE_HIGH);
    coines_attach_interrupt(COINES_APP30_BUTTON_1, button1CB, COINES_PIN_INTERRUPT_FALLING_EDGE);

    coines_close_comm_intf(COINES_COMM_INTF_USB, NULL);

    return 0;
}
```

8.1.6 File listing in External memory

To list the files in the external memory, below snippet can be used. Target: MCU

```
#include <stdio.h>
#include "coines.h"

int main(void)
```

```
    {
        coines_open_comm_intf(COINES_COMM_INTF_USB, NULL);
        DIR *directory;
        struct dirent *dir;
        directory = opendir(".");
        if (directory)
        {
            while ((dir = readdir(directory)) != NULL)
            {
                printf("%s\n", dir->d_name);
            }

            closedir(directory);
        }

        coines_close_comm_intf(COINES_COMM_INTF_USB, NULL);

        return 0;
    }
```

8.1.7 Temperature measurement

This simple program demonstrates how to measure temperature of the board. Target: MCU

```
#include <stdio.h>
    #include <stdlib.h>

    #include "coines.h"

    int main(void)
    {
        int8_t error_code;
        float temp_data = 0;
        enum coines_comm_intf comm_intf = COINES_COMM_INTF_USB;

        error_code = coines_open_comm_intf(comm_intf, NULL);
        if (error_code == COINES_SUCCESS)
        {
            printf("\nSuccessfully connected to board!\n");
        }
        else
        {
            printf("\nUnable to connect with board!\n");
            exit(error_code);
        }

        /* Power up the board */
        coines_set_shuttleboard_vdd_vddio_config(1800, 1800);
        coines_delay_msec(200);

        /* Read temperature data */
        coines_read_temp_data(&temp_data);
        printf("\nTemperature data = %f in degC", temp_data);

        coines_set_shuttleboard_vdd_vddio_config(0, 0);
        coines_delay_msec(100);

        coines_close_comm_intf(comm_intf, NULL);

        return 0;
    }
```

8.1.8 Battery level measurement

This simple program demonstrates how to measure battery level when a battery is connected to the board. Target: MCU

```
#include <stdio.h>
    #include <stdlib.h>

    #include "coines.h"

    int main(void)
    {
        int8_t error_code;
        uint8_t batt_status_percentage = 0;
        uint16_t batt_status_in_milli_volts = 0;
        enum coines_comm_intf comm_intf = COINES_COMM_INTF_BLE;

        error_code = coines_open_comm_intf(comm_intf, NULL);
        if (error_code == COINES_SUCCESS)
        {
            printf("\nSuccessfully connected to board!\n");
        }
        else
        {
            printf("\nUnable to connect with board!\n");
```

```
            exit(error_code);
        }

        /* Read battery level */
        coines_read_bat_status(&batt_status_in_milli_volts, &batt_status_percentage);
        fprintf(bt_w, "Battery level in percentage = %d %% \r\n", batt_status_percentage);
        fprintf(bt_w, "Battery level in millivolts = %d mV \r\n", batt_status_in_milli_volts);

        coines_close_comm_intf(comm_intf, NULL);

        return 0;
    }
```

8.1.9 Configure BLE communication

This example shows how to configure BLE connection. Target: PC

```
#include <stdio.h>
    #include <string.h>
    #include <stdlib.h>

    #include "coines.h"

    /*! Macros to hold the BLE peripheral name and address to be connected */
    /*! Please change the name and address with BLE name of the Application board under test */
    #define BLE_NAME  "APP Board 3.0(B6-E5)"
    #define BLE_ADDR  "dd:fc:ab:af:b6:e5"

    /*! Variable to hold the communication interface type */
    const enum coines_comm_intf comm_intf = COINES_COMM_INTF_BLE;

    int main(void)
    {
        struct ble_peripheral_info ble_config = { BLE_ADDR, "" };
        struct ble_peripheral_info ble_info[40];
        uint8_t peripheral_count, i;
        int8_t result;

        /* Get the BLE peripheral list */
        result = coines_scan_ble_devices(ble_info, &peripheral_count, 7000);
        if (result != COINES_SUCCESS)
        {
            const char *err_str = get_coines_error_str(result);
            printf("\n%s", err_str);
            exit(result);
        }

        /* Print the BLE peripheral list */
        printf("\nBLE devices found:");
        for (i = 0; i < peripheral_count; i++)
        {
            printf("\n[%d] %s [%s]", i, ble_info[i].ble_identifier, ble_info[i].ble_address);
        }

        /* Open BLE connection */
        result = coines_open_comm_intf(comm_intf, &ble_config);
        if (result == COINES_SUCCESS)
        {
            printf("\nSuccessfully connected to board!\n");
        }
        else
        {
            printf("\nUnable to connect with board!\n");
            exit(result);
        }

        /* Close BLE connection */
        coines_soft_reset();
        coines_delay_msec(100);

        coines_close_comm_intf(comm_intf, NULL);

        return 0;
    }
```

The user shall modify BLE settings like address and name before executing this example.

8.1.10 Configure Serial communication

This example shows how to configure Serial COM connection. Target: PC

```
#include <stdio.h>
    #include <string.h>
    #include <stdlib.h>

    #include "coines.h"
```

```c
#define ROBERT_BOSCH_USB_VID   (0x108C)
#define ARDUINO_USB_VID        (0x2341)
#define BST_APP30_CDC_USB_PID  (0xAB3C)
#define BST_APP20_CDC_USB_PID  (0xAB2C)
#define ARDUINO_NICLA_USB_PID  (0x0060)

/*! Variable to hold the communication interface type */
const enum coines_comm_intf comm_intf = COINES_COMM_INTF_USB;

int main(void)
{
    int16_t result;
    struct coines_serial_com_config scom_config;

    scom_config.baud_rate = 38400;
    scom_config.vendor_id = ROBERT_BOSCH_USB_VID;
    scom_config.product_id = BST_APP30_CDC_USB_PID;
    scom_config.com_port_name = "COM4";
    scom_config.rx_buffer_size = 2048;

    /* Open serial connection */
    result = coines_open_comm_intf(comm_intf, &scom_config);
    if (result == COINES_SUCCESS)
    {
        printf("\nSuccessfully connected to board!\n");
    }
    else
    {
        printf("\nUnable to connect with board!\n");
        exit(result);
    }

    /* Close serial connection */
    coines_soft_reset();
    coines_delay_msec(100);

    coines_close_comm_intf(comm_intf, NULL);

    return 0;
}
```

The user shall modify Serial COM settings like vendor ID, product ID and COM port name before executing this example.

8.2 COINES Python examples

8.2.1 Getting board info

The following code snippet shows how to get board information.

```python
import coinespy as cpy
    from coinespy import ErrorCodes

    COM_INTF = cpy.CommInterface.USB

    if __name__ == "__main__":
        board = cpy.CoinesBoard()
        print('coinespy version - %s' % cpy.__version__)
        board.open_comm_interface(COM_INTF)
        if board.error_code != ErrorCodes.COINES_SUCCESS:
            print(f'Could not connect to board: {board.error_code}')
        else:
            b_info = board.get_board_info()
            print(f"coines lib version: {board.lib_version}")
            print(
                f'BoardInfo: HW/SW ID: {hex(b_info.HardwareId)}/{hex(b_info.SoftwareId)}')
            board.close_comm_interface()
```

8.2.2 I2C config and read

This basic program shows how to configure and perform I2C read. Sensor: BMI085

```python
import sys
    import time
    import coinespy as cpy
    from coinespy import ErrorCodes

    COM_INTF = cpy.CommInterface.USB

    if __name__ == "__main__":
        BOARD = cpy.CoinesBoard()

        BOARD.open_comm_interface(COM_INTF)
        if BOARD.error_code != ErrorCodes.COINES_SUCCESS:
```

```
            print(f"Open Communication interface: {BOARD.error_code}")
            sys.exit()

        BMI085_I2C_ADDRESS_ACCEL = 0x18
        BMI085_I2C_ADDRESS_GYRO  = 0x68
        BMI08_REG_ACCEL_CHIP_ID = 0x00

        BOARD.set_shuttleboard_vdd_vddio_config(vdd_val=0, vddio_val=0)

        #  Config I2C pins
        BOARD.set_pin_config(
            cpy.MultiIOPin.SHUTTLE_PIN_8, cpy.PinDirection.OUTPUT, cpy.PinValue.LOW)
        BOARD.set_pin_config(
            cpy.MultiIOPin.SHUTTLE_PIN_SDO, cpy.PinDirection.OUTPUT, cpy.PinValue.LOW)
        # Set PS pin of gyro to HIGH for proper protocol selection
        BOARD.set_pin_config(
            cpy.MultiIOPin.SHUTTLE_PIN_9, cpy.PinDirection.OUTPUT, cpy.PinValue.HIGH)

        # I2C config
        BOARD.config_i2c_bus(
            cpy.I2CBus.BUS_I2C_0, BMI085_I2C_ADDRESS_ACCEL, cpy.I2CMode.STANDARD_MODE)

        BOARD.set_shuttleboard_vdd_vddio_config(vdd_val=3.3, vddio_val=3.3)
        time.sleep(0.2)

        # I2C read
        accel_chip_id = BOARD.read_i2c(
            cpy.I2CBus.BUS_I2C_0, BMI08_REG_ACCEL_CHIP_ID, 1, BMI085_I2C_ADDRESS_ACCEL)
        gyro_chip_id = BOARD.read_i2c(
            cpy.I2CBus.BUS_I2C_0, BMI08_REG_ACCEL_CHIP_ID, 1, BMI085_I2C_ADDRESS_GYRO)

        print(f"Accel chip id: {hex(accel_chip_id[0])}")
        print(f"Gyro chip id: {hex(gyro_chip_id[0])}")

        # Deinit board
        BOARD.set_shuttleboard_vdd_vddio_config(vdd_val=0, vddio_val=0)
        BOARD.soft_reset()

        BOARD.close_comm_interface()
```

The user shall pass GPIO pin numbers, read register address and I2C device address for sensors based on the selected sensor shuttle board. I2C communication require the proper setting of VDD and VDDIO using `set_shuttleboard_vdd_vddio_config`.

8.2.3 SPI config and read

This basic program shows how to configure and perform SPI read. Sensor: BMI085

```
import sys
    import time
    import coinespy as cpy
    from coinespy import ErrorCodes

    COM_INTF = cpy.CommInterface.USB

    if __name__ == "__main__":
        BOARD = cpy.CoinesBoard()

        BOARD.open_comm_interface(COM_INTF)
        if BOARD.error_code != ErrorCodes.COINES_SUCCESS:
            print(f"Open Communication interface: {BOARD.error_code}")
            sys.exit()

        BMI085_ACCEL_CS_PIN = cpy.MultiIOPin.SHUTTLE_PIN_8
        BMI085_GYRO_CS_PIN = cpy.MultiIOPin.SHUTTLE_PIN_14
        BMI08_REG_ACCEL_CHIP_ID = 0x00
        accel_dummy_byte_len = 1

        BOARD.set_shuttleboard_vdd_vddio_config(vdd_val=0, vddio_val=0)

        # Config CS pin
        BOARD.set_pin_config(
            BMI085_ACCEL_CS_PIN, cpy.PinDirection.OUTPUT, cpy.PinValue.HIGH)
        BOARD.set_pin_config(
            BMI085_GYRO_CS_PIN, cpy.PinDirection.OUTPUT, cpy.PinValue.HIGH)
        # Set PS pin of gyro to LOW for proper protocol selection
        BOARD.set_pin_config(
            cpy.MultiIOPin.SHUTTLE_PIN_9, cpy.PinDirection.OUTPUT, cpy.PinValue.LOW)

        #  SPI config
        BOARD.config_spi_bus(cpy.SPIBus.BUS_SPI_0, BMI085_ACCEL_CS_PIN,
                             cpy.SPISpeed.SPI_1_MHZ, cpy.SPIMode.MODE0)

        BOARD.set_shuttleboard_vdd_vddio_config(vdd_val=3.3, vddio_val=3.3)
        time.sleep(0.2)

        # Initialize SPI by dummy read
        reg_data = BOARD.read_spi(cpy.SPIBus.BUS_SPI_0, BMI08_REG_ACCEL_CHIP_ID, 1)

        # SPI read
```

```
        accel_chip_id = BOARD.read_spi(
            cpy.SPIBus.BUS_SPI_0, BMI08_REG_ACCEL_CHIP_ID, 1 + accel_dummy_byte_len, BMI085_ACCEL_CS_PIN)
        gyro_chip_id = BOARD.read_spi(
            cpy.SPIBus.BUS_SPI_0, BMI08_REG_ACCEL_CHIP_ID, 1, BMI085_GYRO_CS_PIN)

        print(f"Accel chip id: {hex(accel_chip_id[accel_dummy_byte_len])}")
        print(f"Gyro chip id: {hex(gyro_chip_id[0])}")

        # Deinit board
        BOARD.set_shuttleboard_vdd_vddio_config(vdd_val=0, vddio_val=0)
        BOARD.soft_reset()

        BOARD.close_comm_interface()
```

The user shall pass GPIO pin numbers, read register address and SPI CS pins for sensors based on the selected sensor shuttle board. SPI communication require the proper setting of VDD and VDDIO using `set_shuttleboard_vdd_vddio_config`.

9. Debugging via VS code

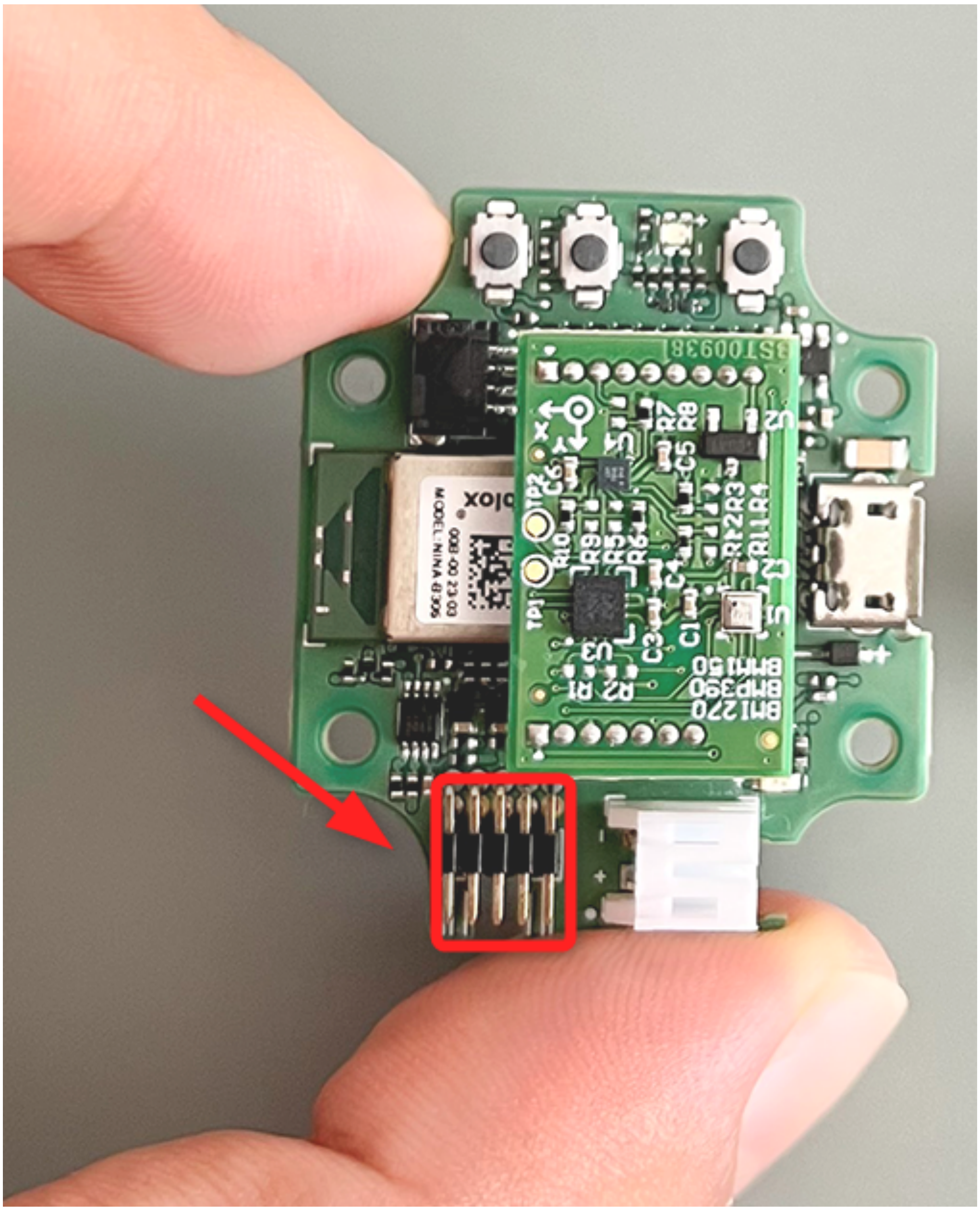
Here are the steps to follow to debug programs via VS code:

• Download Segger software from from https://www.segger.com/downloads/jlink/.

• Refer to https://wiki.segger.com/J-Link_Visual_Studio_Code for using J-link with VS code.

• Download the NRF5 .svd file from Nordic Semiconductor github.

• Connect J-link to SWD debugger connector.



APP3.1 Debugger connector

• Below is the sample launch.json config for VS code debug.

{} launch.json ×

.vscode > {} launch.json > ...

```
{
    // Use IntelliSense to learn about possible attributes.
    // Hover to view descriptions of existing attributes.
    // For more information, visit: https://go.microsoft.com/fwlink/?linkid=830387
    "version": "0.2.0",
    "configurations": [
        {
            "type": "cortex-debug",
            "request": "launch",
            "name": "Debug J-Link",
            "cwd": "${workspaceRoot}",
            "executable": "[illegible]/examples/c/coines_bridge_firmware/coines_bridge_firmware.elf",
            "serverpath": "C:/Program Files/SEGGER/JLink/JLinkGDBServerCL.exe",
            "servertype": "jlink",
            "armToolchainPath":"C:/Program Files (x86)/Arm GNU Toolchain arm-none-eabi/12.2 mpacbti-rel1/bin",
            "device": "nRF52840_xxAA",
            "interface": "swd",
            "showDevDebugOutput": "raw",
            "svdFile": "[illegible]/nRF52840.svd"

        }
    ]
}
```

VS code debug launch.json

10. Media Transfer Protocol (MTP) firmware for APP3.x

The external memory chip W25M02/W25N02 on APP3.x is based on NAND flash.

FAT filesystem on NAND flash memory results in a complicated solution which uses of lot of RAM. Moreover use of FAT without Flash Translation Layer (to save RAM) wears out NAND flash with frequent usage. Hence the choice of FlogFS, a filesystem optimized for use with NAND flash.

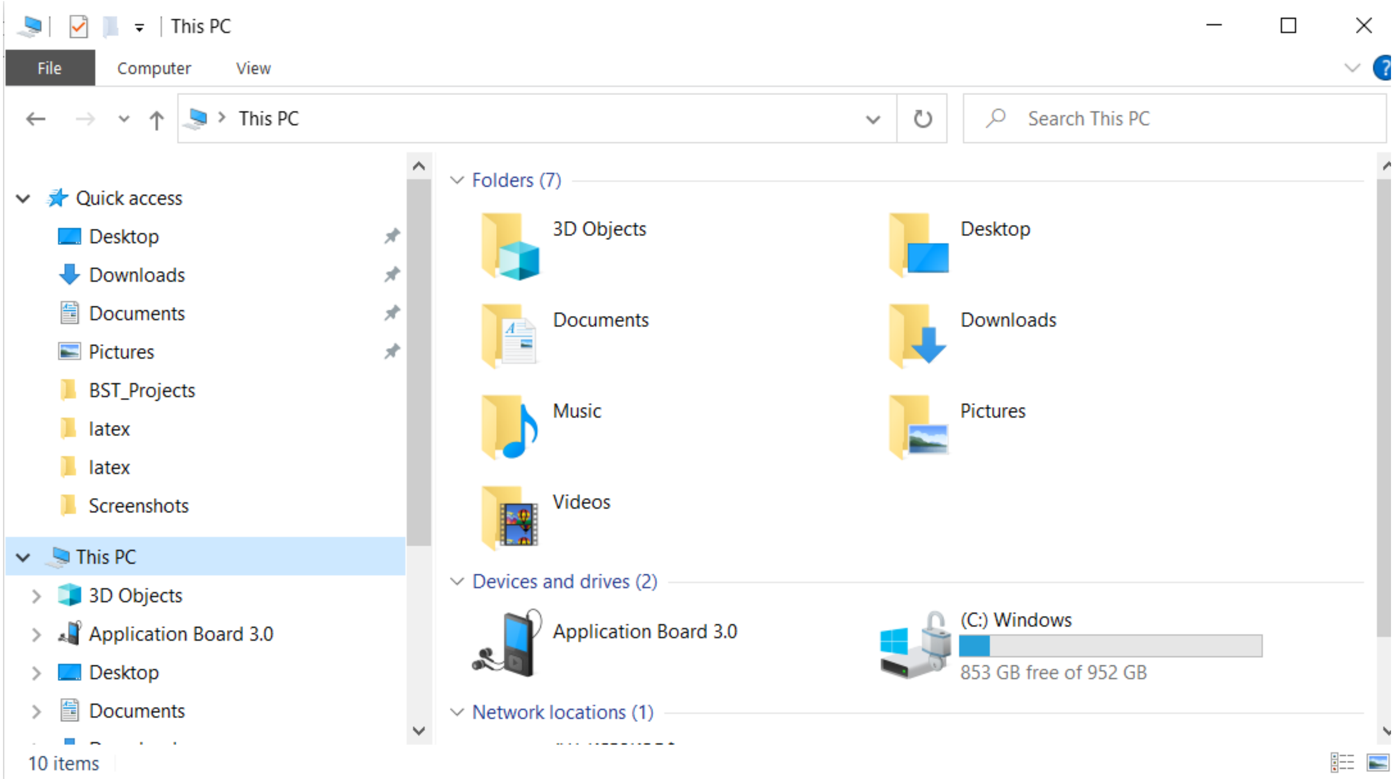
But the use of 'FlogFS', presents a new problem 'Filesystem access from PC via USB'. Use of 'FlogFS' with USB Mass Storage protocol is not possible because operating system can't recognize 'FlogFS' as a valid filesystem.

Use of custom protocol to do filesystem operations would mean re-inventing the wheel and a lot of effort. User also would not have the same experience as with USB Mass Storage.

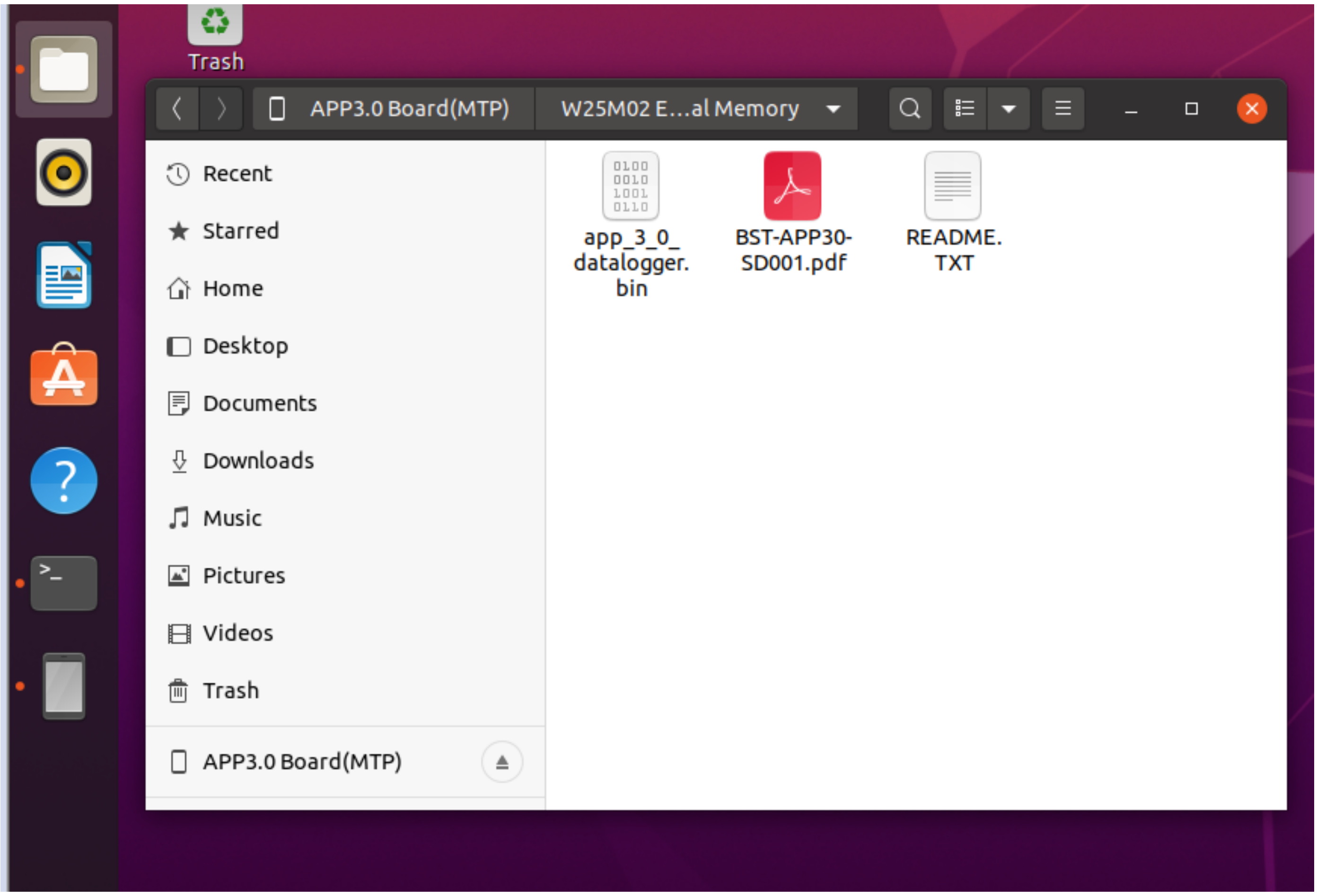
Solution was to go with the \"Media Transfer Protocol\" developed initially by Microsoft for Portable Devices like MP3 players. Starting from Android Kitkat (v4.4), MTP is the only way to access files on an Android device since the whole flash memory (included user storage space) uses filesystems like ext4, YAFFS, F2FS, etc.,

Files in APP3.x's NAND flash memory can be viewed using the USB MTP firmware.

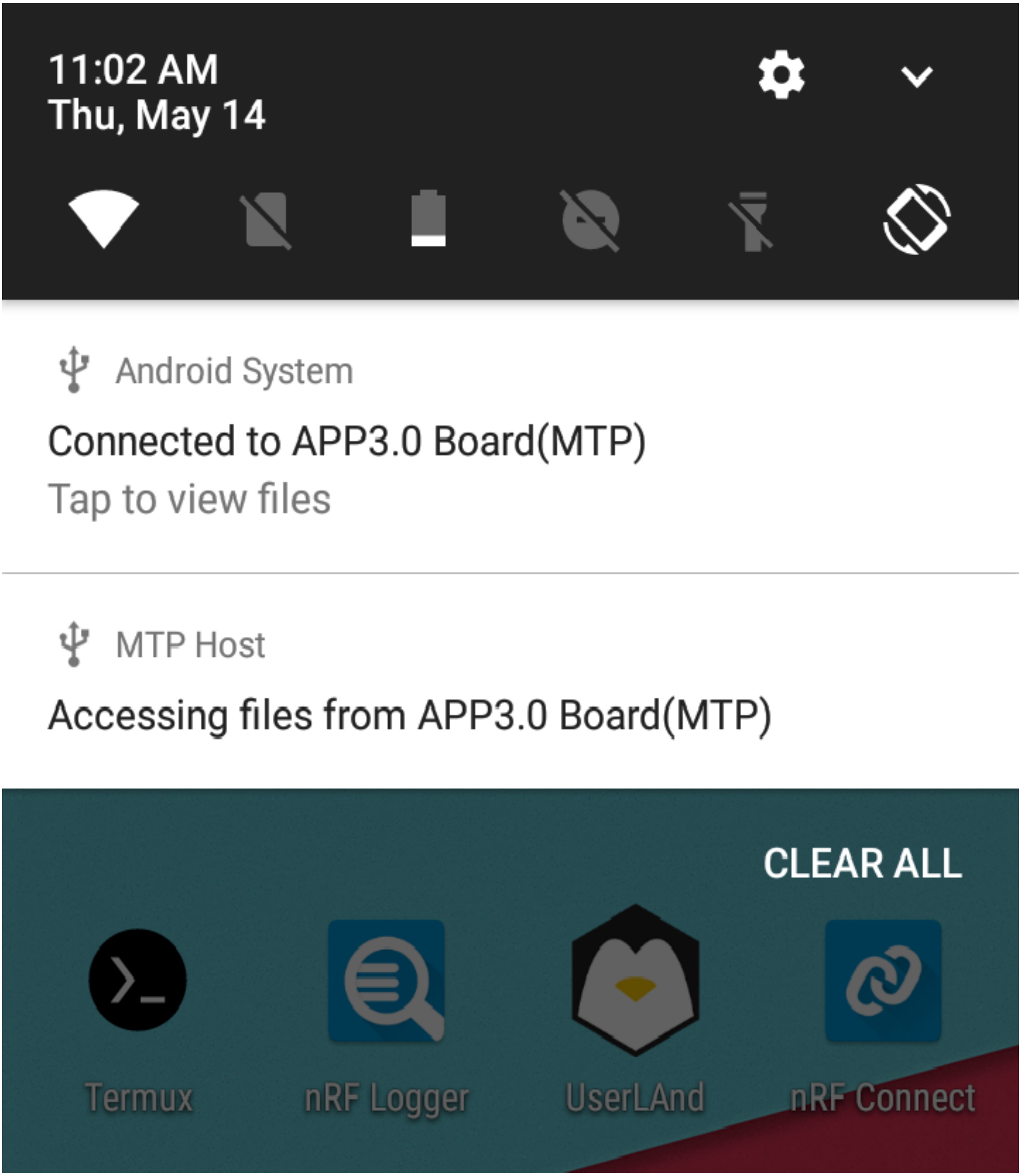
Supported on Windows, Linux, macOS and Android (via USB OTG).



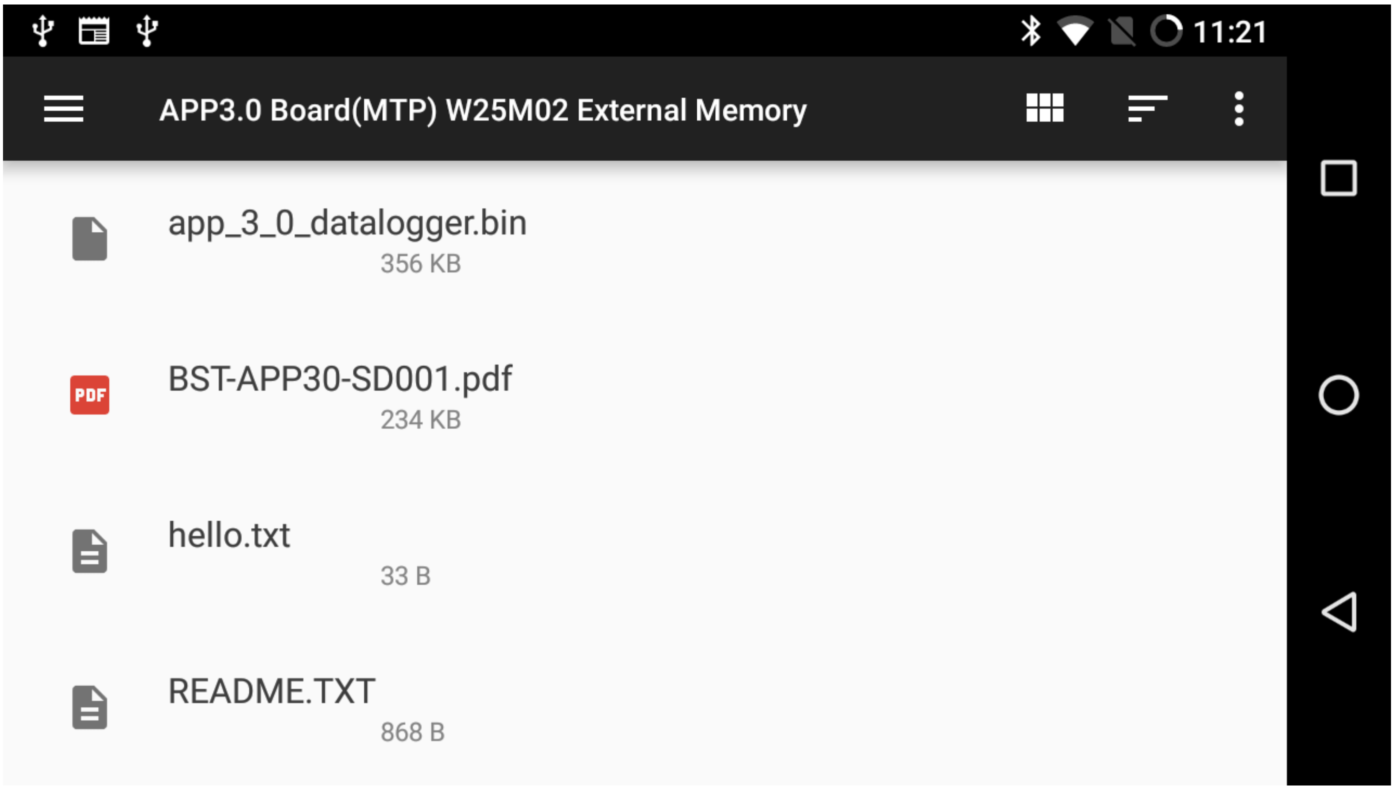
APP3.x in MTP mode on Windows



APP3.x in MTP mode on Linux



APP3.x in MTP mode on Andriod

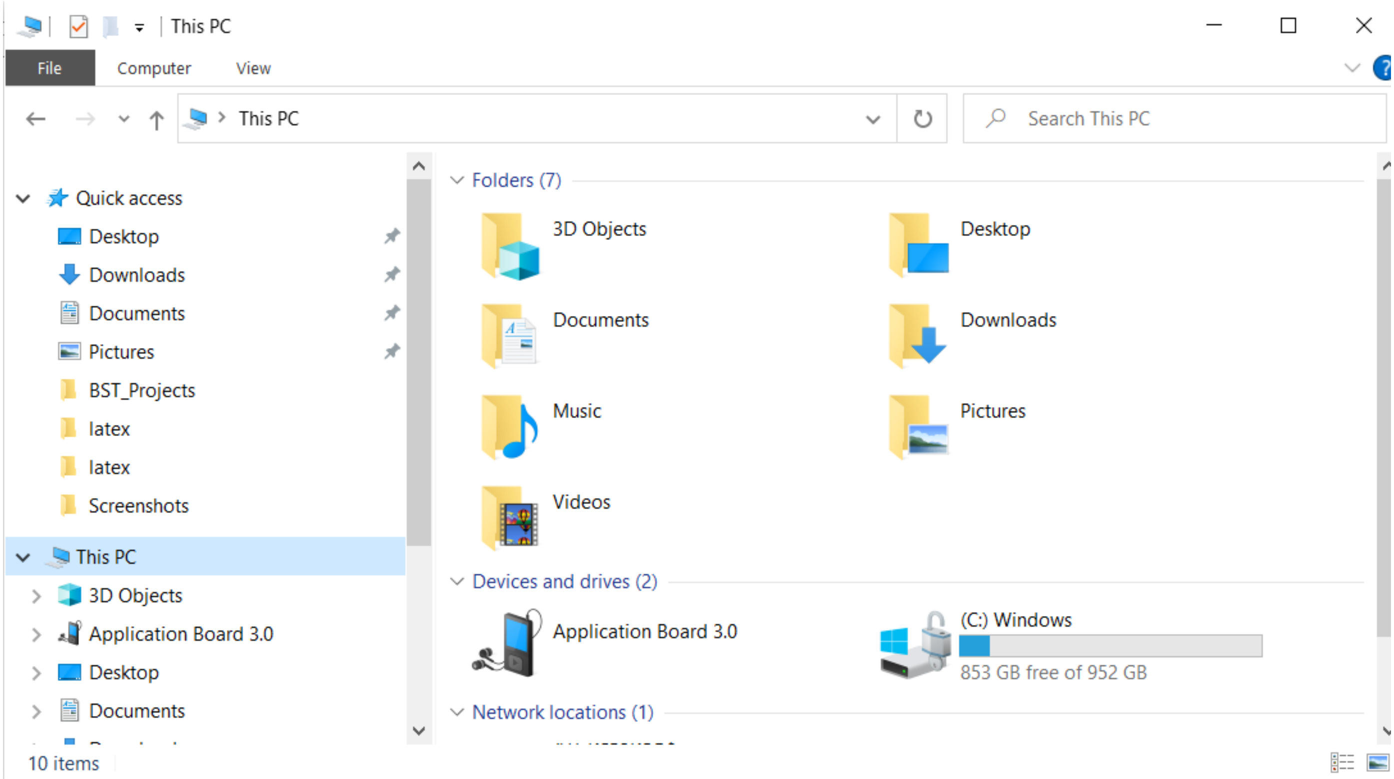


Files in external memory listed on Andriod device

10.1 Copying the files using MTP

The following procedure demonstrates how to copy files using MTP:

- APP3.x comes with the preloaded MTP firmware update package.
- Refer to section 12{reference-type="ref" reference="SwitchModes"} to switch to MTP mode
- The device will enumerate as an MTP device with name \"Application Board 3.x\". Click on it and select the \"W25M02 External Memory\"
- The device will list all the available files and all required files can be copied.



Copy data log files to the PC over USB MTP

11. USB/BLE DFU bootloader

A USB/BLE Bootloader for APP3.x/nRF52840 and Nicla Sense ME/nRF52832 chip comply with below items:

- https://www.usb.org/sites/default/files/DFU_1.1.pdf
- nRF5 SDK v15.2.0 - BLE Secure DFU Bootloader

11.1 Key Features

11.1.1 USB DFU

The key features of USB DFU are as follows:

- Code download to RAM or FLASH
- Code read back (upload) from RAM or FLASH (Useful for taking firmware backups)
- Works with Windows, Linux, macOS and Android.

11.1.2 BLE DFU

The key features of BLE DFU are as follows:

- Code download to FLASH.
- Works with PC and mobile devices with iOS/Android.

Bootloader was written taking into account the following aspects:

- Usability.

a. No special driver installation or admin rights should be required.

b. The update process should be straight forward.

- Maintainability

a. Open source community takes care of PC side tools. For eg: dfu-util is a cross platform tool.

b. Use Google Chrome's WebUSB to update firmware. Sample implementation https://devanlai.github.io/webdfu/dfu-util/

- Size
- COINES on MCU.

11.2 Invoking the Bootloader

1. To invoke Bootloader from Hardware, switch the board to bootloader mode (refer to section 12{reference-type="ref" reference="SwitchModes"}).
2. To invoke Bootloader from Software, use the below snippets in your program based on the board selected.
3. APP3.x

a. Write 0x4E494F43 ('N','I','O','C') to MAGIC_LOCATION (0x2003FFF4)

b. Write 0x0 or 0xF0000 to APP_START_ADDR (0x2003FFF8)

c. Call NVIC_SystemReset()

```c
#define  MAGIC_LOCATION (0x2003FFF4)
#define  APP_START_ADDR (*(uint32_t *)(MAGIC_LOCATION+4)

*((uint32_t *)MAGIC_LOCATION) == 0x4E494F43;
APP_START_ADDR = 0xF0000;
//APP_START_ADDR = 0x0;
NVIC_SystemReset();
```

```
<!-- -->
```

- Nicla Sense ME Board

````
1.  Write 0x544F4F42 ('T','O','O','B') to MAGIC_LOCATION
    (0x2000F804)

2.  Call NVIC_SystemReset()

    ``` {.objectivec language="C"}

           #define  MAGIC_LOCATION (0x2000F804)
           #define  APP_START_ADDR (*(uint32_t *)(MAGIC_LOCATION+4)

           *((uint32_t *)MAGIC_LOCATION) == 0x544F4F42;
           NVIC_SystemReset();

    ```
````

It is to be noted that the same feature can also be used to perform application switch (2 or more applications can reside in the same flash memory at different address locations). Just write the application start address to APP_START_ADDR instead of bootloader address

11.3 Using the Bootloader via USB

The commands below demonstrate how to use dfu-util for different scenarios:

- Path to dfu-util:

Write firmware to Flash memory using following command

- dfu-util -a FLASH -D \<firmware>.bin -R

Write firmware to RAM memory using following command

- dfu-util -a RAM -D \<firmware>.bin -R

Read firmware from Flash memory using following command

- dfu-util -a FLASH -U \<firmware>.bin

Read firmware from RAM memory using following command

- dfu-util -a RAM -U \<firmware>.bin

Read device serial number/ BLE MAC address

- dfu-util -l

  Note: Not applicable for Nicla Sense ME board

11.4 Using the Bootloader via BLE

To update the bootloader firmware via BLE, proceed as follows:

- PC (Windows, Linux or macOS) Python script present in following path can use the binary file directly.

a. Refer to section 12{reference-type="ref" reference="SwitchModes"} to switch to Bootloader mode

b. Run the command:

- `pip install -r requirements.txt`

c. Scan for devices to find BLE MAC address using below command

- `python app30-ble-dfu.py -l`

d. Update firmware by using MAC address obtained in the previous step and firmware BIN file

- `python app30-ble-dfu.py -d D7:A3:CE:8E:36:14 -f <firmware>.bin`

- Android devices

a. Generate ZIP package using https://pypi.org/project/adafruit-nrfutil/ before using nRF ToolBox for BLE or nRF connect for mobile.

- `adafruit-nrfutil dfu genpkg -dev-type 0x0052 -application <firmware>.bin dfu-package.zip`

  Note: Not applicable for Nicla Sense ME board

12. Switching to Operating Modes

12.1 APP2.0 (or) APP3.x

The process for switching modes for the Application board involves these steps:

- Bootloader mode - Turn OFF and ON the board with T2 pressed, blue LED glows indicating that the board switched to bootloader mode.
- MTP mode - Turn OFF and ON the board with T1 pressed, green LED glows indicating that the board switched to MTP mode.

12.2 Nicla Sense ME board

The process for switching modes for the Nicla Sense ME board involves these steps:

- Bootloader mode - Press three times reset button, blue LED glows indicating that the board switched to bootloader mode.
- Application Mode - Press three times reset button to switch to application mode

13. Updating Bootloader and MTP firmware using COINES

To update the firmware, follow these steps:

14. FAQs

1. **What to do in case of any communication or initialization failure while running examples?** Resetting or rebooting the board will help solving such issues.
2. **Why is there no output in my terminal application after cross-compiling and downloading an example on the MCU?** The code example on the MCU waits until the serial port of the board is opened. However, opening the port is not enough, the user has to ensure that also the DTR signal is set (this is required due to have higher compatibiliy among different terminal applications).
3. **How to fix libusb not found issue on macOS (arm64)?**

   Please try the below steps to fix the issue.

a. Install libusb: Libusb will be automatically installed as part of the COINES installation. However, If it's not installed automatically, you can use Homebrew to install it. `brew install libusb` After running above command, libusb should be installed on your system. On Intel Mac: On M1 Mac:

b. Add the path in

coines.mk

```
        BLE_LIB_PATH_ARCH += $(BLE_LIB_PAT
    else
        DRIVER = LIBUSB_DRIVER
        ifeq ($(shell uname -m),arm64)
            LIBPATHS += /opt/homebrew/lib
        endif
    endif
```

COINES file structure

4. **How do I recover the original program when bootloader was erased accidentally on Application Board 3.x?** COINES SDK does not provide a way to restore the board to original state.
5. **How to run multiple application boards using COINES in a single computer?** When multiple USB devices are connected to a PC, by configuring Serial COM settings for a script, one can communicate with them separately. Please refer to 8.1.10{reference-type="ref" reference="serialComConfig"} for implementation.

For more FAQs, visit Bosch Sensortec MEMS sensors forum.

15. Annexure

15.1 GPIO mapping

15.1.1 GPIO mapping of APP2.0 shuttle board pins

The APP2.0 shuttle board has total of 28 pins, of which some have a predefined functionality and some can be used as GPIO by the user.

The shuttle board connector details are given in the table below.

::: {#tab:shtbrdpins}

Pin number on Name / Pin number on Name / shuttle board function shuttle board function 1 VDD (3.3V) 28 SHTLE_COD #4 2 VDDIO (3.3V) 27 SHTLE_COD #3 3 GND 26 SHTLE_COD #2 4 SPI MISO 25 SHTLE_COD #1 5 SPI: MOSI / I^2C: SDA 24 SHTLE_COD #0 6 SPI: SCK / I^2C: SCL 23 SHTLE_COD_GND 7 SPI: CS 22 IO_4 (GPIO #4) 8 IO_5 (GPIO #5) 21 IO_7 (GPIO #7) 9 IO_0 (GPIO #0) 20 IO_6 (GPIO #6) 10 SHTLE_COD #5 19 IO_8 (GPIO #8) 11 SHTLE_COD #6 18 SCL (see note) 12 SHTLE_COD #7 17 SDA (see note) 13 SHTLE_COD #8 16 IO_3 (GPIO #3) 14 IO_1 (GPIO #1) 15 IO_2 (GPIO #2)

: Overview of shuttle board pins and their function :::

Note:

- In COINES functions, the pins are addressed using the same numbers as on the shuttle board. For example, the GPIO #5 has the pin number 8.
- In some cases (depending on the sensor), the I^2C lines are shuttle board pin 6 for the clock signal SCL and shuttle board pin 5 for the data line SDA. In such cases pins 17 and 18 may not be connected. Please carefully read the shuttle board documentation.

15.1.2 GPIO mapping of APP3.x shuttle board pins

The APP3.x shuttle board has a total of 16 pins, 7 on the left and 9 on the right. (with shuttle board pins facing downwards)

Note:

- In COINES functions, the pins are addressed as on the APP3.x shuttle board. For example, the GPIO #5 is addressed as `COINES_MINI_SHUTTLE_PIN_2_6`.
- Supported VDD voltages on APP3.x are 0, 1.8V and 2.8V.
- Supported VDDIO voltage on APP3.x is 1.8V.

::: {#tab:shtbrdpins}

Pin number on Name / Pin number on Name / shuttle board function shuttle board function 1_1 VDD (1.8/2.8V) 2_1 SPI_CS 1_2 VDDIO (1.8) 2_2 SPI: SCK / I^2C: SCL 1_3 GND 2_3 SPI: MISO 1_4 GPIO0 2_4 SPI: MOSI / I^2C: SDA 1_5 GPIO1 2_5 GPIO4* 1_6 GPIO2 2_6 GPIO5* 1_7 GPIO3 2_7 IOXP_INT* 2_8 PlugDet* 2_9 EEPROM_RW

: Overview of APP3.x shuttle board pins and their function :::

*SPI pins for secondary interface - CS:GPIO4, SCK:GPIO5, MISO:IOXP_INT, MOSI:PlugDet

15.2 COINES C functions

15.2.1 coinesAPI calls: Interface and board information

coines_open_comm_intf

Opens the communication interface.

```
int16_t coines_open_comm_intf(enum coines_comm_intf intf_type,void *arg);
```

In case of MCU Target, API waits indefinitely for serial port or BLE connection (`MCU_APP30` target and `MCU_APP31` target).

In case of PC Target, one can configure communication settings either by passing the address of `coines_serial_com_config` or `ble_peripheral_info` to `*arg` .

Serial com configuration: If `*arg` is NULL for `COINES_COMM_INTF_USB` , first com port enumerated will be used for communication. The serial com configuration structure contains the following items. Refer to 8.1.10{reference-type="ref" reference="serialComConfig"} for its implementation.

```
struct coines_serial_com_config
{
    uint32_t baud_rate; /*< Baud rate */
    uint16_t vendor_id; /*< vendor Id */
    uint16_t product_id; /*< Product Id */
    char* com_port_name; /*< serial com port name */
    uint16_t rx_buffer_size; /*< RX response buffer size */
};
```

BLE com configuration: If `*arg` is NULL for `COINES_COMM_INTF_BLE` , the nearest Application board for the host BLE will be used for communication. The ble com configuration structure contains the following items. Refer to 8.1.9{reference-type="ref" reference="bleComConfig"} for its implementation.

```
struct ble_peripheral_info
{
    char ble_address[COINES_CHAR_MAX_LEN]; /*< BLE device address */
    char ble_identifier[COINES_CHAR_MAX_LEN]; /*< BLE device identifier */
};
```

coines_close_comm_intf

Closes the communication interface.

```
int16_t coines_close_comm_intf(enum coines_comm_intf intf_type,void *arg);
```

coines_get_board_info

Gets the board information.

```
int16_t coines_get_board_info(struct coines_board_info *data);
```

The data structure contains the following items

```
struct coines_board_info {
    /*!Board hardware ID */
    uint16_t hardware_id;
    /*!Board software ID */
    uint16_t software_id;
    /*!Type of the board like APP2.0, Arduino Due*/
    uint8_t board;
    /*!Shuttle ID of the sensor connected*/
    uint16_t shuttle_id;
};
```

15.2.2 coinesAPI calls: GPIO oriented calls

coines_set_pin_config

Sets the pin direction and the state.

```
int16_t coines_set_pin_config(enum coines_multi_io_pin pin_number, enum coines_pin_direction direction, enum coines_pin_value pin_value);
```

coines_get_pin_config

Gets the pin configuration.

```
int16_t coines_get_pin_config(enum coines_multi_io_pin pin_number, enum coines_pin_direction *pin_direction, enum coines_pin_value *pin_value);
```

coines_set_shuttleboard_vdd_vddio_config

Configures the VDD and VDDIO of the sensor. For APP2.0, a voltage level of 0 or 3300 mV is supported. Any values above 0 will default to 3300 mV.

```
int16_t coines_set_shuttleboard_vdd_vddio_config(uint16_t vdd_millivolt, uint16_t vddio_millivolt);
```

15.2.3 coinesAPI calls: Sensor communication

coines_config_i2c_bus

Configures the I^2C bus.

```
int16_t coines_config_i2c_bus(enum coines_i2c_bus bus, enum coines_i2c_mode i2c_mode);
```

The first argument refers to the bus on the board. Currently, on APP2.0, there is only one bus available, so the argument is always COINES_I2C_BUS_0.

The following I^2C modes are available:

```
COINES_I2C_STANDARD_MODE
COINES_I2C_FAST_MODE
COINES_I2C_SPEED_3_4_MHZ
COINES_I2C_SPEED_1_7_MHZ
```

coines_config_spi_bus

Configures the SPI bus of the board. The argument coines_spi_bus refers to the bus on the board. On APP2.0, there is only one bus available, so the user should only use COINES_SPI_BUS_0. The SPI speed can be chosen in various discrete steps, as defined in enum coines_spi_speed in coines.h. (For example, COINES_SPI_SPEED_2_MHZ sets the SPI speed to 2 MHz.)

```
int16_t coines_config_spi_bus(enum coines_spi_bus bus, uint32_t spi_speed, enum coines_spi_mode spi_mode);
```

coines_config_i2s_bus

This API is used to configure the I^2S bus to match the TDM configuration

```
int16_t coines_config_i2s_bus(uint16_t data_words, coines_tdm_callback callback);
```

Arguments:

- `data_words` : number of words to use in the buffer. Max is set at COINES_TDM_BUFFER_SIZE_WORDS.
- `callback` : register a callback to be called to process and copy the data.

coines_deconfig_spi_bus

This API is used to de-configure the SPI bus

```
int16_t coines_deconfig_spi_bus(enum coines_spi_bus bus);
```

coines_deconfig_i2c_bus

This API is used to de-configure the I^2C bus

```
int16_t coines_deconfig_i2c_bus(enum coines_i2c_bus bus);
```

coines_deconfig_i2s_bus

This API is used to stop the I^{2}S/TDM interface from reading data from the sensor

```
void coines_deconfig_i2s_bus(void);
```

coines_write_i2c

Writes 8-bit register data to the I^{2}C device at `COINES_I2C_BUS_0`.

```
int8_t coines_write_i2c(enum coines_i2c_bus bus,uint8_t dev_addr, uint8_t reg_addr, uint8_t *reg_data, uint16_t count);
```

Arguments:

- `bus` : I^{2}C bus to be used
- `dev_addr` : I^{2}C device address.
- `reg_addr` : Starting address for writing the data.
- `reg_data` : Data to be written.
- `count` : Number of bytes to write.

coines_read_i2c

Reads 8-bit register data from the I^{2}C device at `COINES_I2C_BUS_0`.

```
int8_t coines_read_i2c(enum coines_i2c_bus bus,uint8_t dev_addr, uint8_t reg_addr, uint8_t *reg_data, uint16_t count);
```

Arguments:

- `bus` : I^{2}C bus to be used
- `dev_addr` : I^{2}C device address.
- `reg_addr` : Starting address for reading the data.
- `reg_data` : Buffer to take up the read data.
- `count` : Number of bytes to read.

coines_i2c_set

This API is used to write the data in I2C communication.

```
int8_t coines_i2c_set(enum coines_i2c_bus bus, uint8_t dev_addr, uint8_t *data, uint8_t count);
```

Arguments:

- `bus` : I^{2}C bus to be used
- `dev_addr` : I^{2}C device address.
- `data` : Data to be written.
- `count` : Number of bytes to write.

coines_i2c_get

This API is used to read the data in I2C communication.

```
int8_t coines_i2c_get(enum coines_i2c_bus bus, uint8_t dev_addr, uint8_t *data, uint8_t count);
```

Arguments:

- `bus` : I^2C bus to be used
- `dev_addr` : I^2C device address.
- `data` : Data read from the sensor.
- `count` : Number of bytes to read.

coines_write_spi

Writes 8-bit register data to the SPI device at `COINES_SPI_BUS_0` .

```
int8_t coines_write_spi(enum coines_spi_bus bus,uint8_t dev_addr, uint8_t reg_addr, uint8_t *reg_data, uint16_t count);
```

Arguments:

- `bus` : SPI bus to be used.
- `dev_addr` : Chip select pin number.
- `reg_addr` : Starting address for writing the data.
- `reg_data` : Data to be written.
- `count` : Number of bytes to write.

coines_read_spi

Reads 8-bit register data from the SPI device at `COINES_SPI_BUS_0` .

```
int8_t coines_read_spi(enum coines_spi_bus bus,uint8_t dev_addr, uint8_t reg_addr, uint8_t *reg_data, uint16_t count);
```

Arguments:

- `bus` : SPI bus to be used.
- `dev_addr` : Chip select pin number.
- `reg_addr` : Starting address for reading the data.
- `reg_data` : Buffer to take up the read data.
- `count` : Number of bytes to read.

coines_delay_msec

Introduces delay in millisecond.

```
void coines_delay_msec(uint32_t delay_ms);
```

coines_delay_usec

Introduces delay in microsecond.

```
void coines_delay_usec(uint32_t delay_us);
```

coines_uart_init

This API is used to initialize the UART communication

```
int8_t coines_uart_init(enum coines_uart_instance uart_instance, enum coines_uart_parity parity, enum coines_uart_flow_control flow_control, uint32_t
baud_rate);
```

Arguments:

- `uart_instance` : Specifies the UART instance
- `parity` : UART parity
- `flow_control` : UART flow control mode
- `baud_rate` : UART baud rate

coines_uart_read

This API is used to read the data in UART communication

```
uint16_t coines_uart_read(enum coines_uart_instance uart_instance, uint8_t *buffer, uint16_t length);
```

Arguments:

- `uart_instance` : Specifies the UART instance
- `buffer` : Pointer to the buffer to store the data
- `length` : Length of the buffer

coines_uart_write

This API is used to write the data in UART communication

```
int8_t coines_uart_write(enum coines_uart_instance uart_instance, uint8_t *buffer, uint16_t length);
```

Arguments:

- `uart_instance` : Specifies the UART instance
- `buffer` : Pointer to the data buffer which need to be written
- `length` : Length of the buffer

15.2.4 coinesAPI calls: Streaming feature

Note :

1. The below APIs are supported only on PC Target.
2. A simpler approach of using `coines_attach_interrupt()` API for is available for MCU.

coines_config_streaming

Sets the configuration for streaming sensor data.

```
int16_t coines_config_streaming(uint8_t channel_id, struct coines_streaming_config *stream_config, struct coines_streaming_blocks *data_blocks);
```

Arguments:

- `channel_id` : An integer number that can be used as identifier/index to the sensor data that will be streamed for this setting
- `stream_config` : Contains information regarding interface settings and streaming configuration.
- `coines_streaming_blocks` : Contains information regarding numbers of blocks to read, register address and size for each block.

Note: The below parameters should always be set:

- `data_block.no_of_blocks` : number of blocks to stream (must at least be one)
- For each block b:
- `data_block.reg_start_addr[b]` : start address of the block in the register map
- `stream_block.no_of_data_bytes[b]` : number of bytes to read, starting from the start address

For reading data from I^2C bus,then set the below parameters:

- `stream_config.intf = COINES_SENSOR_INTF_I2C;`
- `stream_config.i2c_bus` : I^2C bus (in case of APP2.0, this is always `COINES_I2C_BUS_0`)
- `stream_config.dev_addr` : I^2C address of the sensor

For reading data from SPI bus, then set the below parameters:

- `stream_config.intf = COINES_SENSOR_INTF_SPI;`
- `stream_config.spi_bus` : SPI bus (in case of APP2.0, this is always `COINES_SPI_BUS_0`)
- `stream_config.cs_pin` : CS pin of the sensor, information can be obtained from the shuttle board documentation for the sensor.

When polling mode is requested, set the below parameters:

- `stream_config.sampling_units` :\ either milliseconds (`COINES_SAMPLING_TIME_IN_MILLI_SEC`)\ or microseconds (`COINES_SAMPLING_TIME_IN_MICRO_SEC`)
- `stream_config.sampling_time` : sampling period in the unit as defined in\ `stream_config.sampling_units`

When interrupt mode is requested, set the below parameters:

- `stream_config.int_pin` : pin of the interrupt which shall trigger the sensor read-out. If the interrupt output of the sensor is used, the required information about the pin number can be obtained from the shuttle board documentation for the sensor.
- `stream_config.int_timestamp` : it can be configured if the sensor data is tagged with a timestamp (`COINES_TIMESTAMP_ENABLE`) or not (`COINES_TIMESTAMP_DISABLE`).

coines_start_stop_streaming

Starts or stops sensor data streaming.

```
int16_t coines_start_stop_streaming(enum coines_streaming_mode stream_mode, uint8_t start_stop);
```

Arguments:

- `stream_mode` : streaming mode (either `COINES_STREAMING_MODE_POLLING` or\ `COINES_STREAMING_MODE_INTERRUPT`)
- `start_stop` : flag to either start (`COINES_STREAMING_START`) or stop (`COINES_STREAMING_STOP`) the streaming

coines_read_stream_sensor_data

Reads the data streamed from the sensor.

```
int16_t coines_read_stream_sensor_data(uint8_t sensor_id, uint32_t number_of_samples, uint8_t *data, uint32_t *valid_samples_count);
```

Arguments:

- `sensor_id` : id of the sensor
- `number_of_samples` : number of samples the user wishes to read (not implemented)
- `data` : data buffer

- Interrupt streaming - Packet counter + Register data + Timestamp
- Polling streaming - Register data

- `valid_samples_count` : number of samples the user has actually received (may be less than `number_of_samples`)

Example of a packet:

Format of streaming packages

In the above figure, the following meaning apply to the mentioned abreviations:

- r_p: Value at register address p
- a: Size of register block--0
- r_{p+a}: Value at register address p

Similarly is the case for r_q, j and r_{q+j}. See the `coines_streaming_blocks` structure for information regarding register blocks.

The packet counter and the timestamp can be obtained as follows:

- `packet_counter = (byte3_c << 24) | (byte2_c << 16) | (byte1_c << 8) | (byte0_c)`
- `timestamp = (byte5_t << 40) | (byte4_t << 32) | (byte3_t << 24) | (byte2_t << 16) | (byte1_t << 8) | (byte0_t)`

The 48-bit timestamp is enabled by using\ `coines_trigger_timer(COINES_TIMER_START, COINES_TIMESTAMP_ENABLE);`

Timestamp in microseconds can be obtained using below formula:

- \(\displaystyle Timestamp\ (\mu s) = \frac{48bit_timestamp}{30}\)

coines_trigger_timer

Triggers the timer in firmware and also enables or disables the time stamp feature.

```
int16_t coines_trigger_timer(enum coines_timer_config tmr_cfg,enum coines_time_stamp_config ts_cfg);
```

Arguments:

- `tmr_cfg` : start, stop or reset the timer (`COINES_TIMER_START` , `COINES_TIMER_STOP` or\ `COINES_TIMER_RESET`)
- `ts_cfg` : Enables/disables microcontroller timestamp (`COINES_TIMESTAMP_ENABLE` or\ `COINES_TIMESTAMP_DISABLE`)

15.2.5 coinesAPI calls: Other useful APIs

coines_get_millis

Returns the number of milliseconds passed since the program started

```
uint32_t coines_get_millis();
```

coines_get_micro_sec

Returns the number of microseconds passed since the program started

```
uint64_t coines_get_micro_sec();
```

coines_attach_interrupt

Attaches an interrupt to a Multi-IO pin.Works only on MCU.

```
void coines_attach_interrupt(enum coines_multi_io_pin pin_number,void (*callback)(uint32_t, uint32_t),enum coines_pin_interrupt_mode int_mode);
```

Arguments:

- `pin_number` : Multi-IO pin
- `callback` : Name of the function to be called on detection of interrupt
- `int_mode` : Trigger modes - change (`COINES_PIN_INTERRUPT_CHANGE`),\ rising edge (`COINES_PIN_INTERRUPT_RISING_EDGE`),\ falling edge (`COINES_PIN_INTERRUPT_FALLING_EDGE`)

coines_detach_interrupt

Detaches interrupt from a Multi-IO pin.Works only on MCU.

```
void coines_detach_interrupt(enum coines_multi_io_pin pin_number);
```

Arguments:

- `pin_number` : Multi-IO pin.

coines_intf_available

Return the number of bytes available in the read buffer of the interface.Works only on APP3.x MCU target.

```
uint16_t coines_intf_available(enum coines_comm_intf intf);
```

Arguments:

- `intf` : Type of interface (USB, COM, or BLE)

coines_intf_connected

Check if the interface is connected.Works only on APP3.x MCU target.

```
bool coines_intf_connected(enum coines_comm_intf intf);
```

Arguments:

- `intf` : Type of interface (USB, COM, or BLE)

coines_flush_intf

Flush the write buffer.Works only on APP3.x MCU target.

```
void coines_flush_intf(enum coines_comm_intf intf);
```

Arguments:

- `intf` : Type of interface (USB, COM, or BLE)

coines_read_intf

Read data over the specified interface.Works only on APP3.x MCU target.

```
uint16_t coines_read_intf(enum coines_comm_intf intf, void *buffer, uint16_t len);
```

Arguments:

- `intf` : Type of interface (USB, COM, or BLE)
- `buffer` : Pointer to the buffer to store the data
- `len` : Length of the buffer

coines_write_intf

Write data over the specified interface.Works only on APP3.x MCU target.

```
uint16_t coines_write_intf(enum coines_comm_intf intf, void *buffer, uint16_t len);
```

Arguments:

- `intf` : Type of interface (USB, COM, or BLE)
- `buffer` : Pointer to the buffer storing the data
- `len` : Length of the buffer

coines_get_version

Returns pointer to COINES version string

```
char* coines_get_version(void);
```

coines_soft_reset

Resets the device. After reset device jumps to the address specified in makefile(APP_START_ADDRESS).

```
void coines_soft_reset(void);
```

coines_read_temp_data

This API is used to read the temperature sensor data.

```
int16_t coines_read_temp_data(float *temp_data);
```

Arguments:

- `temp_conv_data` : Buffer to retrieve the sensor data in degree Celsius.

coines_read_bat_status

This API is used to read the battery status.

```
int16_t coines_read_bat_status(uint16_t *bat_status_mv, uint8_t *bat_status_percent);
```

Arguments:

- `bat_status_mv` : Buffer to retrieve the battery status in millivolt
- `bat_status_percent` : Buffer to retrieve the battery status in percentage

coines_ble_config

This API is used to configure BLE name and power. It should be called before calling coines_open_comm_intf API.

```
int16_t coines_ble_config(struct coines_ble_config *ble_config);
```

Arguments:

- `ble_config` : structure holding ble name and power details

coines_set_led

This API is used to set led state(on or off).

```
int16_t coines_set_led(enum coines_led led,enum coines_led_state led_state);
```

Arguments:

- `led` : led to which the state has to be set.
- `led_state` : state to be set to the given led.

coines_timer_config

This API is used to configure the hardware timer.

```
int16_t coines_timer_config(enum coines_timer_instance instance, void* handler);
```

Arguments:

- `instance` : timer instance.
- `handler` : callback to be called when timer expires.

coines_timer_deconfig

This API is used to de-configure the hardware timer.

```
int16_t coines_timer_deconfig(enum coines_timer_instance instance);
```

Arguments:

- `instance` : timer instance.

coines_timer_start

This API is used to start the configured hardware timer.

```
int16_t coines_timer_start(enum coines_timer_instance instance, uint32_t timeout);
```

Arguments:

- `instance` : timer instance.
- `timeout` : timeout in microseconds.

coines_timer_stop

This API is used to stop the hardware timer.

```
int16_t coines_timer_stop(enum coines_timer_instance instance);
```

Arguments:

- `instance` : timer instance.

coines_get_realtime_usec

This API is used to get the current counter(RTC) reference time in usec

```
uint32_t coines_get_realtime_usec(void);
```

coines_delay_realtime_usec

This API is used to introduce delay based on high precision RTC(LFCLK crystal) with the resolution of 30.517 usec.

```
void coines_delay_realtime_usec(uint32_t period);
```

Arguments:

- `period` : required delay in microseconds

coines_attach_timed_interrupt

Attaches a timed interrupt to a Multi-IO pin.

```
int16_t coines_attach_timed_interrupt(enum coines_multi_io_pin pin_number, void (*timed_interrupt_cb)(uint64_t,uint32_t,uint32_t), enum
coines_pin_interrupt_mode int_mode);
```

Arguments:

- `pin_number` : Multi-IO pin.
- `timed_interrupt_cb` : Name of the function to be called on detection of interrupt.
- `int_mode` : Trigger modes - change,rising edge,falling edge.

coines_detach_timed_interrupt

Detaches a timed interrupt from a Multi-IO pin.

```
int16_t coines_detach_timed_interrupt(enum coines_multi_io_pin pin_number);
```

Arguments:

- `pin_number` : Multi-IO pin.

coines_echo_test

This API is used to test the communication.

```
int16_t coines_echo_test(uint8_t *data, uint16_t length);
```

Arguments:

- `data` : Data to be sent for testing.
- `length` : Length of the data.

coines_shuttle_eeprom_write

This API is used to write the content into shuttle eeprom.

```
int16_t coines_shuttle_eeprom_write(uint16_t start_addr, uint8_t *buffer, uint16_t length);
```

Arguments:

- `start_addr` : EEPROM write address.
- `buffer` : Pointer to the buffer.
- `length` : Length of the buffer.

coines_shuttle_eeprom_read

This API is used to read the content from shuttle eeprom.

```
int16_t coines_shuttle_eeprom_read(uint16_t start_addr, uint8_t *buffer, uint16_t length);
```

Arguments:

- `start_addr` : EEPROM read address.
- `buffer` : Pointer to the buffer.
- `length` : Length of the buffer.

coines_yield

This API can be defined to perform a task when yielded from an ongoing blocking call.

```
void coines_yield(void);
```

coines_execute_critical_region

This API is used to execute the function inside critical region.

```
void coines_execute_critical_region(coines_critical_callback callback);
```

Arguments:

- `callback` : function to execute.

coines_scan_ble_devices

This API is used to connect to BLE Adapter and return list of BLE peripherals found during BLE scan.

```
    int16_t coines_scan_ble_devices(struct ble_peripheral_info *ble_info, uint8_t *peripheral_count, size_t scan_timeout_ms)
```

Arguments:

- `ble_info` : array of struct containing found BLE peripheral information
- `peripheral_count` : number of BLE peripherals found
- `scan_timeout_ms` : timeout for BLE scan

15.3 COINES Python functions

As coinespy is only a wrapper on top of coinesAPI, the following API documentation is limited to the wrapper only. Details about meaning of variables and functionality can be found in the corresponding coinesAPI documentation in the chapter above. The following function calls are defined within the class `CoinesBoard` . Thus in order to access the functions, the user has to create an object of that class first.

```
import coinespy as cpy
    coinesboard = cpy.CoinesBoard()
```

15.3.1 coinespy API calls: Interface and board information

open_comm_interface

Sets the communication interface between board and PC to USB, Serial or BLE.

```
coinesboard.open_comm_interface(interface=CommInterface.USB, serial_com_config: SerialComConfig = None,
ble_com_config: BleComConfig = None) -> ErrorCodes
```

For the definition of `CommInterface`, refer to 15.3.6.3{reference-type="ref" reference="CommInterface"}.

close_comm_interface

Disposes the resources used by the USB/serial/BLE communication.

```
coinesboard.close_comm_interface(arg=None) -> ErrorCodes
```

get_board_info

Obtains board specific information.

```
BoardInfo = coinesboard.get_board_info()

# Return:
BoardInfo.HardwareId    # Hardware ID
BoardInfo.SoftwareId    # Firmware version information
BoardInfo.Board         # Board type
BoardInfo.ShuttleID     # ID of shuttle, in case a shuttle is detected
```

scan_ble_devices

This API is used to connect to BLE Adapter and return list of BLE peripherals found during BLE scan.

```
ble_info, peripheral_count  = coinesboard.scan_ble_devices(scan_timeout_ms=0) -> Tuple[list, int]
```

For the definition of parameters, refer to 15.2.5.29{reference-type="ref" reference="coinesScanBleDevices"}.

echo_test

This API is used to test the communication.

```
coinesboard.echo_test(data: List[int]) -> ErrorCodes
```

Arguments:

- `data`: Data to be sent for testing.

15.3.2 coinespy API calls: GPIO oriented calls

set_pin_config

Configures the state, level and direction of a GPIO pin

```
coinesboard.set_pin_config(pin_number: MultiIOPin, direction: PinDirection, output_state: PinValue) -> ErrorCodes
```

For the definition of `MultiIOPin`, refer to 15.3.6.8. For the definition of `PinDirection`, refer to 15.3.6.1{reference-type="ref" reference="PinDirection"}. For `PinValue`, refer to 15.3.6.2.

get_pin_config

Obtains information regarding the Pin's state, level and direction.

```
PinConfigInfo = coinesboard.get_pin_config(pin_number: MultiIOPin)

# Return:
PinConfigInfo.direction         # 0: INPUT, 1: OUTPUT
PinConfigInfo.switch_state       # 0: OFF, 1: ON
PinConfigInfo.level             # 1: HIGH, 0: LOW
```

set_shuttleboard_vdd_vddio_config

Set the VDD and VDDIO voltage level.

```
coinesboard.set_shuttleboard_vdd_vddio_config(vdd_val: float = None, vddio_val: float = None) -> ErrorCodes

# Example: coinesboard.set_shuttleboard_vdd_vddio_config(3.3, 3.3)
```

set_vdd

Set the VDD voltage level.

```
coinesboard.set_vdd(vdd_val: float = None) -> ErrorCodes

# Example: coinesboard.set_vdd(3.3)
```

set_vddio

Set the VDDIO voltage level.

```
coinesboard.set_vddio(vdd_val: float = None) -> ErrorCodes

# Example: coinesboard.set_vddio(3.3)
```

15.3.3 coinespy API calls: Sensor communication

For the definition of `SPIBus`, refer to 15.3.6.11. For the definition of `I2CBus`, refer to 15.3.6.10.

config_i2c_bus

Configures the I^2C bus.

```
coinesboard.config_i2c_bus(bus: I2CBus, i2c_address: int, i2c_mode: I2CMode) -> ErrorCodes
```

For the definition of `I2CMode`, refer to 15.3.6.4.

config_spi_bus

Configures the SPI bus of the board.

```
coinesboard.config_spi_bus(bus: SPIBus, cs_pin: MultiIOPin, spi_speed=SPISpeed, spi_mode=SPIMode) -> ErrorCodes
```

For the definition of `MultiIOPin`, refer to 15.3.6.8. For the definition of `SPISpeed`, refer to 15.3.6.5. For the definition of `SPIMode`, refer to 15.3.6.7.

deconfig_i2c_bus

This API is used to de-configure the I^2C bus

```
coinesboard.deconfig_i2c_bus(bus: I2CBus) -> ErrorCodes
```

deconfig_spi_bus

This API is used to de-configure the SPI bus

```
coinesboard.deconfig_spi_bus(bus: SPIBus) -> ErrorCodes
```

write_i2c

Writes 8-bit register data to the I^2C

```
coinesboard.write_i2c(bus: I2CBus, register_address: int, register_value: int, sensor_interface_detail: int = None) -> ErrorCodes
```

For the definition of parameters, refer to 15.2.3.7{reference-type="ref" reference="CoinesWriteI2c"}.

read_i2c

Reads 8-bit register data from the I^2C

```
register_data = coinesboard.read_i2c(bus: I2CBus, register_address: int, number_of_reads=1, sensor_interface_detail: int = None)
```

For the definition of parameters, refer to 15.2.3.8{reference-type="ref" reference="CoinesReadI2c"}.

write_spi

Writes 8-bit register data to the SPI device

```
coinesboard.write_spi(bus: SPIBus, register_address: int, register_value: int, sensor_interface_detail: int = None) -> ErrorCodes
```

For the definition of parameters, refer to 15.2.3.11{reference-type="ref" reference="CoinesWriteSpi"}.

read_spi

Reads 8-bit register data from the SPI device.

```
register_data = coinesboard.read_spi(bus: SPIBus, register_address: int, number_of_reads=1, sensor_interface_detail: int = None)
```

For the definition of parameters, refer to 15.2.3.12{reference-type="ref" reference="CoinesReadSpi"}.

delay_milli_sec

Introduces delay in millisecond.

```
coinesboard.delay_milli_sec(time_in_milli_sec=100)
```

delay_micro_sec

Introduces delay in microsecond.

```
coinesboard.delay_micro_sec(time_in_micro_sec=1)
```

15.3.4 coinespy API calls: Streaming feature

config_streaming

Sets the configuration for streaming sensor data.

```
coinesboard.config_streaming(sensor_id: int,
    stream_config: StreamingConfig, data_blocks: StreamingBlocks) -> ErrorCodes
```

Arguments:

- `sensor_id` : An integer number that can be used as identifier/index to the sensor data that will be streamed for this setting
- `stream_config` : Contains information regarding interface settings and streaming configuration.
- `data_blocks` : Contains information regarding numbers of blocks to read, register address and size for each block.

Note: The below parameters should always be set:

- `data_blocks.NoOfBlocks` : number of blocks to stream (must at least be one)
- For each block b:

- `data_blocks.RegStartAddr[b]` : start address of the block in the register map
- `data_blocks.NoOfDataBytes[b]` : number of bytes to read, starting from the start address

For reading data from I^2C bus,then set the below parameters:

- `stream_config.Intf = cpy.SensorInterface.I2C.value`
- `stream_config.I2CBus` : I^2C bus (in case of APP2.0 and APP3.x, this is always\ `cpy.I2CBus.BUS_I2C_0.value`)
- `stream_config.DevAddr` : I^2C address of the sensor

For reading data from SPI bus, then set the below parameters:

- `stream_config.Intf = cpy.SensorInterface.SPI.value;`
- `stream_config.SPIBus` : SPI bus (in case of APP2.0 and APP3.x, this is always\ `cpy.SPIBus.BUS_SPI_0.value`)
- `stream_config.CSPin` : CS pin of the sensor, information can be obtained from the shuttle board documentation for the sensor.
- `stream_config.SPIType` : 0 : 8-bit SPI; 1 : 16-bit SPI

When polling mode is requested, set the below parameters:

- `stream_config.SamplingUnits` : either milliseconds or microseconds. Refer to 15.3.6.15{reference-type="ref" reference="SamplingUnits"}.
- `stream_config.SamplingTime` : sampling period in the unit as defined in\ `stream_config.SamplingUnits`

When interrupt mode is requested, set the below parameters:

- `stream_config.IntPin` : pin of the interrupt which shall trigger the sensor read-out. If the interrupt output of the sensor is used, the required information about the pin number can be obtained from the shuttle board documentation for the sensor.
- `stream_config.IntTimeStamp` : it can be configured if the sensor data is tagged with a timestamp - 1 or not - 0.
- `stream_config.HwPinState` : State of the hardware pin connected to the interrupt line - 0/1 : Low/high

Below parameters are common for both streaming types:

- `stream_config.IntlineCount` : Number of interrupt lines to be used for monitoring interrupts.
- `stream_config.IntlineInfo` : List of pin numbers that correspond to interrupt lines being used for interrupt monitoring.
- `stream_config.ClearOnWrite` : 0/1 : Disable/enable \"clear on write\" feature

The below parameters should be set only when stream_config.ClearOnWrite = 1:

- `stream_config.ClearOnWriteConfig.StartAddress` : Address of the sensor register at which the process of clearOnWrite should initiate.
- `stream_config.ClearOnWriteConfig.DummyByte` : Number of padding bytes that must be added before clearing the bytes starting from the designated address.
- `stream_config.ClearOnWriteConfig.NumBytesToClear` : Number of bytes that need to be cleared.

Below is the Python code snippet for interrupt streaming

```
# Store streaming settings in local variables
accel_stream_settings = dict(
    I2C_ADDR_PRIMARY=0x18,
    NO_OF_BLOCKS = 2,
    REG_X_LSB= [0x12, 0x00],
    NO_OF_DATA_BYTES= [6, 1],
    CHANNEL_ID=1,
    CS_PIN=cpy.MultiIOPin.SHUTTLE_PIN_8.value,
    INT_PIN=cpy.MultiIOPin.SHUTTLE_PIN_21.value,
    INT_TIME_STAMP=1,
)
gyro_stream_settings = dict(
    I2C_ADDR_PRIMARY=0x68,
    NO_OF_BLOCKS = 2,
    REG_X_LSB= [0x02,0x00],
    NO_OF_DATA_BYTES = [6, 1],
    CHANNEL_ID=2,
    CS_PIN=cpy.MultiIOPin.SHUTTLE_PIN_14.value,
    INT_PIN=cpy.MultiIOPin.SHUTTLE_PIN_22.value,
    INT_TIME_STAMP=1,
)


# set the config_streaming parameters
stream_config = cpy.StreamingConfig()
data_blocks = cpy.StreamingBlocks()
if self.interface == cpy.SensorInterface.I2C:
    stream_config.Intf = cpy.SensorInterface.I2C.value
    stream_config.I2CBus = cpy.I2CBus.BUS_I2C_0.value
    stream_config.DevAddr = sensor["I2C_ADDR_PRIMARY"]

elif self.interface == cpy.SensorInterface.SPI:
    stream_config.Intf = cpy.SensorInterface.SPI.value
    stream_config.SPIBus = cpy.SPIBus.BUS_SPI_0.value
    stream_config.CSPin = sensor["CS_PIN"]

if sensor_type == bmi08x.SensorType.ACCEL and self.interface == cpy.SensorInterface.SPI:
    # extra dummy byte for SPI
    dummy_byte_offset = 1
else:
    dummy_byte_offset = 0

data_blocks.NoOfBlocks = sensor["NO_OF_BLOCKS"]
for i in range(0, data_blocks.NoOfBlocks):
    data_blocks.RegStartAddr[i] = sensor["REG_X_LSB"][i]
    data_blocks.NoOfDataBytes[i] = sensor["NO_OF_DATA_BYTES"][i] + dummy_byte_offset

stream_config.IntTimeStamp = sensor["INT_TIME_STAMP"]
stream_config.IntPin = sensor["INT_PIN"]

# call config_streaming API for each sensor to configure the streaming settings
ret = coinesboard.config_streaming(
    accel_sensor_id, self.accel_stream_config, self.accel_data_blocks)
ret = coinesboard.config_streaming(
    gyro_sensor_id, self.accel_stream_config, self.accel_data_blocks)
```

start_stop_streaming

Starts or stops sensor data streaming.

```
coinesboard.start_stop_streaming(stream_mode: StreamingMode, start_stop: StreamingState) -> ErrorCodes
```

For the definition of `StreamingMode`, refer to 15.3.6.13{reference-type="ref" reference="StreamingMode"}. For the definition of `StreamingState`, refer to 15.3.6.14{reference-type="ref" reference="StreamingState"}.

read_stream_sensor_data

Reads the data streamed from the sensor.

```
coinesboard.read_stream_sensor_data(sensor_id: int, number_of_samples: int,
    buffer_size=STREAM_RSP_BUF_SIZE) -> Tuple[ErrorCodes, list, int]
```

Return:\ Tuple of ErrorCodes, data and valid_samples_count For the detailed definition of parameters, refer to 15.2.4.3{reference-type="ref" reference="coinesReadStreamSensorData"}.

15.3.5 coinespy API calls: Other useful APIs

flush_interface

Flush the write buffer.

```
coinesboard.flush_interface()
```

soft_reset

Resets the device.

```
coinesboard.soft_reset()
```

15.3.6 Definition of constants

PinDirection

Pin mode definitions

```
class PinDirection:
    INPUT = 0  # COINES_PIN_DIRECTION_IN = 0
    OUTPUT = 1
```

PinValue

Pin level definitions

```
class PinValue:
    LOW = 0  # COINES_PIN_VALUE_LOW = 0
    HIGH = 1
```

CommInterface

Definition of Communication interface

```
class CommInterface:
    USB = 0
    SERIAL = 1
    BLE = 2
```

I2CMode

Definition of the speed of I2C bus.

```
class I2CMode:
    STANDARD_MODE = 0 # Standard mode - 100kHz
    FAST_MODE = 1 # Fast mode - 400kHz
    SPEED_3_4_MHZ = 2 # High Speed mode - 3.4 MHz
    SPEED_1_7_MHZ = 3 # High Speed mode 2 - 1.7 MHz
```

SPISpeed

Definition of the speed of SPI bus.

```
class SPISpeed:
    SPI_10_MHZ = 6
    SPI_7_5_MHZ = 8
    SPI_6_MHZ = 10
    SPI_5_MHZ = 12
    SPI_3_75_MHZ = 16
    SPI_3_MHZ = 20
    SPI_2_5_MHZ = 24
    SPI_2_MHZ = 30
    SPI_1_5_MHZ = 40
    SPI_1_25_MHZ = 48
    SPI_1_2_MHZ = 50
```

```
    SPI_1_MHZ = 60
    SPI_750_KHZ = 80
    SPI_600_KHZ = 100
    SPI_500_KHZ = 120
    SPI_400_KHZ = 150
    SPI_300_KHZ = 200
    SPI_250_KHZ = 240
```

SPITransferBits

Definition of the SPI bits.

```
class SPITransferBits:
    SPI8BIT = 8 # 8 bit register read/write
    SPI16BIT = 16 # 16 bit register read/write
```

SPIMode

Definition of the SPI mode.

```
class SPIMode:
    MODE0 = 0x00 # SPI Mode 0: CPOL=0; CPHA=0
    MODE1 = 0x01 # SPI Mode 1: CPOL=0; CPHA=1
    MODE2 = 0x02 # SPI Mode 2: CPOL=1; CPHA=0
    MODE3 = 0x03 # SPI Mode 3: CPOL=1; CPHA=1
```

MultiIOPin

Definition of the shuttle board pin(s)

```
class MultiIOPin(Enum):
    SHUTTLE_PIN_7 = 0x09 # CS pin
    SHUTTLE_PIN_8 = 0x05 # Multi-IO 5
    SHUTTLE_PIN_9 = 0x00 # Multi-IO 0
    SHUTTLE_PIN_14 = 0x01 # Multi-IO 1
    SHUTTLE_PIN_15 = 0x02 # Multi-IO 2
    SHUTTLE_PIN_16 = 0x03 # Multi-IO 3
    SHUTTLE_PIN_19 = 0x08 # Multi-IO 8
    SHUTTLE_PIN_20 = 0x06 # Multi-IO 6
    SHUTTLE_PIN_21 = 0x07 # Multi-IO 7
    SHUTTLE_PIN_22 = 0x04 # Multi-IO 4
    SHUTTLE_PIN_SDO = 0x1F

    # APP3.x pins
    MINI_SHUTTLE_PIN_1_4 = 0x10  # GPIO0
    MINI_SHUTTLE_PIN_1_5 = 0x11  # GPIO1
    MINI_SHUTTLE_PIN_1_6 = 0x12  # GPIO2/INT1
    MINI_SHUTTLE_PIN_1_7 = 0x13  # GPIO3/INT2
    MINI_SHUTTLE_PIN_2_5 = 0x14  # GPIO4
    MINI_SHUTTLE_PIN_2_6 = 0x15  # GPIO5
    MINI_SHUTTLE_PIN_2_1 = 0x16  # CS
    MINI_SHUTTLE_PIN_2_3 = 0x17  # SDO
    MINI_SHUTTLE_PIN_2_7 = 0x1D  # GPIO6
    MINI_SHUTTLE_PIN_2_8 = 0x1E  # GPIO7
```

SensorInterface

To define Sensor interface.

```
class SensorInterface(Enum):
    SPI = 0
    I2C = 1
```

I2CBus

Used to define the I2C type.

```
    class I2CBus(Enum):
    BUS_I2C_0 = 0
    BUS_I2C_1 = 1
    BUS_I2C_MAX = 2
```

SPIBus

Used to define the SPI type.

```
    class SPIBus(Enum):
    BUS_SPI_0 = 0
    BUS_SPI_1 = 1
    BUS_SPI_MAX = 2
```

PinInterruptMode

Defines Pin interrupt modes.

```
class PinInterruptMode(Enum):
    # Trigger interrupt on pin state change
    PIN_INTERRUPT_CHANGE = 0
    # Trigger interrupt when pin changes from low to high
    PIN_INTERRUPT_RISING_EDGE = 1
    # Trigger interrupt when pin changes from high to low
    PIN_INTERRUPT_FALLING_EDGE = 2
    PIN_INTERRUPT_MODE_MAXIMUM = 4
```

StreamingMode

Streaming mode definitions

```
class StreamingMode:
    STREAMING_MODE_POLLING = 0    # Polling mode streaming
    STREAMING_MODE_INTERRUPT = 1  # Interrupt mode streaming
```

StreamingState

Streaming state definitions

```
class StreamingState:
    STREAMING_START = 1
    STREAMING_STOP = 0
```

SamplingUnits

Sampling Unit definitions

```
class SamplingUnits:
    SAMPLING_TIME_IN_MICRO_SEC = 0x01  # sampling unit in micro second
    SAMPLING_TIME_IN_MILLI_SEC = 0x02  # sampling unit in milli second
```

15.4 Error Codes

Error codes are not (always) returned by the different function calls. Internally, a `error_code` variable is maintained which is updated after the function call. It can be read out and checked by the user afterwards.

C Example

```
#include <stdio.h>
#include <stdlib.h>

#include "coines.h"

int main(void)
{
    int16_t error_code = coines_open_comm_intf(COINES_COMM_INTF_USB, NULL);
    if (error_code != COINES_SUCCESS)
    {
        const char *err_str = get_coines_error_str(error_code);
        printf("\n%s", err_str);
        exit(error_code);
    }

    coines_close_comm_intf(COINES_COMM_INTF_USB, NULL);
```

```
    return 0;
}
```

Python Example

```
import coinespy as cpy
board = cpy.CoinesBoard()
try:
    board.open_comm_interface(cpy.CommInterface.USB)
    board.close_comm_interface()
except:
    print(f'Could not connect to board: {board.error_code}')
    exit(board.error_code)
```

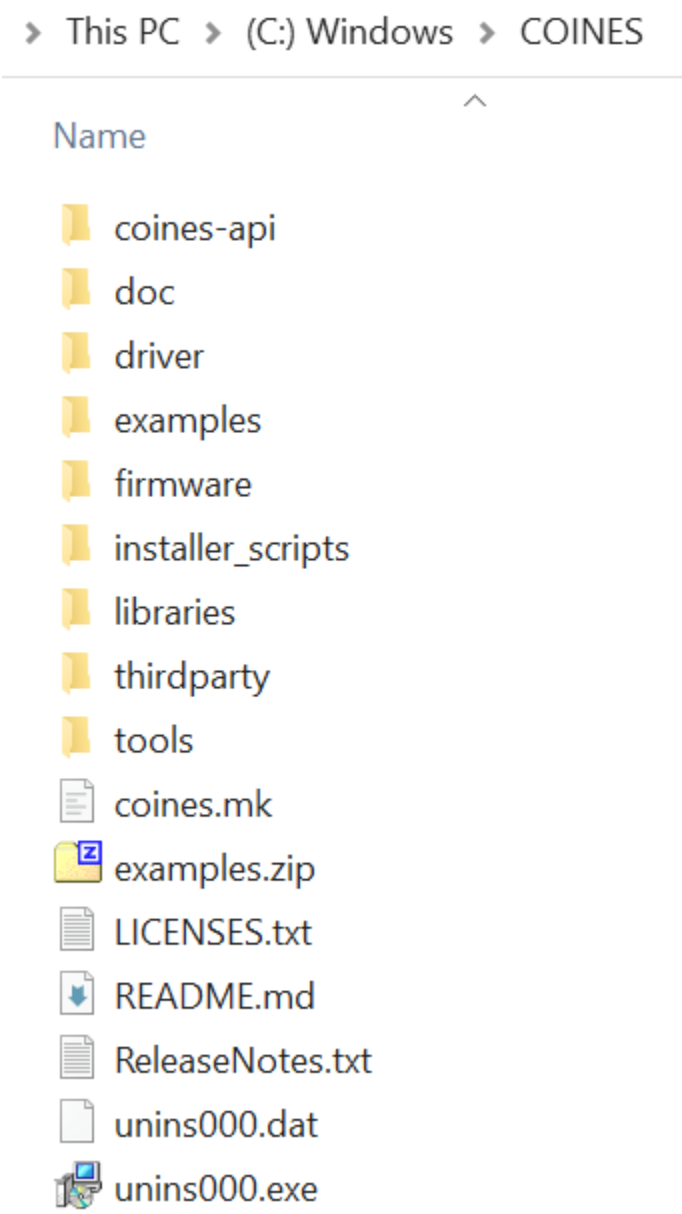
Error code definitions

```
    COINES_SUCCESS = 0
    COINES_E_FAILURE = -1
    COINES_E_COMM_IO_ERROR = -2
    COINES_E_COMM_INIT_FAILED = -3
    COINES_E_UNABLE_OPEN_DEVICE = -4
    COINES_E_DEVICE_NOT_FOUND = -5
    COINES_E_UNABLE_CLAIM_INTERFACE = -6
    COINES_E_MEMORY_ALLOCATION = -7
    COINES_E_NOT_SUPPORTED = -8
    COINES_E_NULL_PTR = -9
    COINES_E_COMM_WRONG_RESPONSE = -10
    COINES_E_SPI16BIT_NOT_CONFIGURED = -11
    COINES_E_SPI_INVALID_BUS_INTERFACE = -12
    COINES_E_SPI_CONFIG_EXIST = -13
    COINES_E_SPI_BUS_NOT_ENABLED = -14
    COINES_E_SPI_CONFIG_FAILED = -15
    COINES_E_I2C_INVALID_BUS_INTERFACE = -16
    COINES_E_I2C_BUS_NOT_ENABLED = -17
    COINES_E_I2C_CONFIG_FAILED = -18
    COINES_E_I2C_CONFIG_EXIST = -19
    COINES_E_TIMER_INIT_FAILED = -20
    COINES_E_TIMER_INVALID_INSTANCE = -21
    COINES_E_TIMER_CC_CHANNEL_NOT_AVAILABLE = -22
    COINES_E_EEPROM_RESET_FAILED = -23
    COINES_E_EEPROM_READ_FAILED = -24
    COINES_E_INIT_FAILED = -25
    COINES_E_STREAM_NOT_CONFIGURED = -26
    COINES_E_STREAM_INVALID_BLOCK_SIZE = -27
    COINES_E_STREAM_SENSOR_ALREADY_CONFIGURED = -28
    COINES_E_STREAM_CONFIG_MEMORY_FULL = -29
    COINES_E_INVALID_PAYLOAD_LEN = -30
    COINES_E_CHANNEL_ALLOCATION_FAILED = -31
    COINES_E_CHANNEL_DE_ALLOCATION_FAILED = -32
    COINES_E_CHANNEL_ASSIGN_FAILED = -33
    COINES_E_CHANNEL_ENABLE_FAILED = -34
    COINES_E_CHANNEL_DISABLE_FAILED = -35
    COINES_E_INVALID_PIN_NUMBER = -36
    COINES_E_MAX_SENSOR_COUNT_REACHED = -37
    COINES_E_EEPROM_WRITE_FAILED = -38
    COINES_E_INVALID_EEPROM_RW_LENGTH = -39
    COINES_E_INVALID_SCOM_CONFIG = -40
    COINES_E_INVALID_BLE_CONFIG = -41
    COINES_E_SCOM_PORT_IN_USE = -42
    COINES_E_UART_INIT_FAILED = -43
    COINES_E_UART_WRITE_FAILED = -44
    COINES_E_UART_INSTANCE_NOT_SUPPORT = -45
    COINES_E_BLE_ADAPTOR_NOT_FOUND = -46
    COINES_E_ADAPTER_BLUETOOTH_NOT_ENABLED = -47
    COINES_E_BLE_PERIPHERAL_NOT_FOUND = -48
    COINES_E_BLE_LIBRARY_NOT_LOADED = -49
    COINES_E_APP_BOARD_BLE_NOT_FOUND = -50
    COINES_E_BLE_COMM_FAILED = -51
    COINES_E_INCOMPATIBLE_FIRMWARE = -52
    COINES_E_UNDEFINED_CODE = -100
```

15.5 COINES SDK structure

- coines-api - Contains source code for low-level interface to Bosch Sensortec's Engineering boards
- doc - Contains COINES SDK user manual
- driver - Contains USB driver for Application boards
- examples - Contains C and python examples
- installer_scripts - Contains Windows batch files that are used internally for install and uninstall functionalities
- libraries and thirdparty - Contains libraries and SDKs used for communication APIs

• tools - Contains tools for Application switch, Firmware update and BLE connect



COINES SDK file structure