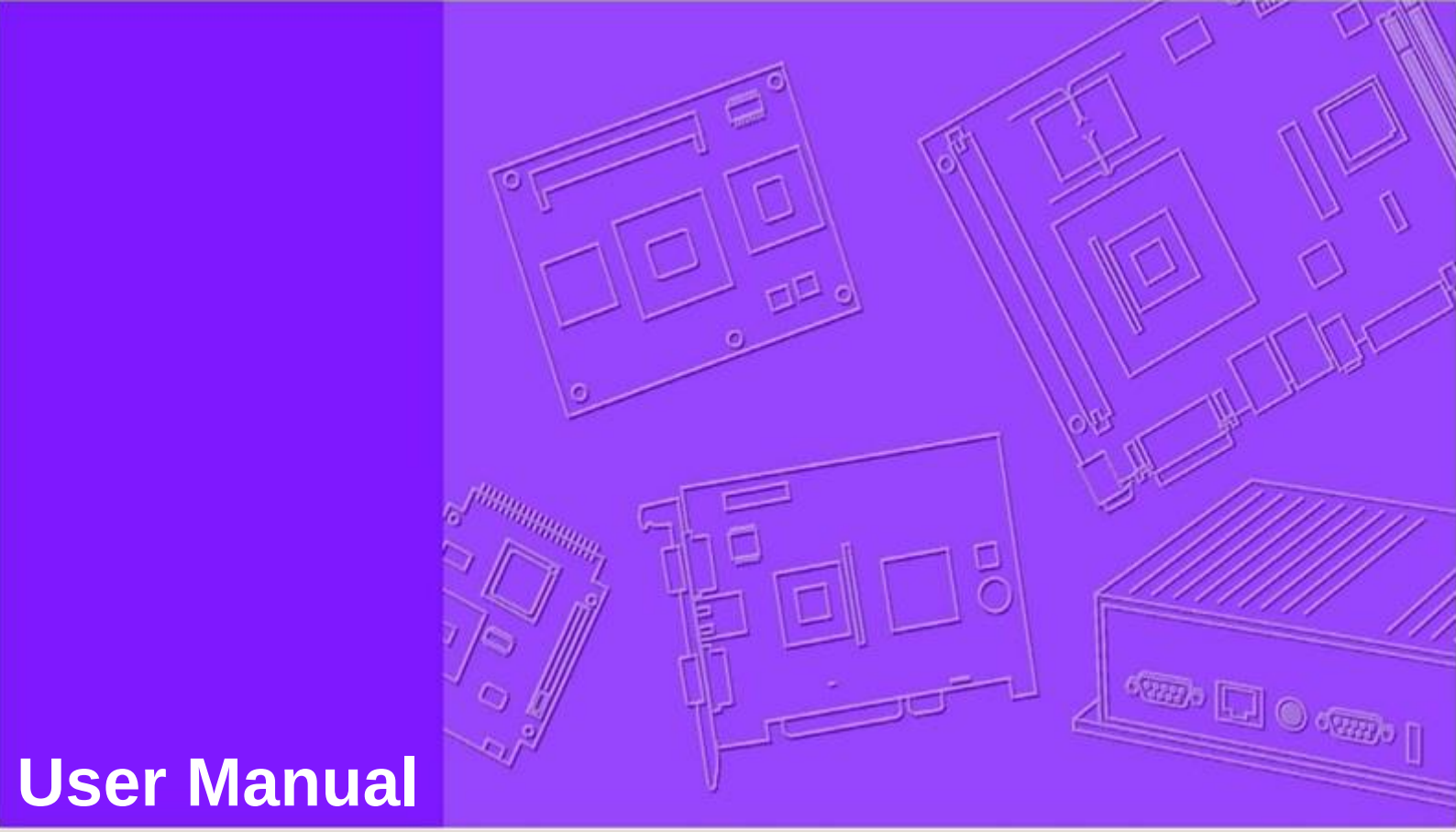

User Manual

WISE-1510

M2.COM LoRa IoT Node

ADVANTECH

Enabling an Intelligent Planet

Copyright

Acknowledgements

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All other product names or trademarks are properties of their respective owners.

Product Warranty (2 years)

Advantech warrants to you, the original purchaser, that each of its products will be free from defects in materials and workmanship for two years from the date of purchase. This warranty does not apply to any products which have been repaired or altered by persons other than repair personnel authorized by Advantech, or which have been subject to misuse, abuse, accident or improper installation. Advantech assumes no liability under the terms of this warranty as a consequence of such events.
Because of Advantech's high quality-control standards and rigorous testing, most of our customers never need to use our repair service. If an Advantech product is defective, it will be repaired or replaced at no charge during the warranty period. For out-of-warranty repairs, you will be billed according to the cost of replacement materials, service time and freight. Please consult your dealer for more details.
If you think you have a defective product, follow these steps:

1. Collect all the information about the problem encountered. (For example, CPU speed, Advantech products used, other hardware and software used, etc.) Note anything abnormal and list any onscreen messages you get when the problem occurs.
2. Call your dealer and describe the problem. Please have your manual, product, and any helpful information readily available.
3. If your product is diagnosed as defective, obtain an RMA (return merchandize authorization) number from your dealer. This allows us to process your return more quickly.
4. Carefully pack the defective product, a fully-completed Repair and Replacement Order Card and a photocopy proof of purchase date (such as your sales receipt) in a

shippable container. A product returned without proof of the purchase date is not eligible for warranty service.

5. Write the RMA number visibly on the outside of the package and ship it prepaid to your dealer.

Declaration of Conformity

FCC Class B

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation.
This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

FCC Caution: Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipmt.t.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

IMPORTANT NOTE:

FCC Radiation Exposure Statement:

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20cm between the radiator & your body.

This module is intended for OEM integrator. The OEM integrator is responsible for the compliance to all the rules that apply to the product into which this certified RF module is integrated. Additional testing and certification may be necessary when multiple modules are used.

USERS MANUAL OF THE END PRODUCT:

In the users manual of the end product, the end user has to be informed to keep at least 20cm separation with the antenna while this end product is installed and operated. The end user has to be informed that the FCC radio-frequency exposure guidelines for an uncontrolled environment can be satisfied.

The end user has to also be informed that any changes or modifications not expressly approved by the manufacturer could void the user's authority to operate this equipment.

If the labelling area is small than the palm of the hand, then additional FCC part 15.19 statement is required to be available in the users manual: This device complies with Part 15 of FCC rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference and (2) this device must accept any interference received, including interference that may cause undesired operation.

LABEL OF THE END PRODUCT:

The final end product must be labeled in a visible area with the following " Contains TX FCC ID: M82-WISE1510 ".

If the labelling area is larger than the palm of the hand, then the following FCC part 15.19 statement has to also be available on the label: This device complies with Part 15 of FCC rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference and (2) this device must accept any interference received, including interference that may cause undesired operation.

IC

This radio transmitter has been approved by Industry Canada to operate with the antenna types listed below with the maximum permissible gain indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés ci-dessous et ayant un gain admissible maximal d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de

brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

This radio transmitter (9404A-WISE1510) has been approved by Industry Canada to operate with the antenna types listed below with the maximum permissible gain indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

*Le présent émetteur radio (*9404A-WISE1510*) a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés ci-dessous et ayant un gain admissible maximal d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.*

Antenna list:

Part No.	MPN	Description
1750008625-01	TH-915i	Dipole Ant. SUB-1G 1.8dBi SMA/M BLK 902-928 IPX6

IMPORTANT NOTE:

IC Radiation Exposure Statement:

This equipment complies with IC RSS-102 radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20cm between the radiator & your body.

Cet équipement est conforme aux limites d'exposition aux rayonnements IC établies pour un environnement non contrôlé. Cet équipement doit être installé et utilisé avec un minimum de 20 cm de distance entre la source de rayonnement et votre corps.

This module is intended for OEM integrator. The OEM integrator is responsible for the compliance to all the rules that apply to the product into which this certified RF module is integrated. Additional testing and certification may be necessary when multiple modules are used.

Any changes or modifications not expressly approved by the manufacturer could void the user's authority to operate this equipment.

USERS MANUAL OF THE END PRODUCT:

In the users manual of the end product, the end user has to be informed to keep at least 20cm separation with the antenna while this end product is installed and operated. The end user has to be informed that the IC radio-frequency exposure guidelines for an uncontrolled environment can be satisfied.

The end user has to also be informed that any changes or modifications not expressly approved by

the manufacturer could void the user's authority to operate this equipment. Operation is subject to the following two conditions: (1) this device may not cause harmful interference and (2) this device must accept any interference received, including interference that may cause undesired operation.

LABEL OF THE END PRODUCT:

The final end product must be labeled in a visible area with the following " Contains IC: 9404A-WISE1510 ".

The Host Model Number (HMN) must be indicated at any location on the exterior of the end product or product packaging or product literature which shall be available with the end product or online.

Packing List

Before setting up the system, check that the items listed below are included and in good condition. If any item does not accord with the table, please contact your dealer immediately.

- 1 WISE-1510
- 1 Screw for WISE-1510
- 1 China RoHs Notice

Optional Accessories

Part No.	Description
1750008598-01	Sub G antenna Dipole L=195mm, 1dBi 902~928 MHz
1750008599-01	Sub G antenna Dipole L=195mm, 1dBi 863~870 MHz
1750008569-01	Antenna Cable SMA to MHF4 L=300mm
1700015038	FPC Cable 10P-0.5mm 7.9cm for DCU2.0
9696WED200E	ASS'Y WISE-ED20 A101-1 M2.COM Daughter
1931000590	Screw M2.5x5L F/S D=5.3 H=0.8 (1+) ST Ni
1700023619-01	A cable USB-A 4P(M)/micro USB 5P(M) 1m ADAM-T212
1700025876-01	M cable USB-A 4P(M)/Plug-in 2P-5.0 90CM
XRISC-ADP-10HW-AG	ADP A/D 100-240V 10W 5V WM
193A231540	POST F=M3*6L M=M3*6L D=5 d=2.88 B=5 H=15 Cu

Development Board

Part No.	Description
9696150000E	ASS'Y WISE-DB1500 A101-1 M2.COM CARRIER

Ordering Information

Part No.	WISE-1510WMB-SDA1N
Frequency Band	902-928MHz for North America (LoRaWAN)
Part No.	**WISE-1510WMB-SDA1E**
Frequency Band	863-870MHz for Europe (LoRaWAN)

Safety Instructions

1. Read these safety instructions carefully.
2. Keep this User Manual for later reference.
3. Disconnect this equipment from any AC outlet before cleaning. Use a damp cloth. Do not use liquid or spray detergents for cleaning.
4. For plug-in equipment, the power outlet socket must be located near the equipment and must be easily accessible.
5. Keep this equipment away from humidity.
6. Put this equipment on a reliable surface during installation. Dropping it or letting it fall may cause damage.
7. The openings on the enclosure are for air convection. Protect the equipment from overheating. DO NOT COVER THE OPENINGS.
8. Make sure the voltage of the power source is correct before connecting the equipment to the power outlet.
9. Position the power cord so that people cannot step on it. Do not place anything over the power cord.
10. All cautions and warnings on the equipment should be noted.
11. If the equipment is not used for a long time, disconnect it from the power source to avoid damage by transient overvoltage.
12. Never pour any liquid into an opening. This may cause fire or electrical shock.
13. Never open the equipment. For safety reasons, the equipment should be opened only by qualified service personnel.
14. If one of the following situations arises, get the equipment checked by service personnel:
    - The power cord or plug is damaged.
    - Liquid has penetrated into the equipment.
    - The equipment has been exposed to moisture.
    - The equipment does not work well, or you cannot get it to work according to the user's manual.
    - The equipment has been dropped and damaged.
    - The equipment has obvious signs of breakage.

DISCLAIMER: This set of instructions is given according to IEC 704-1. Advantech disclaims all responsibility for the accuracy of any statements contained herein.

Change Log:

Date	Version	Description / Major change
2017/01/05	V0.1	Draft version
2017/02/03	V0.2	Modify chapter 3.2 & 3.3 and add Figure. 10
2017/02/13	V0.3	Update optional accessory with Sub G antenna Chapter 5 is added for the instruction to enable LoRaWAN
2017/03/14	V0.4	Modify chapter 3.5~3.7 and 4.
2017/04/10	V0.5	Add chapter 3.5 Memory Layout and update 3.6~3.7
2017/04/12	V0.6	Remove Chapter 1.3, update page 2~3 Declaration of Conformity, Chapter 3.6 and add appendix I and II
2017/04/19	V0.7	Update page 2~5 Declaration of Conformity

Table of Content

1. Product Overview

1.1. Introduction

WISE-1510 is a wireless module integrated with ARM Cortex-M4 Processor and LoRa / LoRaWAN connectivity. This technology is the best solution for Low-Power Wide-Area Network (LPWAN) Applications. LoRaWAN is defined to optimize the power consumption and wide range. Your sensors or applications with low data rate requirement can be achieved years battery lifetime and kilometers long distance connection. Advantech WISE-1510 also provides multi-interfaces for sensor and I/O control. With ARM mbed embedded microprocessor operating system and add-on software stacks, it's convenient to build the application software or sensor algorithm over mbed OS. Data can be quickly and easily acquired and transformed into a different format to communicate with WISE-PaaS or other cloud services. Developer can build their application backbone faster and focus on their applications, value-added services.

The main features of WISE-1510 are:

- ARM Cortex-M4 Core Processor
- Built-in LoRa / LoRaWAN connectivity
- Great for Low Power Wide Range application
- Rich interfaces for sensor and I/O control
- Support mbed OS 5.2
- Support wide temperature -40 ~ 85 °C

1.2. Specifications

Processor System	MCU	ARM Cortex-M4 Core Processor 80MHz STM – STM32L443RC
Memory	RAM	64KB
	Flash	256KB
Form Factor		M2.COM Type A 2230
Spec. Standard		M2 COM Technical SPEC_v1.1
Wireless Network	Standard	LoRa Proprietary (Harmony Link) / LoRaWAN
	Frequency Band	863-870MHz for Europe (LoRaWAN) 902-928MHz* for North America (LoRaWAN)
	Channels	Spreading Factor: 7 ~ 12
	Topology	Star network
	Transmit Power	Up to +18dBm
	Receiver Sensitivity	Up to -136dBm at SF = 12 / 125KHz
	RF Data Rate	50 kbps at FSK mode EU868 (Based on LoRaWAN spec 1R0 version) 21.9 kbps at SF7 mode US915 (Based on LoRaWAN spec 1R0 version)
	Function	End node
	Antenna connector	MHF4 connector
I/O	UART	1 (4-wire, support RTC/CTS)
	I2C	1
	GPIO	8
	PWM	1
	SPI	1
	ADC	4
	USB	1 (device only)
Programming / Debug Port		1 via WISE-ED20 (CN1)
Power		3.3V
Environment	Operational Temperature	-40 ~ 85° C
	Operating Humidity	5% ~ 95% Relative Humidity, non-condensing

Physical Characteristics	Dimensions (WxD)	22 x 30 mm
OS		mbed 5.2

* Note: Frequency Band can be configurable for Japan or Korea by request.

2. H/W Installation

2.1. Board Connector

- M2.COM Type A Module
  - Module size: 22 mm x 30 mm
  - PCB thickness: 0.8 mm ± 10%
  - Pin count: 75 pins
  - Module input voltage: 3.3V DC-in
  - Connector mating force: 30N Maximum
  - Connector current rating: 0.5A / Power contact
  - Connector operation temperature range: -45 °C to +85 °C

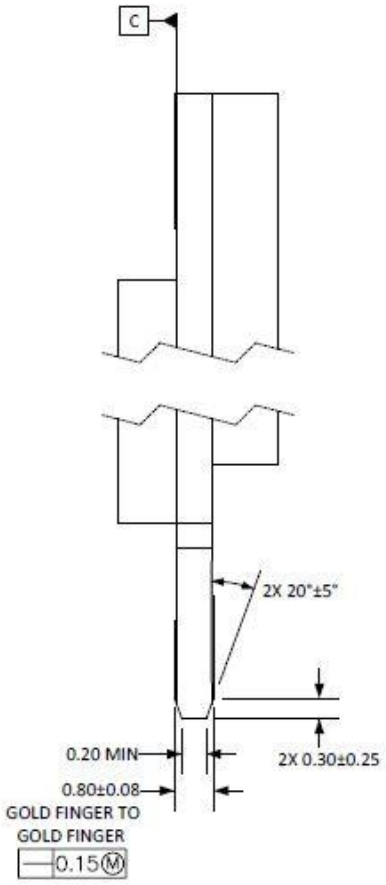


Figure 1 Card Edge Bevel

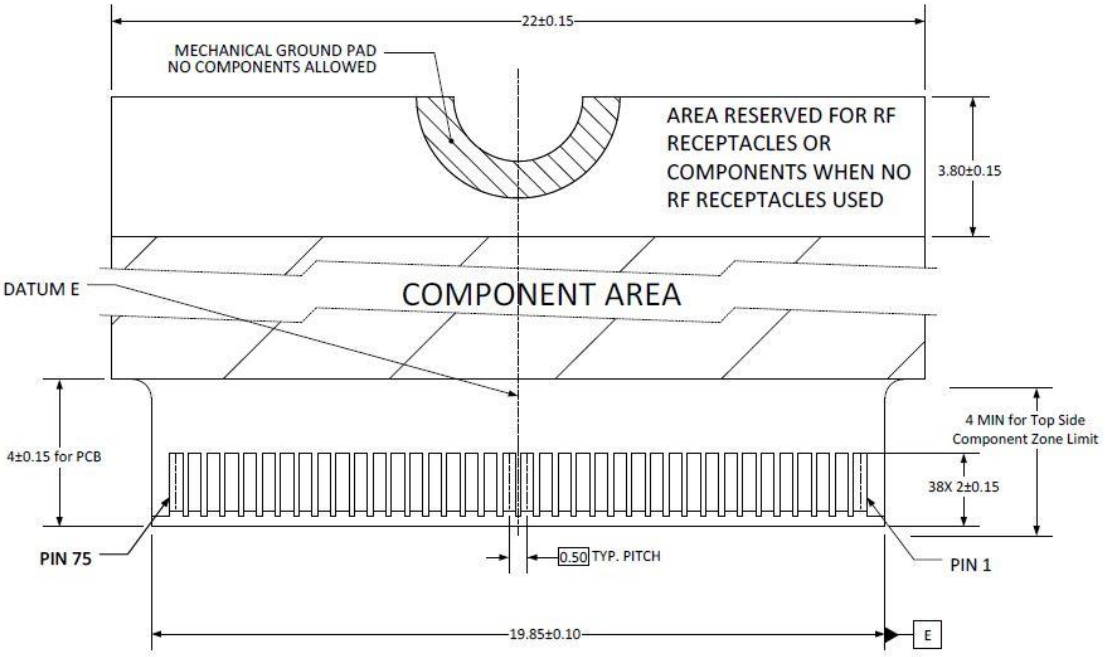


Figure 2 Card Edge Outline-Topside

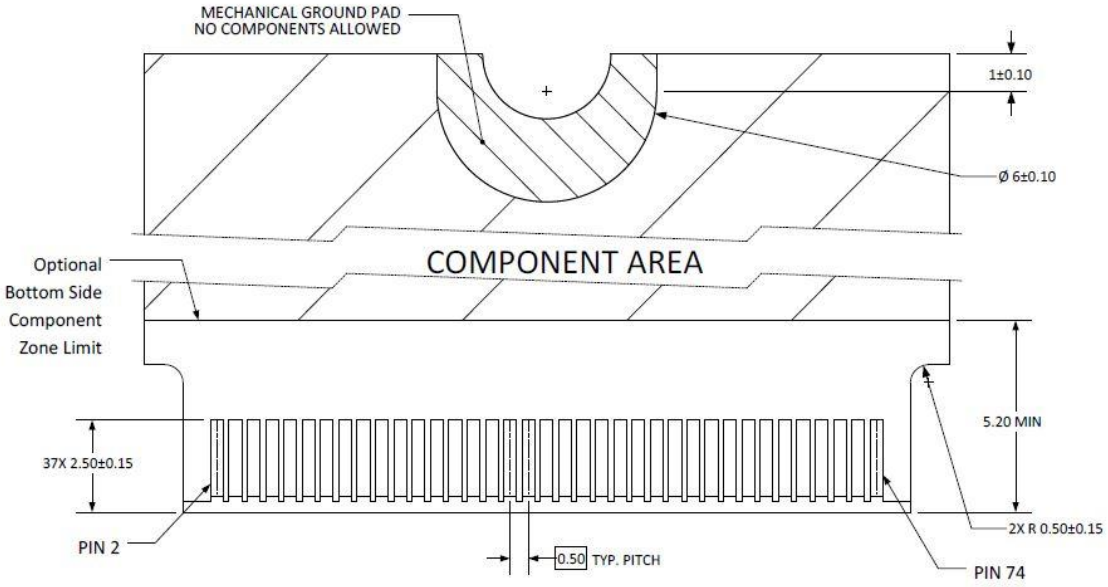


Figure 3 Card Edge Outline-Backside

Reference from PCI Express M.2 Specification Rev 1.0 (Nov 1, 2013) Section 2.3.5 Card PCB Details

2.2. Module Outline

The mechanical dimension information of M2.COM form factor follows the Type A 2230 module size: 22 x 30 mm. Both module types use a 75-position host interface connector and have room to support up to four RF connectors in the upper section.

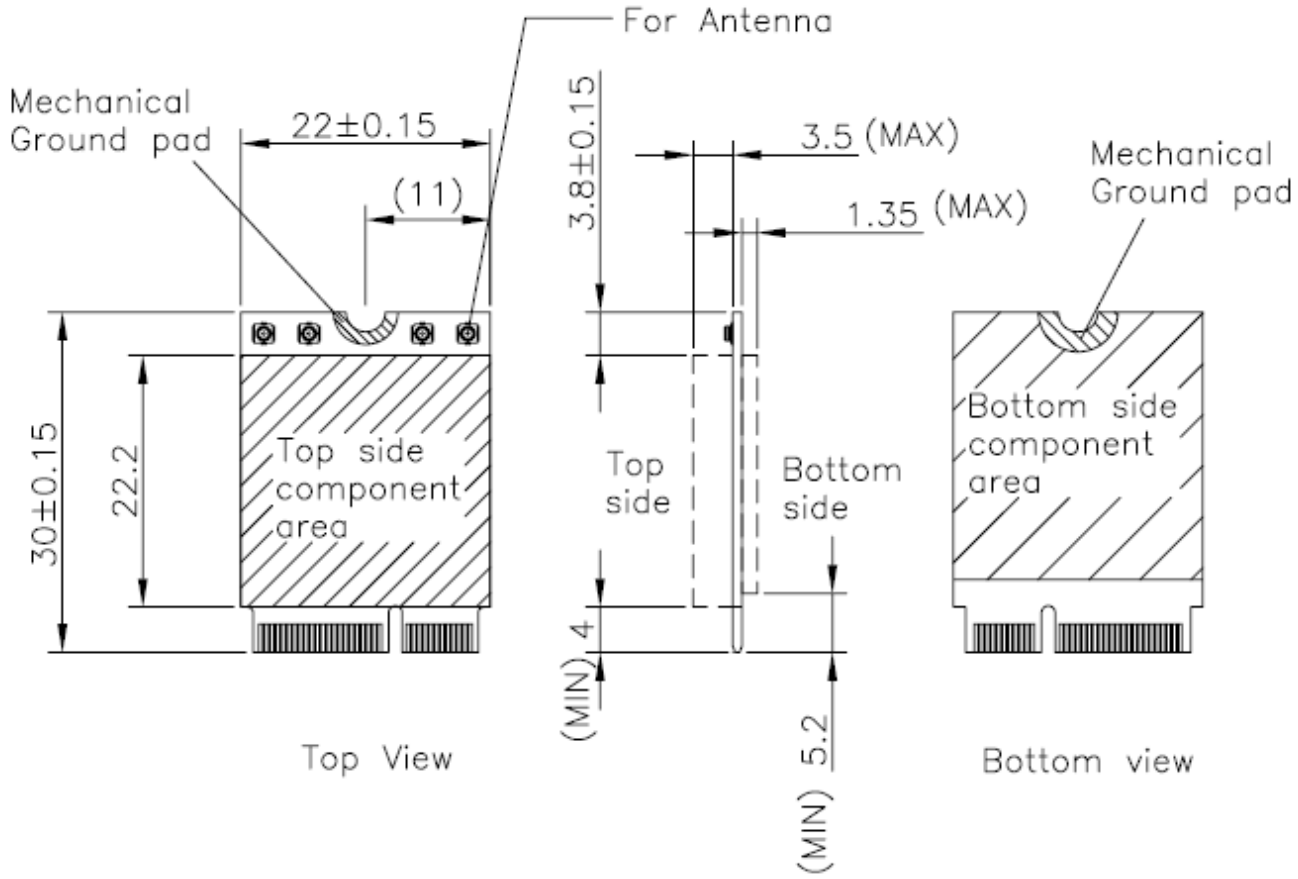


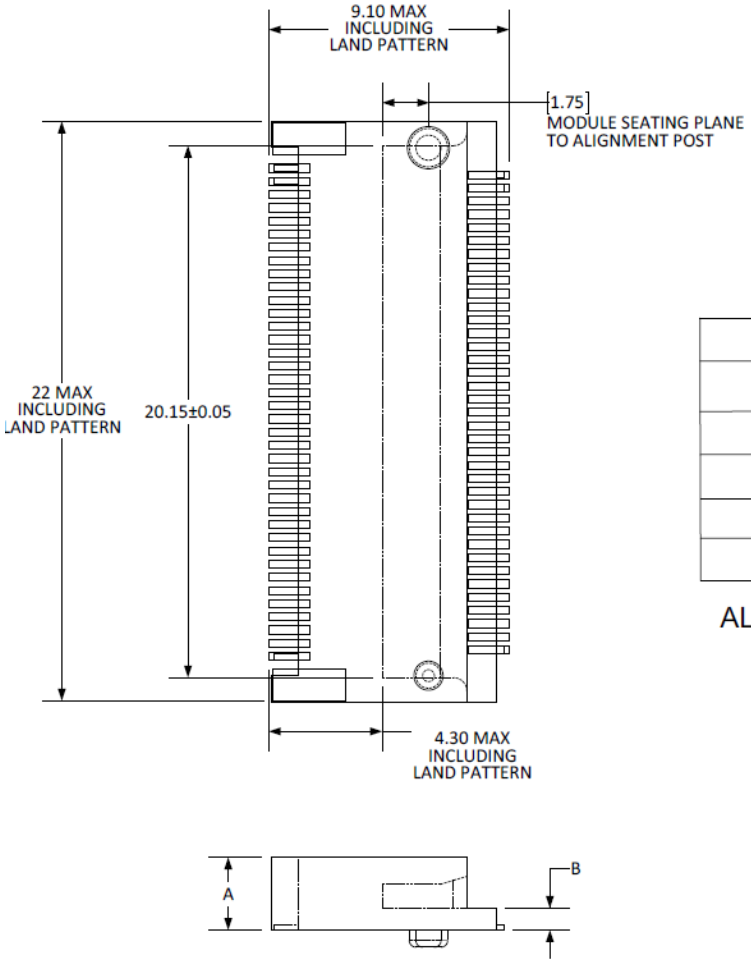
Figure 4 Type A 2230

2.3. Connector Specifications

2.3.1. Top Side Connector Physical Dimensions

The top-side scheme has two connectors that share a common footprint but have different stack-up requirements.

- Length – 22 mm maximum including land pattern
- Width – 9.1 mm maximum including land pattern



Height	A (MAX)	B (MAX)
H2.3	2.25	0.41
H2.5	2.45	0.61
H2.8	2.75	0.89
H3.2	3.20	1.54
H4.2	4.20	2.54

ALL DIMENSIONS mm

Figure 5 Top Side Connector Physical Dimensions

Reference from PCI Express M.2 Specification, Revision 1.0, November 1, 2013

2.3.2. Carrier Board Connection Length

The carrier board connector of M2.COM follows the Type 2230 M.2 module connector:

- The additional increase in length is 7.05mm maximum for top-side connector to the module length.
  - The retention screw adds 2.75 mm maximum.
  - The maximum extension, including land pattern, beyond the module leading edge is 4.3 mm.
- M2.COM module lengths are 30 mm and 42 mm.

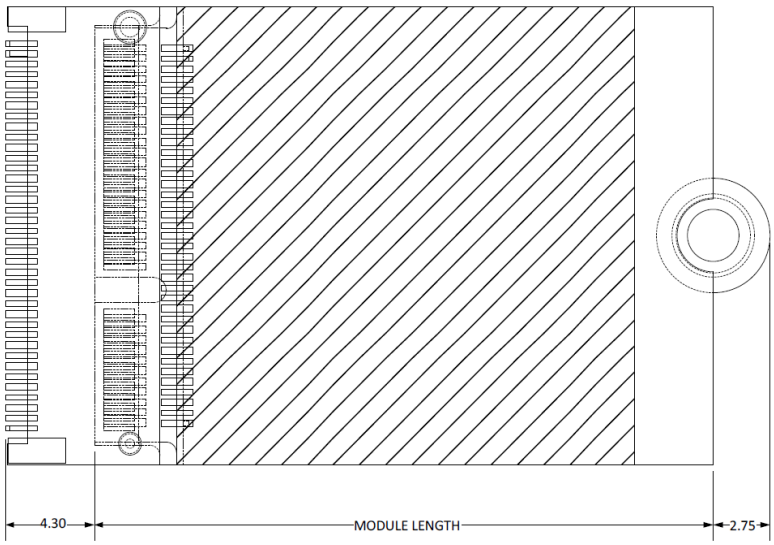


Figure 6 Carrier Board Connection Length

Reference from PCI Express M.2 Specification, Revision 1.0, November 1, 2013

2.3.3. Carrier Board Connector Height

The dimensions of M2.COM form factor follow the Type A 2230 -D3 M.2 module size. Hence, the carrier board connectors must choose H3.2-D3 or H4.2-D5 connector as in the following diagrams.

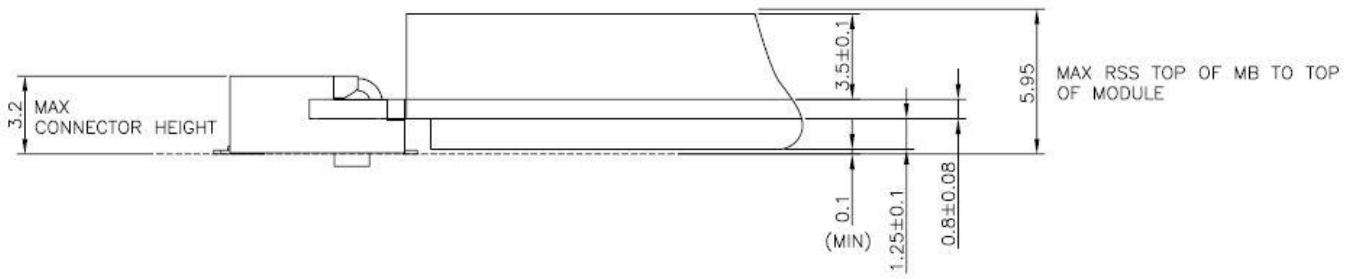


Figure 7 H3.2-D3

Reference from PCI Express M.2 Specification, Revision 1.0, November 1, 2013

2.4. WISE-1510 Pin-Out Map

PIN	M2.COM Signal name	STM32L443RCI6 MCU Pin Name		M2.COM Signal name	PIN
1	GND	GND	3.3V	VCC	2
3	USB_DP	PA12	3.3V	VCC	4
5	USB_DM	PA11		N.C.	6
7	GND	GND		N.C.	8
9	N.C.			N.C.	10
11	N.C.			N.C.	12
13	N.C.			N.C.	14
15	N.C.		PC6	CB_RESET_OUT#	16
17	N.C.		GND	GND	18
19	N.C.		PC9	CB_PWR_ON	20
21	N.C.		PC4	UART TX (O)	22
23	N.C.			Connector Key	
	Connector Key			Connector Key	
	Connector Key			Connector Key	
	Connector Key			Connector Key	
	Connector Key		PB11	UART RX (I)	32
33	GND	GND	PB1	UART RTS (O)	34
35	N.C.		PB13	UART CTS (I)	36
37	N.C.		PA8	GPIO0	38
39	GND	GND	PC8	GPIO1	40
41	PWM0	PA5	PC7	GPIO2	42
43	N.C.		PC5	GPIO3	44
45	GND	GND	PB0	GPIO4	46
47	ADC0	PA7	PA3	GPIO5	48
49	N.C.		PA2	GPIO6	50
51	GND	GND	PB6	GPIO7	52
53	ADC2	PA6		N.C.	54
55	ADC3	PA4	PC2	W_DISABLE#	56
57	GND	GND	PC1	I2C_DATA	58
59	ADC4	PA0	PC0	I2C_CLK	60
61	N.C.		PB15	SPI_MOSI	62
63	GND	GND	PB14	SPI_MISO	64
65	VDD_RTC	VBAT(3.3V)	PB10	SPI_CLK	66
67	Backup#	PA1	PB12	SPI_CS0#	68

69	GND	GND	PB9	SPI_CS1#	70
71	RESET_IN#	NRST	3.3V	VCC	72
73	Wake#	PC3	3.3V	VCC	74
75	GND	GND			

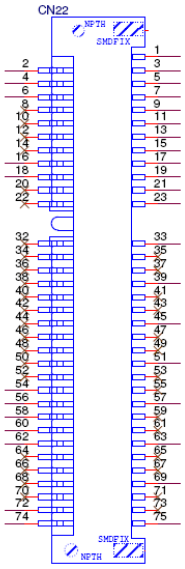
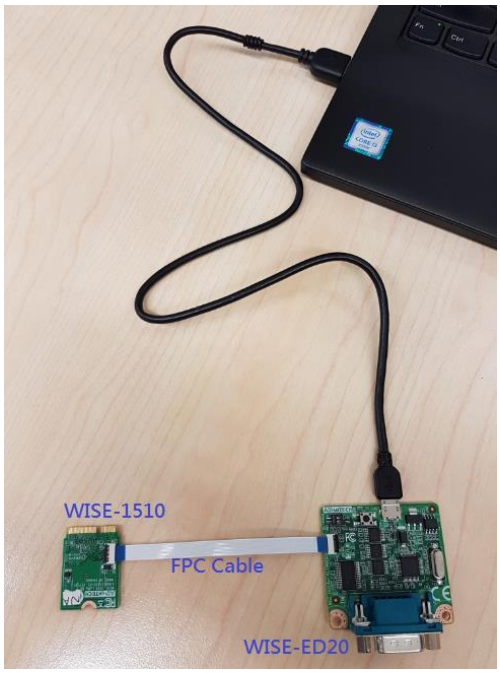


Figure 8 M.2 Connector

2.5. Quick Starter of WISE-1510

2.5.1. Debug Port Connection

1. Connect debug port FPC cable to WISE-1510 debug port (CN1; on the back of PCB)
2. Connect WISE-ED20 debug board to the FPC debug cable.
3. Connect USB-to-microUSB cable from WISE-ED20 to the USB port on your PC.



2.5.2. Debug Port Setting

WISE-1510 can communicate with a host server (Windows or Linux) by using serial cables. Common serial communication programs such as Hyper Terminal, Tera Term or PuTTY can be used in this case. The example below describes the serial terminal setup using Hyper Terminal on a Windows host:

1. Connect WISE-ED20 with your Windows PC by using a serial cable.
2. Open Hyper Terminal on your Windows PC, and select the settings as shown in Figure 9.
3. Terminal will show the image version as Figure 10.

Figure 9 Hyper Terminal Settings for Terminal Setup

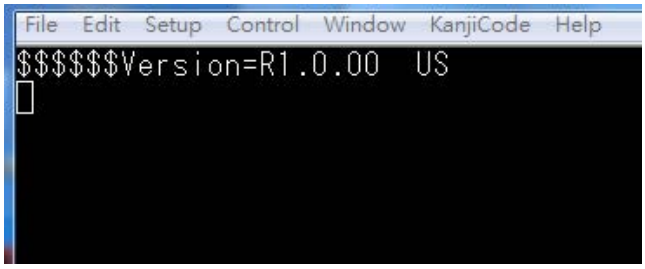


Figure 10 Image version is shown on terminal

3. Development Environment Setup

3.1. Overview

ARM mbed is used for you to create applications running on WISE-1510. Your application code is written in C++. It uses the application programming interfaces (APIs) that mbed OS provides. These APIs allow your code to work on different microcontrollers in a uniform way. This reduces a lot of the challenges in getting started with microcontrollers and integrating large amounts of software. Besides, we also provide you node APIs which facilitates LoRa node development. Our offline development tool is the mbed CLI, a command-line tool. This requires having a toolchain installed on your computer. mbed CLI is the name of the ARM mbed command-line tool, packaged as mbed-cli, which enables the full mbed workflow: repositories version control, maintaining dependencies, publishing code, updating from remotely hosted repositories and invoking ARM mbed's own build system and export functions, among other operations. The basic workflow for mbed CLI is to:

1. Initialize a new repository, for either a new application (or library) or an imported one.
2. Build the application code.
3. Test your build.
4. Publish your application.

3.2. Installation

To install mbed CLI, related tools are required to be installed first. Please refer to the video tutorial. (https://www.youtube.com/watch?v=cM0dFoTuU14)
Please follow the steps described in the tutorial video to install mbed CLI.

1. Install Python

mbed CLI supports Windows, Linux and Mac OS X operating systems. You can select the OS you prefer to work with. mbed CLI is a Python script, so you'll need Python to use it. The version 2.7.11 of Python has been verified with mbed CLI.
https://www.python.org/downloads/release/python-2711/
Note: mbed CLI is incompatible with Python 3.

2. (Optional) Install Git or Mercurial

   If you would like to maintain your source code in repositories, you can continue with the next step. mbed CLI supports both Git and Mercurial repositories, you can install which one you prefer:

Git - version 1.9.5 or later (https://git-scm.com/).
Mercurial - version 2.2.2 or later (https://www.mercurial-scm.org/).
If you don't want to use repositories, you can just skip it.

3. Install gcc

mbed CLI invokes the mbed OS 5 tools for various features, such as compiling, testing and exporting to industry standard toolchains. To compile your code, you will need either a compiler or an IDE:

- Compilers: GCC ARM, ARM Compiler 5, IAR.
- IDE: Keil uVision, DS-5, IAR Workbench.

We select GCC ARM Embedded, so you can install version 4.9 of GCC ARM Embedded (https://launchpad.net/gcc-arm-embedded).
Note: Version 5.0 or any other versions above may be incompatible with the tools.

4. Install mbed CLI

You can get the latest stable version of mbed CLI from PyPI

```
$ pip install mbed-cli
```

Note: On Linux or Mac, you may need to run with sudo.

Finally, you've to extract the source code to the working directory from the SDK we released. The structure of the working directory is as below:

```
docs/                                          <-- Documents for SDK
loranode_L443_sdk_R1_0_02/mbed-os/             <-- mbed os
loranode_L443_sdk_R1_0_02/libHLLoraNode.a      <-- Harmony Link Lora Node library
loranode_L443_sdk_R1_0_02/node_api.h           <-- Node API header file
loranode_L443_sdk_R1_0_02/main.cpp             <-- Sample code
```

3.3. Configuration

After the installation of required tool chains, please set up the directory of mbed CLI to link the folder of toolchains which you want to use for compiling the source tree.
You can set the GCC ARM Embedded location via the command as below:

```
$ mbed config --global GCC_ARM_PATH "C:\Program Files\GCC_ARM"
[mbed] C:\Program Files\GCC_ARM now set as global GCC_ARM_PATH
```

Next, you can select the tool chain and target platform which mbed CLI uses to build applications. Change directory to target mbed program.

```
$ mbed config target NUCLEO_L443RC
[mbed] NUCLEO_L443RC now set as default target in program "xxxxx"
```

```
$ mbed config toolchain GCC_ARM
[mbed] GCC_ARM now set as default toolchain in program "xxxx"
```

You can see the active mbed CLI configuration via:

```
$ mbed config --list
[mbed] Global config:
GCC_ARM_PATH =C:\Program Files\GCC_ARM
[mbed] Local config (xxxx):
TOOLCHAIN=GCC_ARM
TARGET=NUCLEO_L443RC
```

3.4. Compilation

mbed CLI uses the current directory as a working context. This means that before calling any mbed CLI command, you must first change to the working directory containing the code. Then, Use the mbed compile command to compile your code:

```
$ mbed compile -c
Building project xxxxx (NUCLEO_L443RC, GCC_ARM)
Scan: .
Scan: mbed
Scan: env
Compile [    0.5%]: base64.cpp
Compile [    1.0%]: oslmic.cpp
…
Compile [100.0%]: node_sapi.cpp
Link: xxxxx
Elf2Bin: xxxxx
+------------------+--------+-------+-------+
| Module           |    .text | .data |    .bss |
+------------------+--------+-------+-------+
| Fill             |       223 |       16 |       41 |
| Misc             |    104316 |    7804 |    5017 |
| drivers          |      3592 |        4 |      224 |
```

```
| hal                        |      802 |        0 |        8 |
| platform                   |     1782 |        4 |      297 |
| rtos                       |      910 |        4 |        4 |
| rtos/rtx                   |     7369 |       20 |     6870 |
| targets/TARGET_STM         |    19944 |        4 |     1719 |
| Subtotals                  |   138938 |     7856 |    14180 |
+----------------------------+----------+----------+----------+
Allocated Heap: unknown
Allocated Stack: unknown
Total Static RAM memory (data + bss): 22036 bytes
Total RAM memory (data + bss + heap + stack): 22036 bytes
Total Flash memory (text + data + misc): 146794 bytes

Image: ./BUILD/NUCLEO_L443RC/GCC_ARM/xxxxx.bin
```

Now, you have your application in binary format ready for flashing.

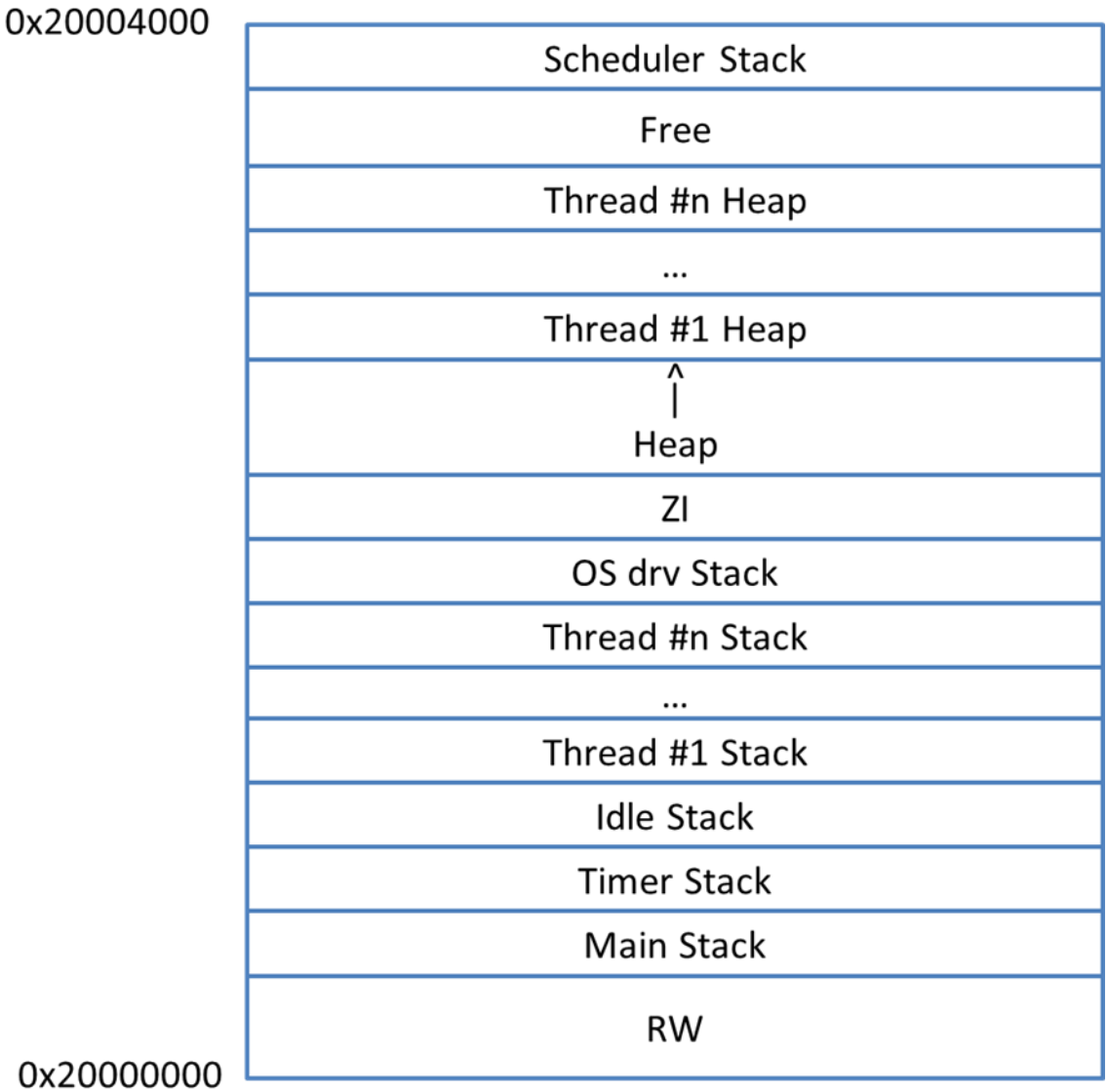
3.5. Memory Layout

A basic overview of mbed memory model is as below:

Each thread of execution in the RTOS has a separate stack. When you use the RTOS, before explicitly initializing any additional thread, you will have four separate stacks:

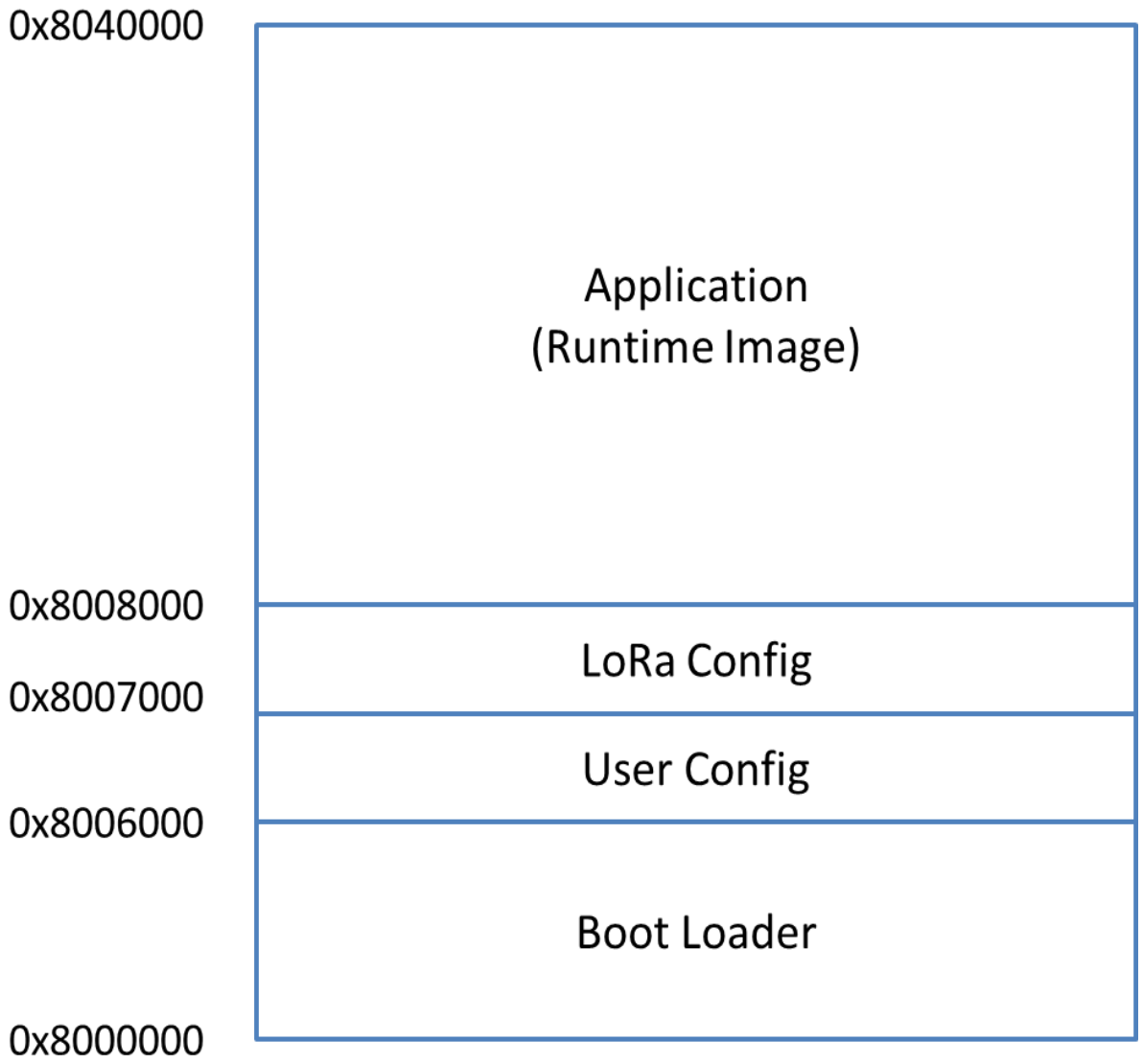
- The stack of the main thread (executing the main function).
- The idle thread executed each time all the other threads are waiting for external or scheduled events. This is particularly useful for implementing energy saving strategies (like sleep).
- The timer thread that executes all the time-scheduled tasks (periodic and nonperiodic).
- The stack of OS scheduler itself (also used by the ISRs).

Stack checking is turned on for all threads, and the kernel will error if an overflow condition is detected.


0x20004000
Scheduler Stack
Free
Thread #n Heap
...
Thread #1 Heap
^
|
Heap
ZI
OS drv Stack
Thread #n Stack
...
Thread #1 Stack
Idle Stack
Timer Stack
Main Stack
RW
0x20000000

3.6. Partitioning

The content of flash is portioned by boot loader as below:



Boot Loader occupies the first 16 kilo-bytes starting at 0x8000000. LoRa Config partition is used to store LoRa parameters, which occupies no more than 4 kilo-bytes. All user own parameters should be written into User Config partition, for which another 4 kilo-bytes are reserved. Application (Runtime image) partition is where users' application is stored, up to 224 kilo-bytes can be used.

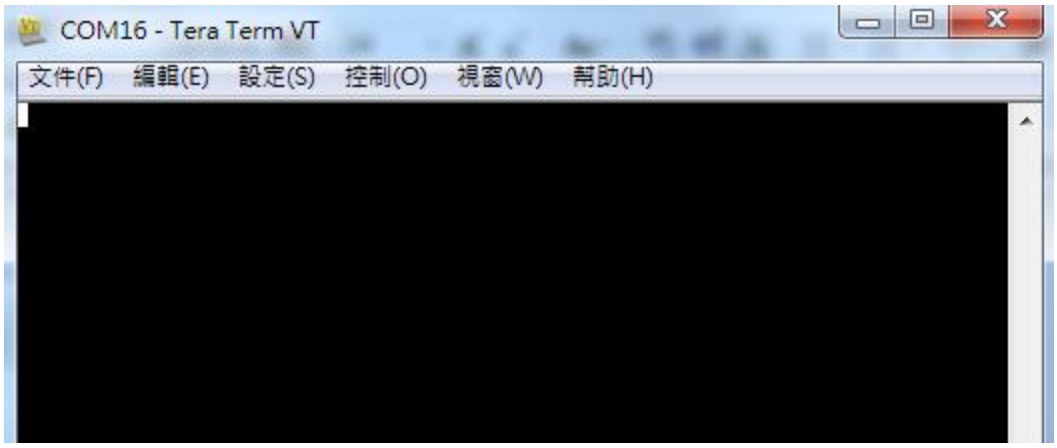
3.7. Flashing Application (Runtime Image)

To flash runtime image, your terminal program needs to support “Y-Modem”.
Tera Term is used for demonstration here.

Step 1: UART port connect via debug board

Connect USB-to-microUSB cable from WISE-ED20 to the USB port on your Windows PC. (Red frame is reset button.)

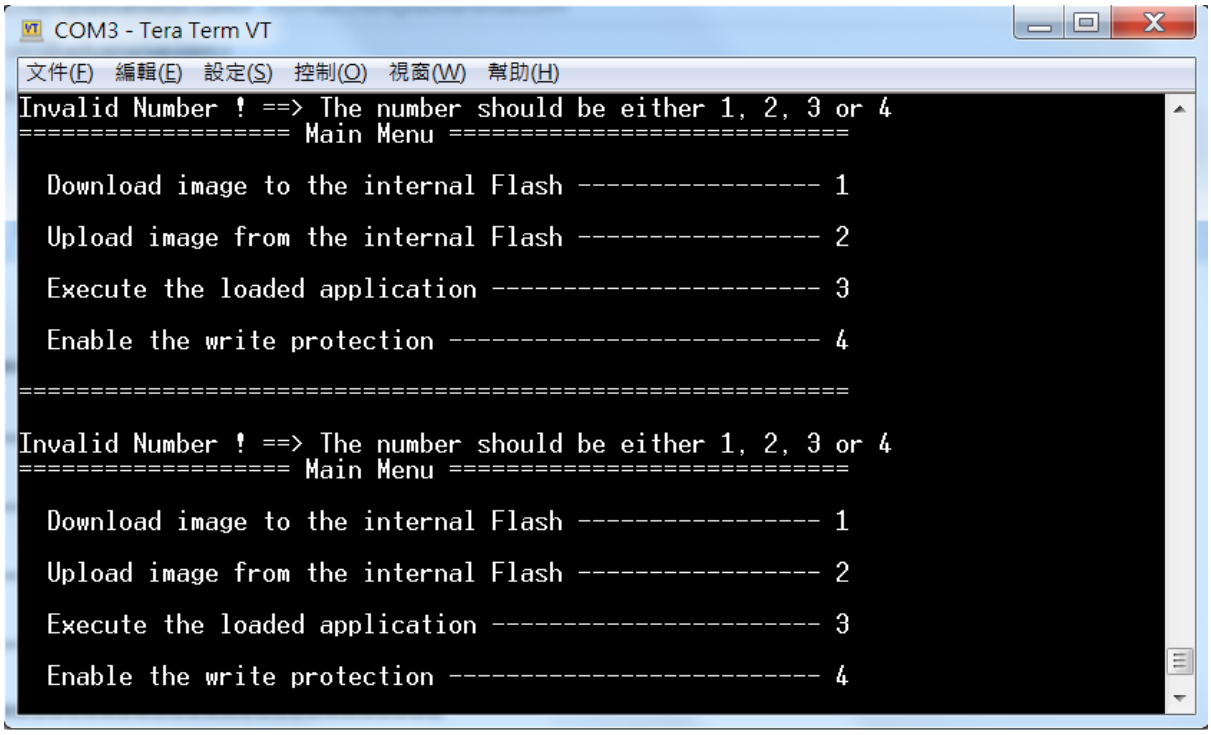
Open the corresponding COM port in serial program, ex: Tera Term.
Set baud rate to 115200.



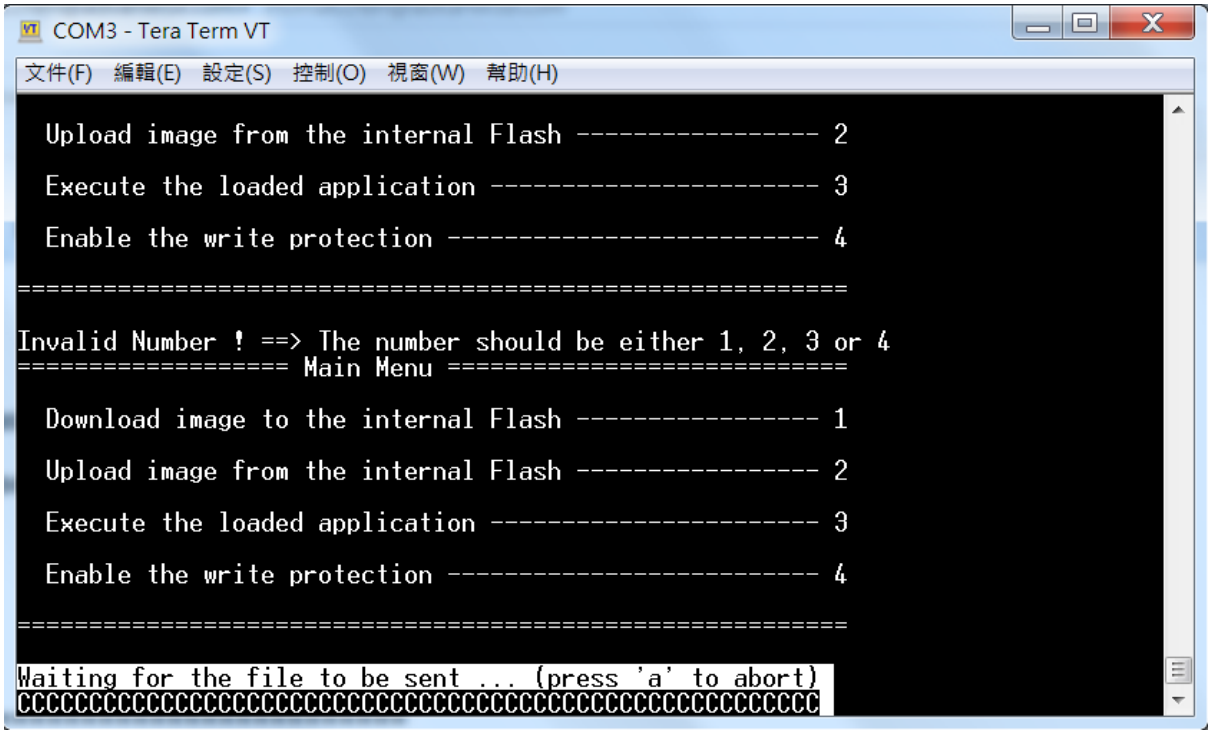
Step 2: Runtime image upgrade mode

Press ‘u’ on the PC keyboard and press reset button on ED-20 debug board.

The terminal will show messages as below.

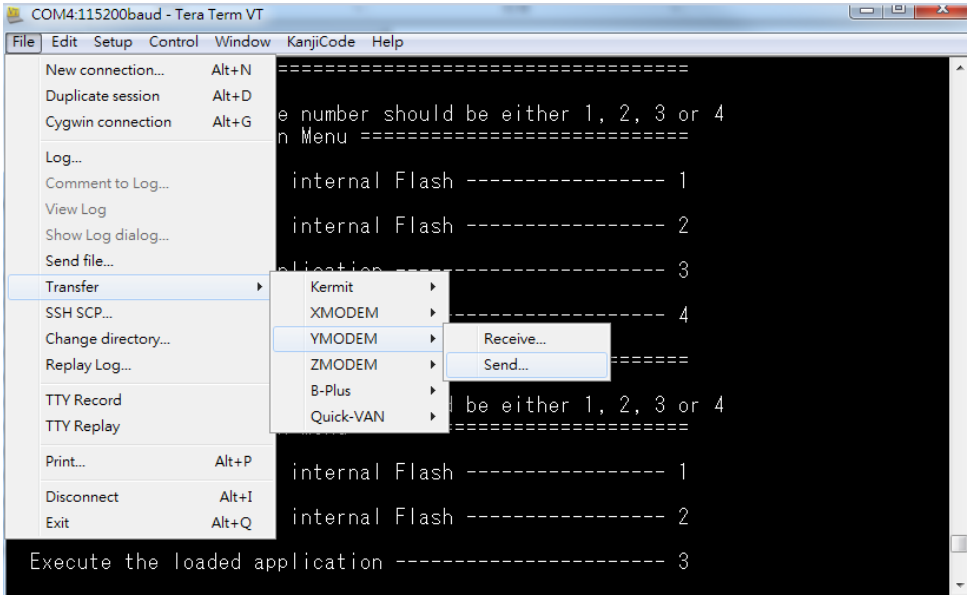


Press "1" to “Download image to the internal Flash”.



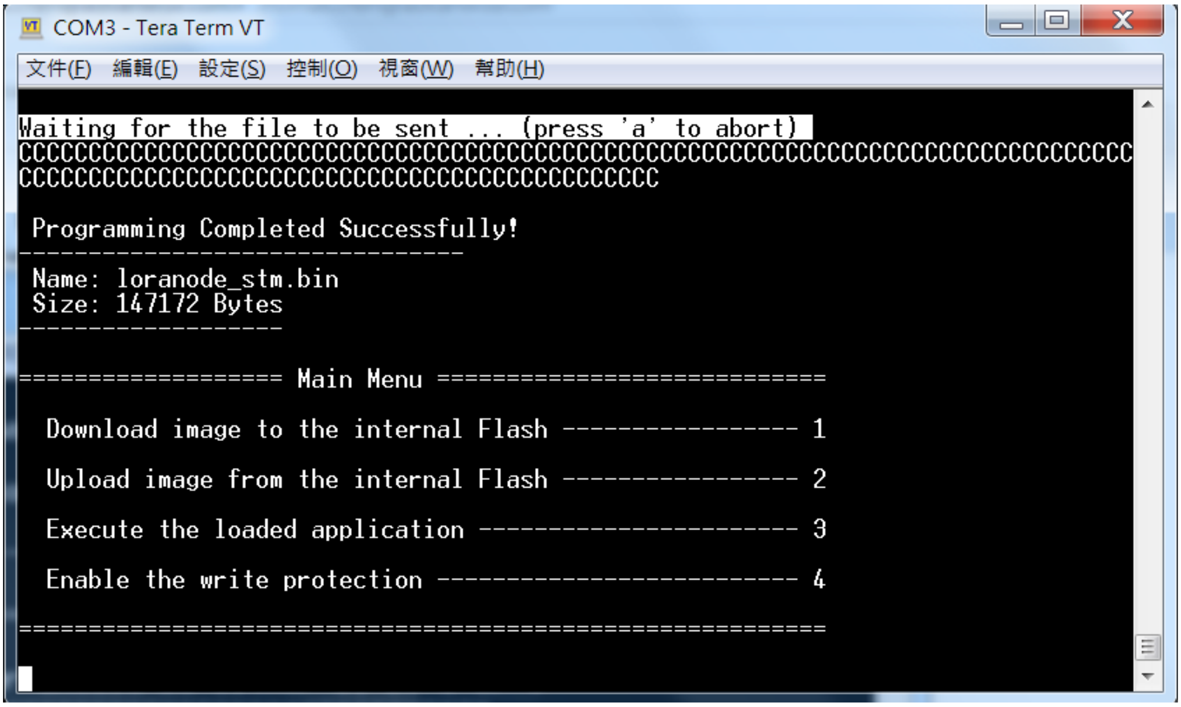
Step 3: Start upgrading via Y modem

Select the run-time image ".bin" file via Y-Modem.



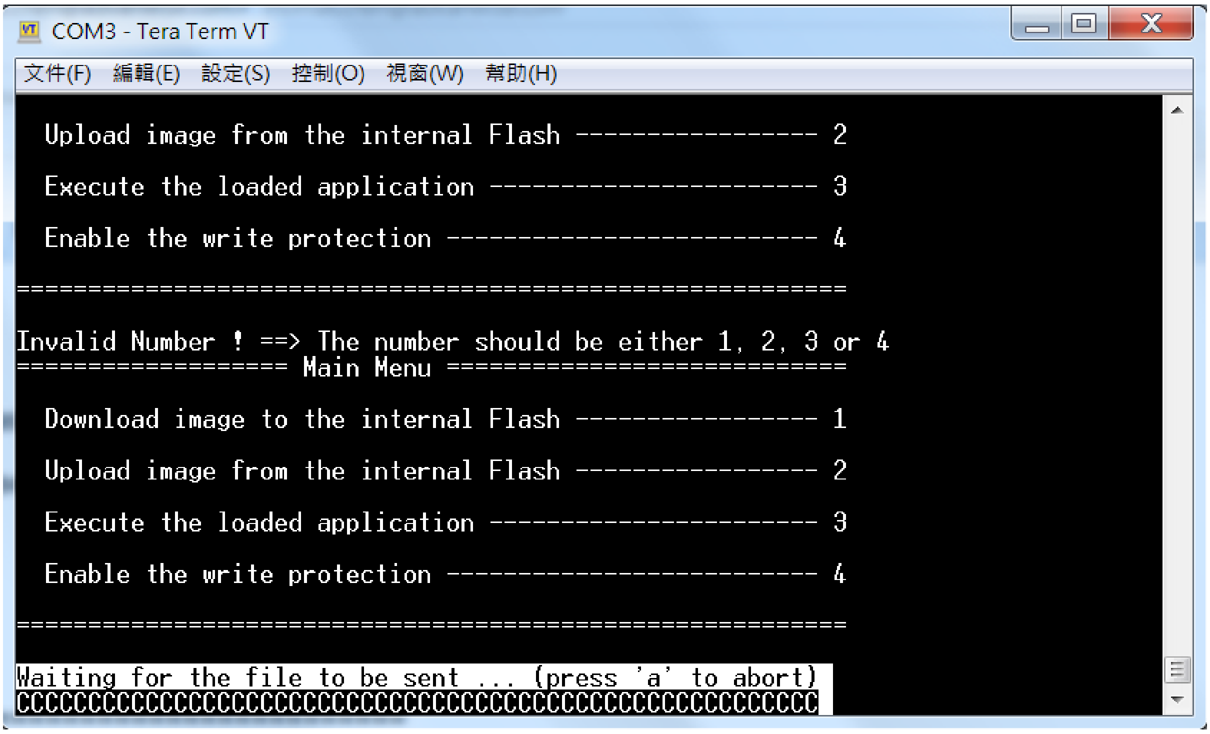
Waiting for run-time image transmission is complete.

After downloading completed, the terminal will show as below.



Step 4: Reset device

Press reset button on ED-20 debug board to reset device.



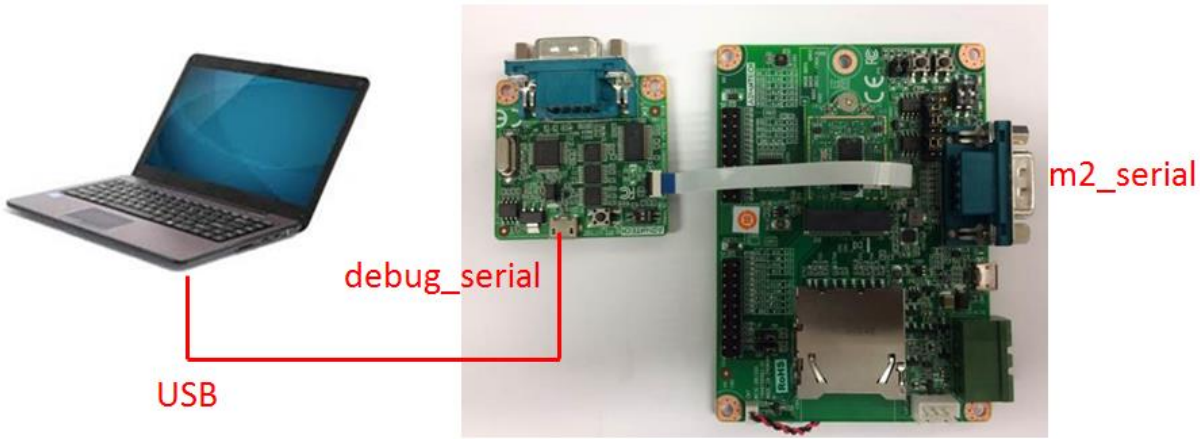
3.8. Testing

Now, you're ready to test your WISE-1510. The sample application we created is to send sensor data every 5 seconds via LoRa if values are changed. To observe it, you can connect the debug port as described earlier. After reset WISE-1510, the result is shown on your Terminal as below:

```
$$$$$$Version=R1.0.05S US
DevEui=76FE48FFFF000004
AppEui=00000000000000AB
DevAddr=FF000004
NwkSKey=00000000000000000000000000000011
AppSKey=00000000000000000000000000000011
DevActMode=2
DevOpMode=1
DevClass=3
AdvwiseDataRate=4
DevAdvwiseFreq=923300000Hz
DevAdvwiseTxPwr=20dBm
Lora Joined!!
TX: 11 c 1 3 0 8 9f 2 2 23 1 3 2 1 c2 4 2 0 7d
TX: 11 c 1 3 0 8 a1 2 2 22 f8 3 2 1 c2 4 2 0 7d
TX: 11 c 1 3 0 8 9f 2 2 22 e5 3 2 1 c2 4 2 0 7d
TX: 11 c 1 3 0 8 9f 2 2 22 db 3 2 1 c2 4 2 0 7d
```

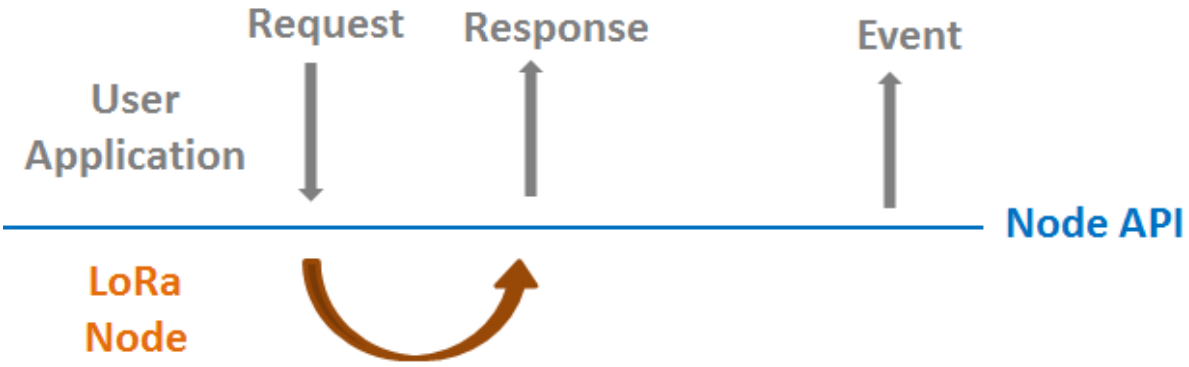
4. Application Development

Node APIs were provided to assist user develop applications. There are 2 UART interfaces in WISE-1510. “debug_serial” is used for user development and debug. User can see debug information of sample code via debug_serial. “m2_serial” is the UART interface of M2.com.



4.1. Node API

Following show the architecture of the layer of LoRa Node and user application. User can send request to LoRa node via API and got response. Besides, application can also be notified by callback function if some event occurs from LoRa node.



Node APIs were listed as below:

- System Start/reboot
  - nodeApiInitCarrierBoard
  - nodeApiStartLora
  - nodeApiReboot
- Configuration get/set/save/factory reset

nodeApiGetDevEui

nodeApiGetAppEui

nodeApiGetAppKey

nodeApiGetDevAddr

nodeApiGetNwkSKey

nodeApiGetAppSKey

nodeApiGetDevActMode

nodeApiGetDevOpMode

nodeApiGetDevAdvwiseFreq

nodeApiGetDevAdvwiseDataRate

nodeApiGetDevAdvwiseTxPwr

nodeApiSetDevEui

nodeApiSetAppEui

nodeApiSetAppKey

nodeApiSetDevAddr

nodeApiSetNwkSKey

nodeApiSetAppSKey

nodeApiSetDevActMode

nodeApiSetDevOpMode

nodeApiSetDevAdvwiseFreq

nodeApiSetDevAdvwiseDataRate

nodeApiSetDevAdvwiseTxPwr

nodeApiSaveCfg

nodeApiLoadCfg

nodeApiApplyCfg

nodeApiFactoryReset

- LoRa callback function register/status check/send data

  nodeApiSetTxDoneCb

  nodeApiSetRxDoneCb

  nodeApiJoinState

  nodeApiSendData

- System deep sleep (low power) mode

nodeApiSetDevSleepRTCWakeup

The detailed description of APIs can be found in /docs/html/index.html in the released SDK.

4.2. Sample Code for API

If WISE-1510 was plugged in M2.com carrier board (WISE-DB1500), do below action to enable M2.com carrier board.

```
491     /* Init carrier board, must be first step */
492     nodeApiInitCarrierBoard();
```

Set boud rate of debug_serial and m2_serial.

```
494     debug_serial.baud(115200);
495     m2_serial.baud(115200);
```

Create sensor thread.

```
497     p_node_sensor_temp_hum_thread=new Thread(node_sensor_temp_hum_thread);
498     p_node_sensor_co2_thread=new Thread(node_sensor_voc_co2_thread);
```

Set and apply node configuration.

```
500     /*
501      * Init configuration at beginning
502      */
503     node_set_config();
504
505     /*Apply to module*/
506     nodeApiApplyCfg();
```

Start LoRa.

```
508     /*
509      * Start Lora
510      */
511     nodeApiStartLora();
```

Start LoRa State loop to start rx/tx data.

```
517     /*
518      *  Node state loop
519      */
520     node_state_loop();
```

Deep sleep mode is supported but disabled in default, please enable NODE_DEEP_SLEEP_MODE_SUPPORT if you want to try low power mode.

```
17  #define NODE_DEEP_SLEEP_MODE_SUPPORT 0
```

2 API were used to notify user application that LoRa finished transmit or receive action. What you should do is Register callback function in the beginning.

```
363     nodeApiSetTxDoneCb(node_tx_done_cb);
364     nodeApiSetRxDoneCb(node_rx_done_cb);
```

Make sure node successfully joined LoRa gateway.

```
366     while((nodeApiJoinState()==0))
367     {
368         /* wait for Lora Joined */
369         Thread::wait(10);
370     }
```

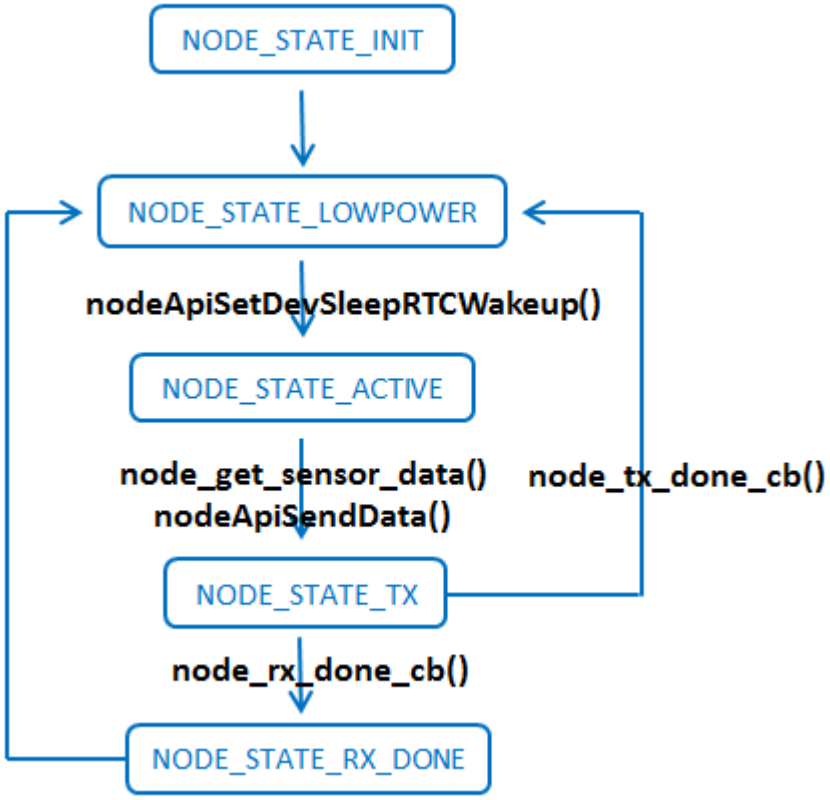
Then, start to run the state machine. If no data need to send, enter deep sleep mode and wait for waking up NODE_ACTIVE_PERIOD_IN_SEC seconds.

```
385                     static int count=0;
386                     #if NODE_DEEP_SLEEP_MODE_SUPPORT
387                     nodeApiSetDevSleepRTCWakeup(1);
388                     #else
389                     Thread::wait(1000);
390                     #endif
391
392                     if(node_state!=NODE_STATE_RX_DONE)
393                     {
394                         if(count%NODE_ACTIVE_PERIOD_IN_SEC==0)
395                         {
396                             node_state=NODE_STATE_ACTIVE;
397                         }
398                     }
399                     count++;
```

This example send sensor (Temperature, Humidity) data periodically, user should modify node_get_sensor_data() to implement read sensor data.

If Tx complete, node_tx_done_cb() will transfer to NODE_STATE_LOWPOWER and prepare to read/send sensor data again.

If LoRa node got downlink data, node_rx_done_cb() will be invoked to get data. Then transfer to NODE_STATE_LOWPOWER.



The detailed description of Sample code can be found in /docs/html/index.html in the released SDK.

Appendix I: Node Setup Parameters

In the sample application, there is a function node_set_config() as below:

```
186 void node_set_config()
187 {
188     char deveui[32]={};
189     char devaddr[16]={};
190
191
192   1 if(nodeApiGetFuseDevEui(deveui,16)!=NODE_API_OK)
193     {
194         NODE_DEBUG("Get fuse DevEui failed\r\n");
195         return;
196     }
197
198     nodeApiSetDevEui(deveui);
199   2 nodeApiSetAppEui("00000000000000ab");
200     nodeApiSetAppKey("00000000000000000000000000000011");
201   3 strcpy(devaddr,&deveui[8]);
202     nodeApiSetDevAddr(devaddr);
203   4 nodeApiSetNwkSKey("00000000000000000000000000000011");
204     nodeApiSetAppSKey("00000000000000000000000000000011");
205   5 nodeApiSetDevActMode("2");
206   6 nodeApiSetDevOpMode("1");
207   7 nodeApiSetDevClass("3");
208   8 nodeApiSetDevAdvwiseDataRate("4");
209     nodeApiSetDevAdvwiseFreq("923300000");
210     nodeApiSetDevAdvwiseTxPwr("20");
211 }
```

This function is used to configure all parameters of nodes. Let's go through them briefly.

1. Device EUI (DevEUI) is read from eFuse, and set without any change.
2. Two application dependent parameters, application EUI (AppEUI) and application key (APPKey), are set respectively (line 218 and 219).
3. Device address (DevAddr) is derived from DevEUI by extracting the last 8 bytes (line 220), and set (line 221). It's up to users to define the format as long as it matches with gateway's setting.
4. Two session keys: network session key (NwkSKey) and application session key (AppSKey) are set (line 222 and 223).
5. So far, all required parameters for node activation are set properly. Then, you can decide to activate the node by either ABP (Activation By Provisioning) or OTAA (Over-The-Air Activation). Here, we set it to ABP (line 224). Please be noted that, only three of the above parameters are used for ABP, including DevAddr, NwkSKey and AppSKey. If you'd like to use OTAA, then change the input parameter of nodeApiSetDevActMode() from 2 to 1. The other three parameters are used for OTAA, including DevEUI, AppEUI, and APPKey are set.
6. Select nodes to work with LoRaWAN or Harmony Link by setting the device

operating mode (DevOpMode): 1 for Harmony Link* and 2 for LoRaWAN. Here, Harmony Link is selected as the default. (line 225) If you'd like to use LoRaWAN, change it from 1 to 2.

* Harmony Link is Advantech's proprietary LoRa MAC.

7. You can select which class of Node: 1 for Class A, and 3 for Class C. (2 for Class B is reserved for future use.) Here, Class C is selected (line 226).
8. The remaining part are used to set radio related parameters, including data rate (DevAdvwiseDataRate), frequency (DevAdvwiseFreq) and transmission power (DevAdvwiseTxPwr) (line 227~229). Please be noted all of RF parameters are region dependent, so you've to set their values accordingly. Make sure you DO NOT violate the regional regulation.

After all parameters are configured, be reminded to apply them by nodeApiApplyCfg().

Appendix II: Sensor Data Format

In the sample application, node_get_sensor_data() encodes sensor data according to the following format:

Length (1 Octet)	MsgType (1 Octet)	Multiple TLVs

,where

Length: Total TLV length

MsgType: Fixed as 0xc

Multiple TLVs are one or more Tag-Length-Values: tag matches with gateway's setting, length is sensor data length, and value is sensor data. All octets are in hexadecimal.

For example, LoRa Payload Field setting on WISE-3610 is as below:

If temperature is 25.55 Celsius degree, translate decimal 2555 to hexadecimal 9FB. Similarly, if humidity is 60.55%, translate from decimal 6055 to hexadecimal 17A7.

The encoded data will be

0x9 | 0xc | 0x1 | 0x3 | 0x1 | 0x9 | 0xFB | 0x2 | 0x2 | 0x17 | 0xA7

, where

0x9: the Total TLV length, included two TLVs

0xc: the fixed MsgType

0x1 | 0x3 | 0x1 | 0x9 | 0xFB: the first TLV with tag id (0x1), value length (0x3), and positive (0x1) value (0x9FB)

0x2 | 0x2 | 0x17 | 0xA7: the second TLV with tag id (0x2), value length (0x2), and unsigned value (0x17A7)

Be reminded temperature "Sign" setting is On, 1 extra byte is required to indicate (0 means negative, and 1 means positive) , but humidity "Sign" setting on gateway is Off, so no extra 1 byte is required.

Users are free to define their own payload field format, but only sensor data encoded according to the above format can be decoded successfully, and displayed on LoRa Dashboard on WISE-3610.