LoryPlug/CPU

SDK Manual

Version: 1.0

May 24, 2019

Revision History

Revision Date	Document Version	Pages	Description
May 24, 2019	1.0	All	New

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This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Caution
THE GRANTEE IS NOT RESPONSIBLE FOR ANY CHANGES OR MODIFICATIONS NOT EXPRESSLY APPROVED BY THE PARTY RESPONSIBLE FOR COMPLIANCE. SUCH MODIFICATIONS COULD VOID THE USER'S AUTHORITY TO OPERATE THE EQUIPMENT.

IMPORTANT NOTE : FCC RF Radiation Exposure Statement
This equipment complies with FCC RF radiation exposure limits set forth for an uncontrolled environment.
This equipment should be installed and operated with a minimum distance of 20 centimeters between the radiator and your body. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

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.

This Wireless LoRa module has been granted modular approval for mobile applications. OEM integrators for host products may use the module in their final products without additional FCC certification if they meet the following conditions. Otherwise, additional FCC approvals must be obtained.
The host product with the module installed must be evaluated for simultaneous transmission requirements.
The user's manual for the host product must clearly indicate the operating requirements and conditions that must be observed to ensure compliance with current FCC RF exposure guidelines.
To comply with FCC regulations limiting both maximum RF output power and human exposure to RF radiation, use this module only with the included onboard antenna.
A label must be affixed to the outside of the host product with the following statements:
Contains FCC ID: PROLORYPLUGCPUV10
The final host / module combination may also need to be evaluated against the FCC Part 15B criteria for unintentional radiators in order to be properly authorized for operation as a Part 15 digital device.

OEM/Integrators Installation Manual

- The module is limited to OEM installation ONLY.
- The OEM integrator is responsible for ensuring that the end-user has no manual instruction to remove or install module.
- The module is limited to installation in mobile or fixed applications, according to Part 2.1091(b).
- The OEM Integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed.
- Separate approval is required for all other operating configurations, including portable configurations with respect to Part 2.1093 and different antenna configurations.

Instructions to the OEM/Integrator

- The OEM Integrator must include the instructions or statements required by Part 15.19 and 15.21 in the user manual.
- The OEM Integrator must include a separate section in the host user's manual concerning the operating conditions to satisfy RF exposure compliance.
- There is requirement that the grantee provide guidance to the host manufacturer for compliance with Part 15B requirements.

Contents

1. Overview

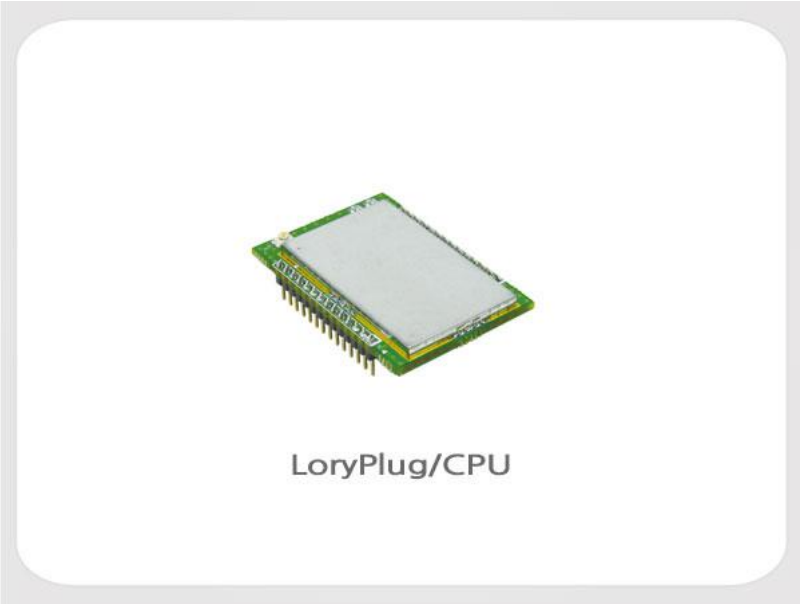
The LoryPlug/CPU SDK is a programmable CPU module that allows users to develop LoRa-based End Devices. Users can easily develop End Devices with various sensors by using a source code (API and library) provided by the LoryPlug/CPU module. A variety of devices based on LoryNet platform provided by SystemBase allow remote monitoring and control to End Devices on the other side of the globe.

A complete circuit diagram and source code are provided to develop the product by using the UART, I2C, and SPI communication interfaces provided by the LoryPlug/CPU module.

2. Features

- Supports I/O interface (UART(2CH), I2C(1CH), ADC(2CH), GPIO (6EA))
- Transforms and transmits I/O interface to LoRa signals
- Supports industrial-grade operating temperature: -40 ~ 85℃ (-40 ~ 185℉)

3. Package

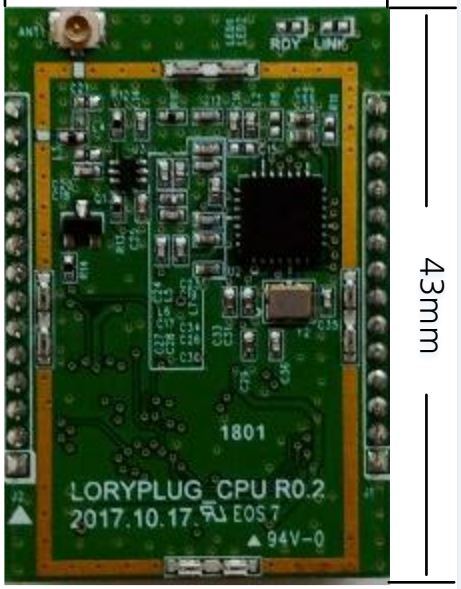


Package	Ordering Information
LoryPlug/CPU	LoryPlug/CPU v1.0.2
Helical Antenna	HW-920H-S

4. Hardware

4.1 Specification

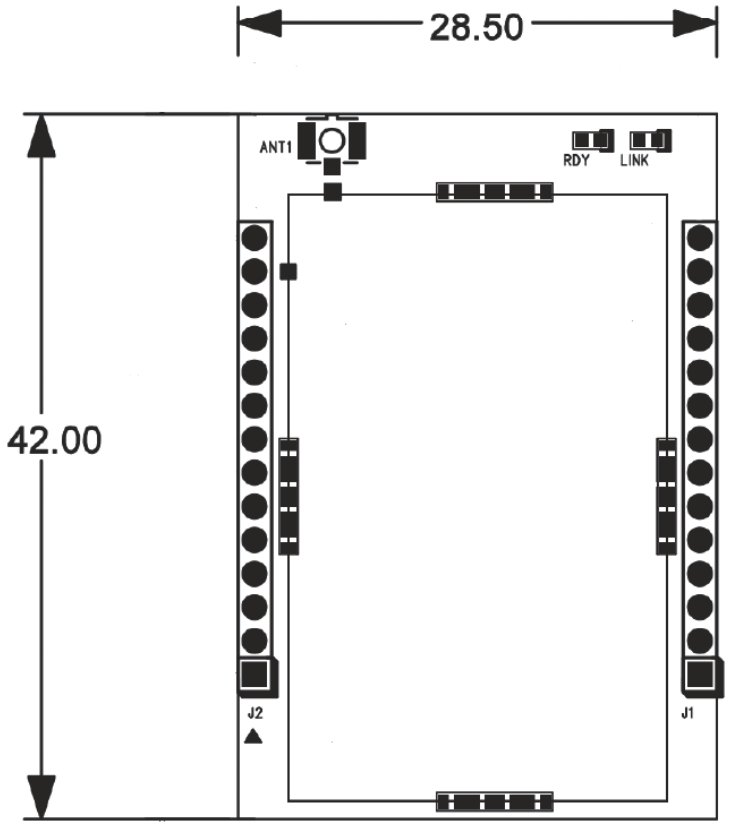
GND	GND	14	27mm	28	GND	GND
RF Out	Extern	13		27	I2C2_SDA	PB11
GND	GND	12		26	I2C2_SCL	PB10
NRST	NC	11		25	Battery	PB1
SWCLK	SWCLK	10		24		PB0
SWDIO	SWDIO	9		23	DIP Switch	PB5
PA10	UART1 Tx	8		22	DIP Switch	PB4
PA9	UART1 Rx	7		21	DIP Switch	PB3
GND	GND	6		20	DIP Switch	PA15
PB15	SPI2_MOSI	5		19	UART2 Rx	PA3
PB14	SPI2_MISO	4		18	UART2 Tx	PA2
PB13	SPI2_SCK	3		17	DIP Switch	PA1
PB12	SPI2_NSS	2		16	DIP Switch	PA0
VCC	VCC	1		15	VCC	VCC



Category	Item	Specification
System	CPU	ARM CORTEX-M3
Wired Interface	Port	UART*3, I2C*1, ADC*2, GPIO*6
Wireless Interface	Frequency	Usable Frequency 917.3MHz, 917.9MHz, 918.5MHz, 919.1MHz, 919.7MHz, 920.3MHz, 920.7MHz, 920.9MHz, 921.1MHz, 921.3MHz, 921.5MHz, 921.7MHz, 921.9MHz, 922.1MHz, 922.3MHz. 922.5MHz, 922.7MHz, 922.9MHz. 923.1MHz, 923.3MHz
Display	LED	RDY, LINK
Power	Input	3.3V
Connector	B TO B	MOLEX SD-53748-002
Operating Conditions	Temperature	-40℃ ~ +85℃ (-40℉ ~ +185℉)
	Humidity	5~95% Non-Condensing

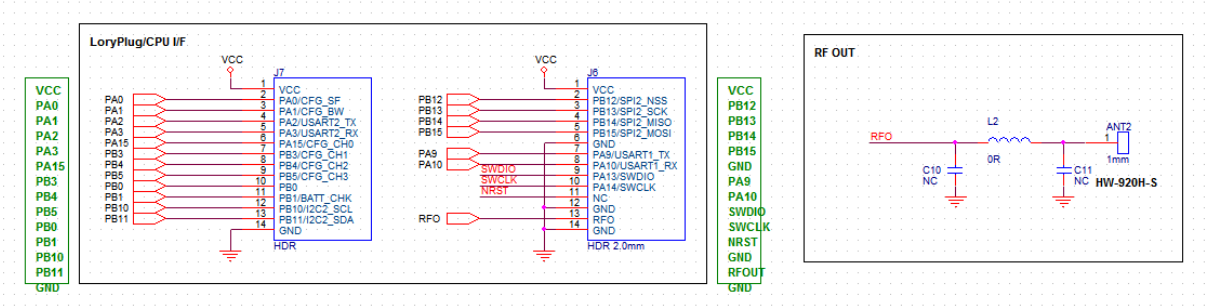
*Wireless certification has been obtained for the specifications listed in the above table. Do not use wireless communication that are different from the above specifications.

4.2 Dimension



unit : mm

4.3 Recommended Antenna Circuit(Example)



GND	GND	14	27mm	28	GND	GND
RF Out	Extern	13		27	I2C2_SDA	PB11
GND	GND	12		26	I2C2_SCL	PB10
NRST	NC	11		25	Battery	PB1
SWCLK	SWCLK	10		24		PB0
SWDIO	SWDIO	9		23	DIP Switch	PB5
PA10	UART1 Tx	8		22	DIP Switch	PB4
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GND	GND	6		20	DIP Switch	PA15
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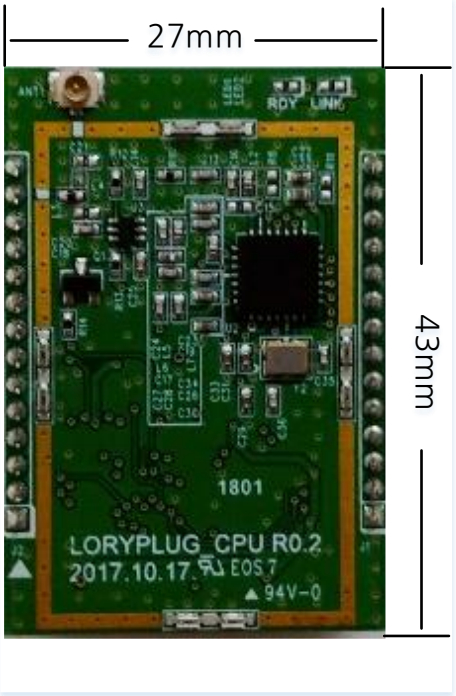
PB14	SPI2_MISO	4		18	UART2 Tx	PA2
PB13	SPI2_SCK	3		17	DIP Switch	PA1
PB12	SPI2_NSS	2		16	DIP Switch	PA0
VCC	VCC	1		15	VCC	VCC



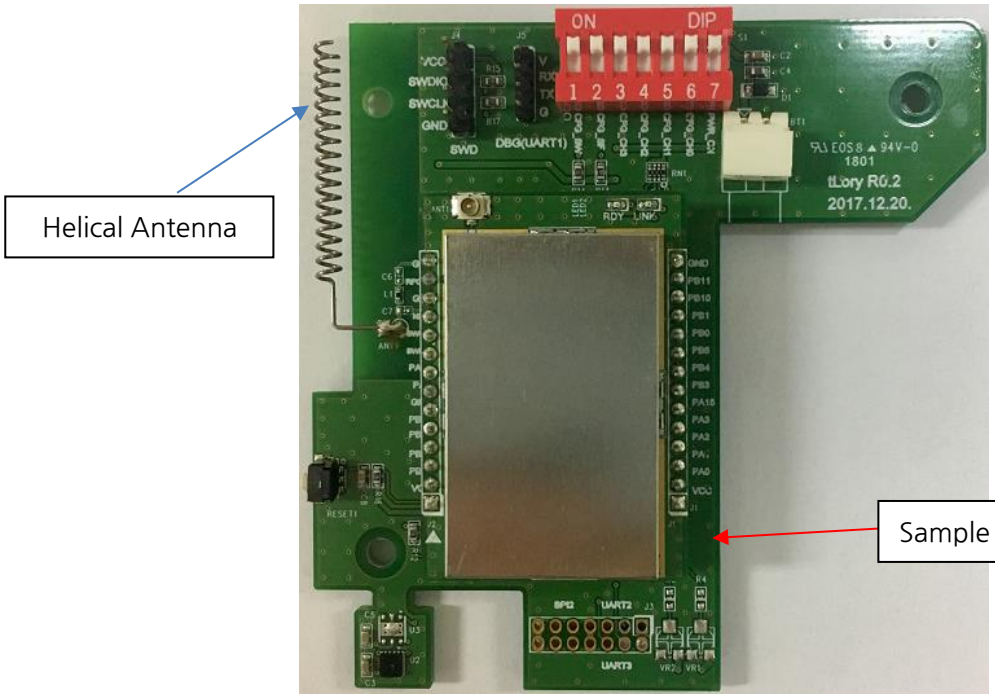
Recommended Antenna Pattern

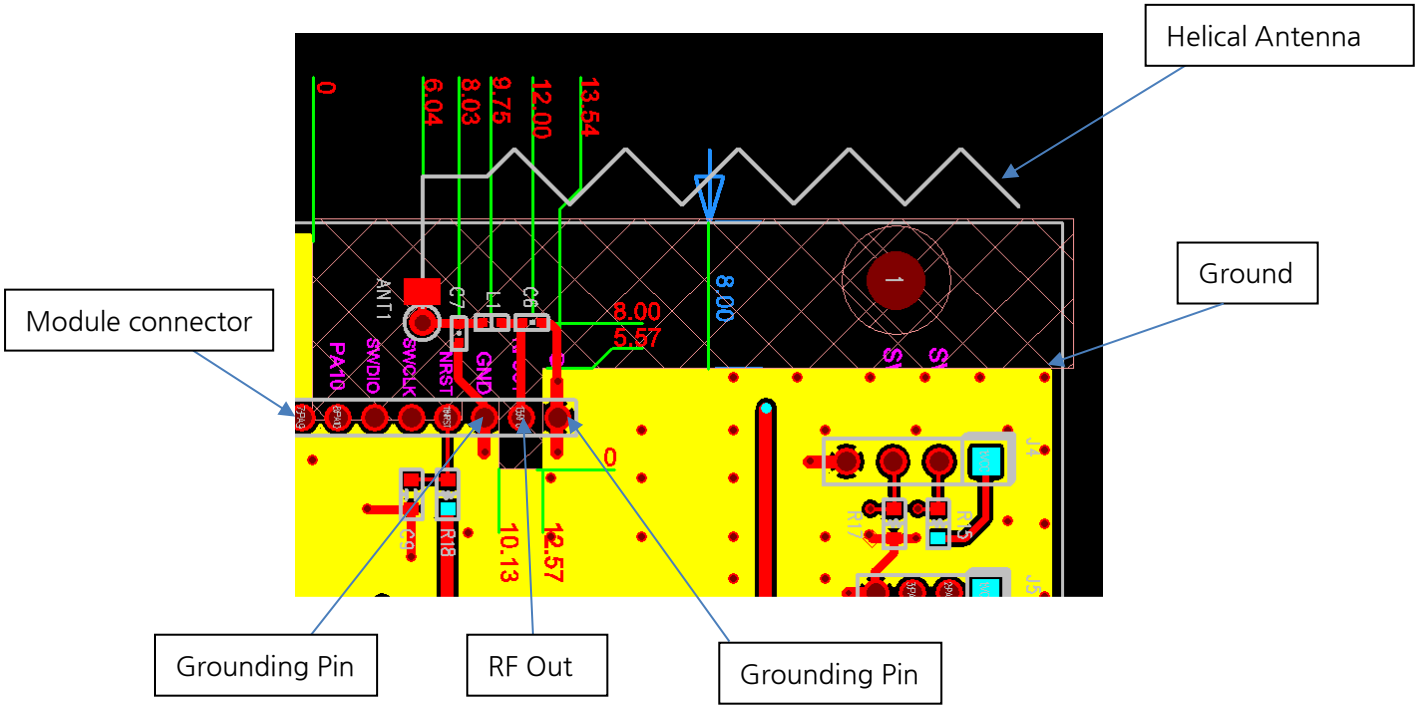
- Recommended Antenna: hanwooltech, HW-920H-S

Recommendation on matching circuit will be provided according to customer's installation conditions.

Sample base board example: Combine the module with the base board as shown in the image below.

The antenna is soldered to the base board.





5. Connection Guide

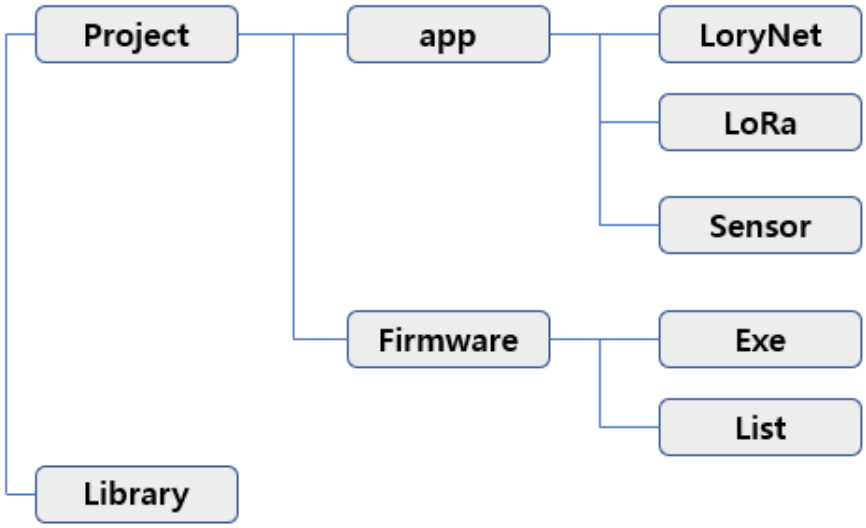
This chapter describes the writing process and notes for user applications. The development and testing of the LoryPlug/CPU used IAR compiler and ST-LINK/V2 Debugger of IAR SYSTEMS.
You can download the IAR compiler from the site below and use it for 30 days by authorizing a free license. Other development environment related matters are as follows.

5.1 Development Environment

- Compiler : IAR 8.3 or above
- Free version IAR Link:
  https://www.iar.com/kr/iar-embedded-workbench2/#!?currentTab=free-trials
- Development Tool : ST-LINK/V2
- Development Language : C Language
- Development OS Environment : Windows10 64bit (Please refer IAR Site for other available OSs)

5.2 Folder Structure

The source and library folder structure provided by the LoryPlug/CPU SDK is as follows:



- Project: main folder of application program
- Library: MCU library provided by STM
- App : main source folder
- LoryNet: LoryNet protocol engine and library sources
- LoRa : LoRa communication port process source
- Sensor : temperature/humidity sensor process source
- Exe : folder where firmware is generated after compiling
- List : memory map information of compiled binary code

5.3 Source Contents

The contents of source files included in the App folder are as follows:

LoryPlug_SDK.eww	: project environment file for IAR compiler
Main.c	: startup program
Sb_struct.h	: Config information and structure used by LoryNet and each process
Sb_defile.h	: default value used by application process
Gpio_init.c	: initialization settings for GPIO ports used by application process
I2c.c	: I2C port settings (temperature/humidity sensor)
Spi.c	: SPI port settings (Serial Flash)
Stm32l1xx_it.c	: interrupt handler settings
LoryNet/Lorynet.c	: LoryNet engine
LogNet/Sb_Library.c	: APIs and libraries
Lora/Lora_Port.c	: LoRa communication port process
Sensor/Th.c	: temperature/humidity sensor process

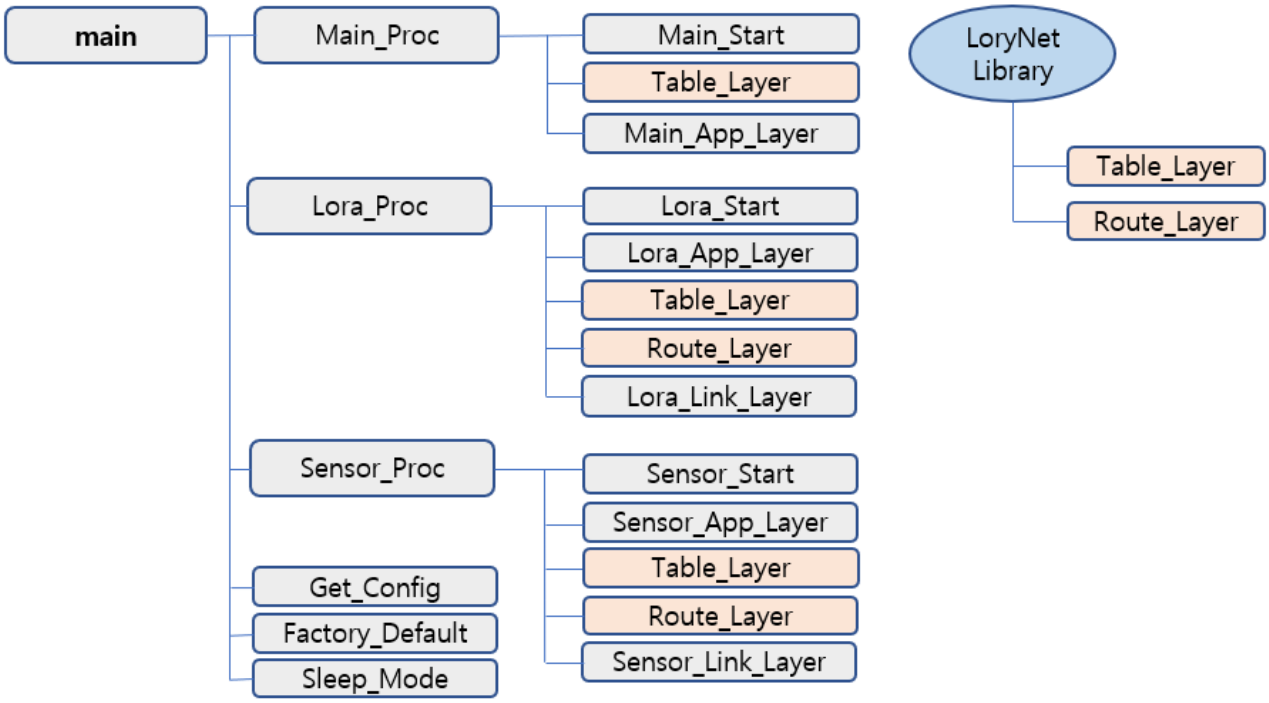
5.4 Function Map

The application included in the LoryPlug/CPU SDK is based on the LoryNet and the structure of the function is as follows:

The application provided is composed of three processes (device, LoRa, sensor) and with the exception of device process, LoRa and sensor processes consists of four layers.

The area users write is primarily the App Layer, where you receive and process data from the other party. Link Layer uses same LoRa and serial processes source which is the communication interface provided by SystemBase, so there is nothing to modify. However, in case of temperature/humidity sensor just as SDK, users can develop applications by modifying the data reading part in Link Layer as it is a case of adding new sensors or devices.

Table Layer and Route Layer are table communication based LoryNet engine provided by SystemBase, which correspond to layers 3,4 (TCP/IP) in OSI 7 layer and can be called and used without modification.



API	Description
Main_Proc	- Initialize the settings used by the device itself on the first call. - Call Table_Layer every 1 second to view and read packets received. - The read packets are processed by App Layer, which is the user-writing area. - Call the LoRa, Sensor port process that belongs to itself.
Lora_Proc	- Initialize the LoRa communication interface settings on the first call. - Read packets from Link Layer to LoRa and raise them to higher Route Layer or send them through the LoRa port if they have packets to send. - Route_Layer places received LoRa packets in the destination table. - Table_Layer analyzes packets that came to him and Read or Write its table information. -App_Layer detects and processes changes in its table information.
Sensor_Proc	- Initialize the Sensor interface settings on the first call. - Regularly read sensor information from Link Layer and renew it to it's table. - Read packets from Link Layer to LoRa and raise them to higher Route Layer or send them through the LoRa port if they have packets to send. - Route_Layer places received LoRa packets in the destination table. - Table_Layer analyzes packets that came to it and R/Ws its table information. - App_Layer detects and processes changes in its table information.
Sleep_Mode	- Regularly enters Sleep Mode by the Scale/Interval time defined in the sensing option of temperature/humidity sensor. - Disconnects the power supply of all peripheral devices before entering the Sleep Mode. - The types of Sleep Modes are mainly Sleep and Standby type. Provided example is Standby Mode, which is a super power-saving mode disconnecting all powers other than RTC for battery use for three years. - In Standby Mode, all power other than RTC is cut off, so when waking up from sleep, it restarts from the beginning just as the power reset

Get_Config	- Read the operation setting information stored in Flash Memory within the MCU.
Factory_Default	- As Flash does not have basic information during the first startup after production, it is used to record the default values in Flash or resets to the factory defaults by Reset Switch.

5.5 APIs

This chapter introduces the various APIs that users can use to program by using LoryPlug/CPU SDK.

Get_Main_Flash		
Function	Reads data which is loaded into Flash Memory in STM CPU	
Format	void Get_Main_Flash (uint32_t addr, uint8_t *Buff, int len)	
Parameter	Addr	Absolute address of Flash Memory
	*Buff	Buffer address to be read and saved and returned
	Len	Length to read
Returns	None	
Notice		

Write_Main_Flash		
Function	Write data on Flash Memory in STM CPU	
Format	void Write_Main_Flash (uint32_t addr, uint8_t *Buff, int len)	
Parameter	Addr	Absolute address of Flash Memory
	*Buff	Buffer address
	Len	Length to save
Returns	None	

Erase_Main_Flash		
Function	Erases the sector before writing data on Flash Memory in STM CPU	
Format	void Erase_Main_Flash (uint32_t addr, int Sector_Ea)	
Parameter	Addr	Absolute address of Flash Memory
	Sector_Ea	Number of sectors to erase (Size of a sector is 1K Bytes)
Returns	None	

Sleep_Mode	
Function	Switch LoryPlug/CPU into Standby mode
Format	void Sleep_Mode ()
Parameter	None
Returns	None
Notice	Sleep mode provided by SDK supports Standby mode as standard. Standby mode is a low power mode which stops all functions except RTC. When waking up at the set time, all state information before standby mode is cleared and runs again from the beginning just as a power reset.

SB_Printf		
Function	Output for debug, which is same as Printf provided by standard C and outputted via Serial Port (Debug Port)	
Format	void SB_Printf (char *Fmt, ···)	
Parameter	Fmt	Output format of standard Printf function
Returns	None	
Notice	Same as the standard Printf and outputted via Serial Port	

SB_msleep	
Function	Makes process wait for the specified time
Format	void SB_msleep (unsigned int msec)

Parameter	msec	Time to wait (msec)
Returns	None	

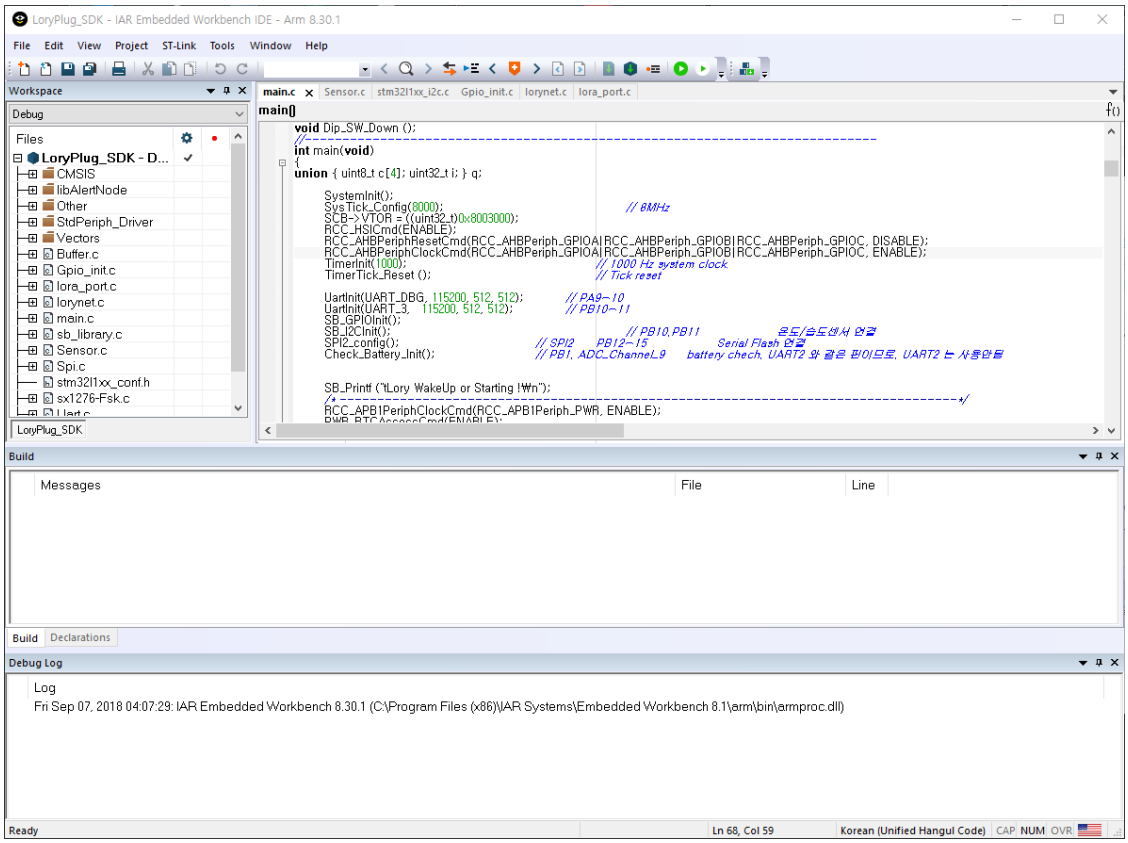
Notice

6. How to Use

The compiler compiles the application sources provided by the LogPlug/CPU and converts them into binary files. This chapter provides example of the use of IAR Embedded Workbench IDE, the most commonly used compiler, and assumes that users' PC has an IAR compiler installed.

6.1 To RUN IAR Compiler

Run IAR IDE by double-clicking on "LoryPlug_SDK.ew" project file in the Project folder.



Select Rebuild All in the Project column or press Ctrl+F7 to compile the source.

If the compile results are correct, a binary file is created as "LoryPlug_CPU.bin" in the Firmware.exe folder.

6.2 Operation Test

For operation test, you can check the operation status by connecting the debug port to PC. Run the communication emulator program on your PC and set the serial settings to 115.2Kbps, Parity None, 8 Bit Data, 1 Stop Bit.

The LogPlug/CPU operation test can be run by changing/compiling/uploading the Defined Test_Mode value early in Main.c.

〈Test Mode〉

Value	Contents
0	Operates in LoryNet mode and regularly transmits temperature/humidity sensor values via LoRa Network to the destination ID 0xffffffe LoryNet device. Depending on the Sleep_ON/OFF option, transfers the sensor value at a one minute distance set by default and repeats the process of entering Sleep mode.
1	The interface under test is on active state of Serial Flash, temperature/humidity sensor, charge state, deep switch and Reset SW.

〈Setup Mode〉

You can enter setup mode if you need to change the default ID and initialize the settings.

Setup Mode remains waiting state for users' Command request. If you set Test_Mode to 0, which is called Operating Mode, the LogPlug/CPU remains all stop except the Timer to conserve battery life, until it wakes up every 60 seconds. For this reason, firmware updates are not possible in Sleep mode, so you can switch to Setup Mode to update the firmware.

To change your ID to No. 255, type:

myid=255 (Enter)

The ID of the LogPlug/CPU must be used within the range of 10000000 to 16000000.

To initialize the settings, type:

default (Enter)

Refer to Factory_CFG() function in main.c for initial values.

To turn on encryption function, type:

aes=1 (Enter)

The AES Key value is set to the Default value if you do not change it.

To change the AES Key value, type as below:

After entering AES Key 16 bytes, you must enter AESIV 16 bytes to change it successfully.

```
aeskey=12345678901234567
You must also type IV(Initialization Vector) [16 Bytes]
12345678901122333
```

〈Interface Test〉

When Test_Mode is set to 1, the following operating status is outputted via Debug Port:

```
Lora Channel=20, Band=7, SFactor=9, Power=14
Erase Sector = 20
Flash Write 128 Bytes
Read Sector  = 20
00 01 02 03 04 05 06 07 - 08 09 0a 0b 0c 0d 0e 0f
10 11 12 13 14 15 16 17 - 18 19 1a 1b 1c 1d 1e 1f
20 21 22 23 24 25 26 27 - 28 29 2a 2b 2c 2d 2e 2f
30 31 32 33 34 35 36 37 - 38 39 3a 3b 3c 3d 3e 3f
40 41 42 43 44 45 46 47 - 48 49 4a 4b 4c 4d 4e 4f
50 51 52 53 54 55 56 57 - 58 59 5a 5b 5c 5d 5e 5f
60 61 62 63 64 65 66 67 - 68 69 6a 6b 6c 6d 6e 6f
70 71 72 73 74 75 76 77 - 78 79 7a 7b 7c 7d 7e 7f

Battery OK
Temperature = 27.82
Humidity    = 14.20
Dip Switch  = 1=1, 2=1, 3=1, 4=1, 5=1, 6=1, Reset=0
```

〈LoryNet Operation 〉

When Test_Mode is set to 0, the following operating status is outputted via Debug Port:

Reads the sensor information and pass temperature/humidity information to destination 0xffffffe at a certain interval.

```
Lora Channel=20, Band=7, SFactor=9, Power=14
Temp=27.14, Humi=14.84, Low Battery=1
38 Tx [18] ff,00,00,03,80,fe,ff,ff,03,80,07,40,01,1b,0e,0e,54,01
Temp=27.14, Humi=13.40, Low Battery=1
137 Tx [18] ff,00,00,03,80,fe,ff,ff,03,80,07,40,01,1b,0e,0d,28,01
Temp=27.14, Humi=12.77, Low Battery=1
238 Tx [18] ff,00,00,03,80,fe,ff,ff,03,80,07,40,01,1b,0e,0c,4d,01
```