Zero Carbon LoRa® Evaluation Board (PC-1570001)

Software Development Procedures

Introduction

These application notes for the Zero Carbon LoRa® Evaluation Board describe an application that uses the ultralow power consumption of the RE01 MCU to implement combined Wi-Fi scanning and proprietary indoor/outdoor tracking functionality. These application notes are accompanied by sample code.

Chapter 1: Introduction explains the system information of the LoRa® LR1110 module. *Chapter 2: Setup Procedure and Application Behavior* explains the setup procedures in detail, and subsequent chapters explain the operating conditions, hardware and software settings, and the behavior of the supplied sample code.

• Supplied sample project
  Prepare the sample project with reference to section 5.3 onward.

Key devices

- Renesas RE01-256KB Group:
  https://www.renesas.com/re01-256kb
- SEMTECH LR1110:
  https://www.semtech.com/products/wireless-rf/lora-edge/lr1110
- Renesas Low IQ - High RSPP LDO ISL9007:
  https://www.renesas.com/products/power-power-management/linear-regulators-ldo/isl9007-high-current-ldo-low-iq-and-high-psrr
- Renesas High Performance Temperature Sensor HS3001:
  https://www.renesas.com/products/sensor-products/humidity-sensors/hs3001-high-performance-relative-humidity-and-temperature-sensor

Related Documents

- RE01 Group Products with 256KB Flash Memory User's Manual: Hardware
  https://www.renesas.com/jp/ja/document/mah/re01-group-products-256-kb-flash-memory-users-manual- hardware?language=ja&r=1321781
- LR1110 User Manual
  https://semtech.my.salesforce.com/sfc/p/#E0000000JelG/a/2R000000UmS7/pGnZPdqyjlcVrUDwZJcBFzlL_9XoIHV8.tZnE70mv3E
- Zero Carbon LoRa® Evaluation Board Tutorial
  https://github.com/ZeroCarbon-LoRaEva/document/blob/main/ZeroCarbon-LoRaEva_Tutorial.md
- Zero Carbon LoRa® Evaluation Board User's Manual
  https://tachibana-denshi-solutions.co.jp/lora_document.php

Notes regarding the use of RF transceivers

The use of radio receivers and transmitters is subject to international standards and domestic regulations. Ensure that use of the product complies with the standards and regulations of the country in which it is used.

CAUTION

Before applying these application notes to another device, modify the software to suit the specifications of the device and thoroughly evaluate its operation.

LEGEND

File and folder names are highlighted as follows:

・ダウンロードした r01an5753xx0100-re-lora.zip を解凍↵
※フォルダパスに空白文字や全角文字が含まれているとビルドエラーになる為、解凍先に注意。↵

Application operations and commands are highlighted as follows:

・Renesas Welcome to e2studio はようこそタブの x を押下↵

Contents

1. Introduction

Before using the sample application, ensure that you have read and understood the Zero Carbon LoRa® Evaluation Board Tutorial (ZeroCarbon-LoRaEva_Tutorial.md).

The sample application uses a private LoRa® network that incorporates each vendor's proprietary communication protocol at the MAC layer. It is customizable for various applications and uses, while enabling optimization of communication networks.

A disadvantage is the need for each user to purchase and set up their own gateways.

However, the greatest advantage is that the costs associated with wireless communication between devices and gateways is eliminated.

(There is no need to subscribe to a wireless communication provider.)

In addition to the ultralow power consumption and energy harvesting functions of the RE01 MCU, the sample application shows how the LoRaEdge™LR1110 module can be used in remote sensing applications. In these application notes, pressing the trigger switch on a Zero Carbon board A (edge) triggers the acquisition of location data (from a Wi-Fi access point (hereinafter *AP*) or GNSS satellite information) and temperature and humidity data by a RE01 MCU-based LoRaEdge™LR1110. This data is then sent by LoRa® communication to LoRa® Cloud via a Zero Carbon board B (GW access) and a gateway (or a PC, hereinafter *GW*), and used to determine the location of the device.

The Zero Carbon board A uses the energy harvesting functionality of the RE01 MCU to charge its rechargeable battery using power supplied from a USB power supply or a solar panel. When the application is not transmitting, the device is placed in standby mode until the next transmission.

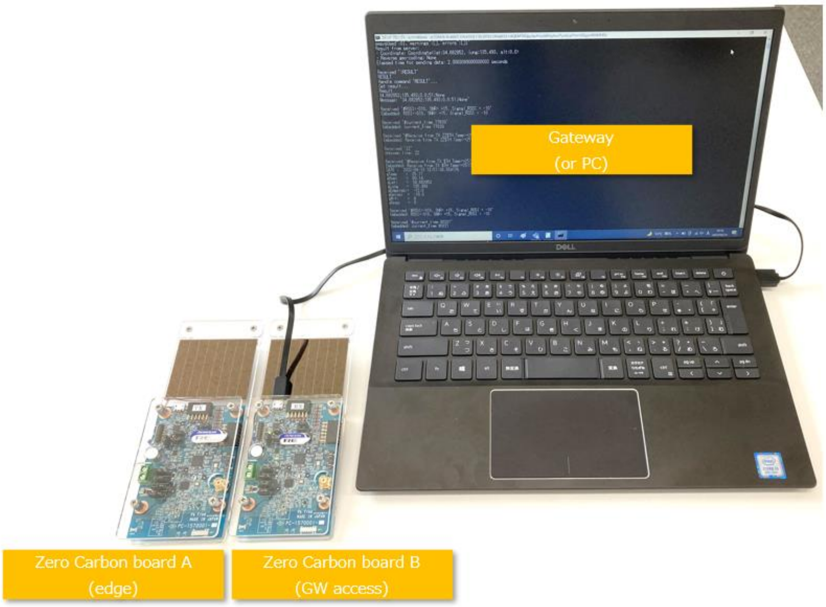

Figure 1 shows the overall setup.

■ Contact information for LoRaWAN® inquiries

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Tachibana Electronic Solutions Co., Ltd.

TEL: 06(7222)8211

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1.1. System overview

The system has four components: A Zero Carbon board A (edge), a Zero Carbon board B (GW access), a GW, and LoRa® Cloud.

The Zero Carbon board A (edge) and Zero Carbon board B (GW access) are based on the same board.

- The components of the common Zero Carbon boards are a Renesas RE01 MCU, a LoRa®LR1110 device, an HS3001 sensor, a rechargeable battery, a GNSS external antenna I/F, an external LoRa® communication antenna I/F, and a solar panel I/F. The jumper and switch settings and the firmware written to the RE01 MCU determine which is board A and which is board B.
- The components of the Zero Carbon board A (edge) are a common Zero Carbon board, a GNSS external antenna, a LoRa® external antenna (can be substituted with an internal antenna), and a solar panel (can be substituted with a USB power supply).
- The components of the Zero Carbon board B (GW access) are a common Zero Carbon board and a USB serial connector (for connecting a USB power supply and communicating with the GW).
- The GW sends Wi-Fi AP information or data received from the GNSS to LoRa® Cloud and receives results in the form of location information. The GW requires an internet connection.
- LoRa® Cloud determines location information based on the received Wi-Fi AP information or GNSS data.
-

System overview

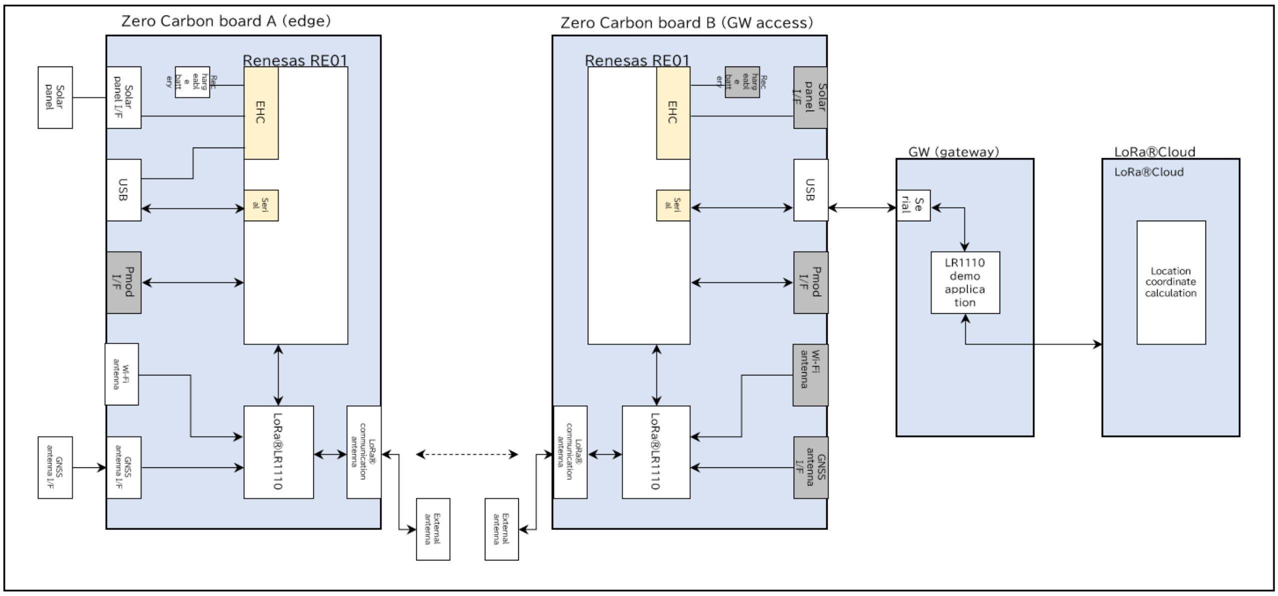


Figure 1-1 System overview

1.2. Pins used

The sample code does not use any MCU pins.

1.3. Required components

Table 1-3 lists the components required to execute the sample application. A barebones setup requires components 1 to 3 in the table.

Table 1-3 List of components

No.	Description	Part number	Made by
1	Zero Carbon board × 2	Zero Carbon LoRa® Evaluation Board	Tokyo Communication Equipment Manufacturing Co., Ltd. (Sold by Tachibana Electronic Solutions Co., Ltd.)
2	GNSS antenna	AA.170.301111	Taoglas Limited
3	USB Type-A to Micro-B cable × 2	-	General consumer product
4	Solar panel (for outdoor use)	AM-1815CA	Panasonic
5	Solar panel (for indoor use)	BCS4430B6	TDK
6	LoRa® dipole antenna	ANT-916-CW-HWR-RPS-ND	Linx Technologies Inc.
7	Connector conversion cable for dipole antenna	CSBMS156C-AND-125N	Antenna Technology Inc.

2. Setup Procedure and Application Behavior

2.1. Setup procedure

This section explains how to set up the sample application.

- Step 1: Set up a **LoRa® Cloud** account and acquire a MANAGE TOKEN.
  See the following resource:
  Zero Carbon LoRa® Evaluation Board Tutorial
  "3. Setting up a LoRa® Cloud Account"

- Step 2: Set up the application environment on the **GW** side.
  See the following resource:
  Zero Carbon LoRa® Evaluation Board Tutorial
  "4. Setting up the Application Environment on the PC"

- Step 3: Set up the environment for the **Zero Carbon board A (edge)**.
  First, update the firmware on the **Zero Carbon board A (edge)**.
  See the following resource:
  Zero Carbon LoRa® Evaluation Board Tutorial
  "7. Updating the Renesas RE01 Firmware (Common to Zero Carbon boards A and B)"

  Next, set the jumpers and switches and other settings to suit the environment.
  See the following resource:
  Zero Carbon LoRa® Evaluation Board Tutorial
  "5. Zero Carbon LoRa® Evaluation Board Jumper and Switch Layout Diagram"
  When powered by solar panel: "a. Settings when using energy harvesting devices"
  When powered by USB: "b. Settings when using USB fast charging " or "c. Settings when using a USB power supply "

  Connect the external GNSS antenna and, if needed, the external LoRa® communication antenna.
  If board A is USB-powered, connect it to a power bank or a PC by a USB cable.

- Step 4: Set up the environment for the **Zero Carbon board B (GW access)**.
  First, update the firmware on the **Zero Carbon board B (GW access)**.
  See the following resource:
  Zero Carbon LoRa® Evaluation Board Tutorial
  "7. Updating the Renesas RE01 Firmware (Common to Zero Carbon boards A and B)"

  Next, set the jumpers, switches, and other settings to suit the environment.
  See the following resource:
  Zero Carbon LoRa® Evaluation Board Tutorial
  "5. Zero Carbon LoRa® Evaluation Board Jumper and Switch Layout Diagram"
  "f. Settings when using USB to communicate and using a power supply"
  Use a USB cable to connect board B to the **GW**.

- Step 5: Confirm that each board is running.
  Confirm that the LEDs (green) are lit on the **Zero Carbon board A (edge)** and **Zero Carbon board B (GW access)**.

- Step 6: Start the application on the **GW** side.
  See the following resource:
  Zero Carbon LoRa® Evaluation Board Tutorial
  "10-1. Change the current directory to the LR1110 directory created in *4. Setting up the Application Environment on the PC,* and execute the following command"

- Step 7: Operate the system.
  Acquire temperature/humidity and latitude/longitude information.
  See the following resource:
  Zero Carbon LoRa® Evaluation Board Tutorial
  "10-2. Operate the Zero Carbon board A (edge)"

2.2. Application behavior

Figure 2-2 shows the behavior of the sample application after launch.

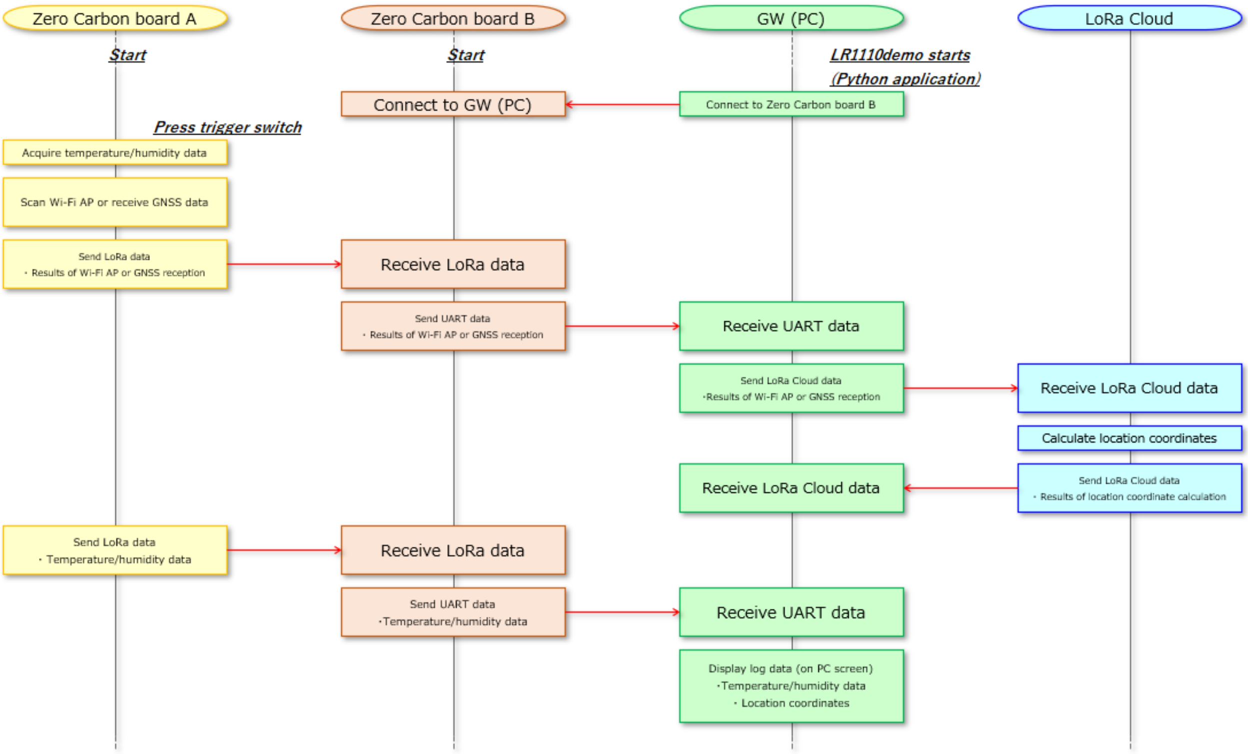


Figure 2-2 Flow of application behavior

3. Operation Check Conditions

The operation of the sample code supplied with these application notes was checked under the conditions in the following table.

Table 3. Operation check conditions

Item		Description
Microcontroller used		R7F0E01182DNG (RE01 256KB Group)
Operating frequency	Main External Oscillator	32MHz crystal oscillator
	Sub External Oscillator	32.768kHz crystal oscillator
Operating voltage		3.3V
Target board		Zero Carbon LoRa® Evaluation Board
Integrated development environment	GCC	Renesas e² studio Version 2021-04 (21.4.0)
C compiler	GCC	GNU ARM Embedded Version 6.3.1.20170620
Debugger		E2 lite
CMSIS driver package version		Ver 1.20
Sample version	document	2022-04-25 11:02 JST
	ZeroCarbonProjectPatch	2022-04-25 13:47 JST
	lr1110_evk_demo_app	2022-04-25 11:03 JST
	lr1110_modem_driver	2022-01-08 10:38 JST
	lr1110_driver	2022-01-08 9:57 JST
	re-driver_package	2022-01-06 19:57 JST

4. Hardware Configuration

This section explains in detail the hardware setup associated with the Zero Carbon board A (edge) and the Zero Carbon board B (GW access).

Figure 4 illustrates the layout of the jumpers, switches, and other elements.

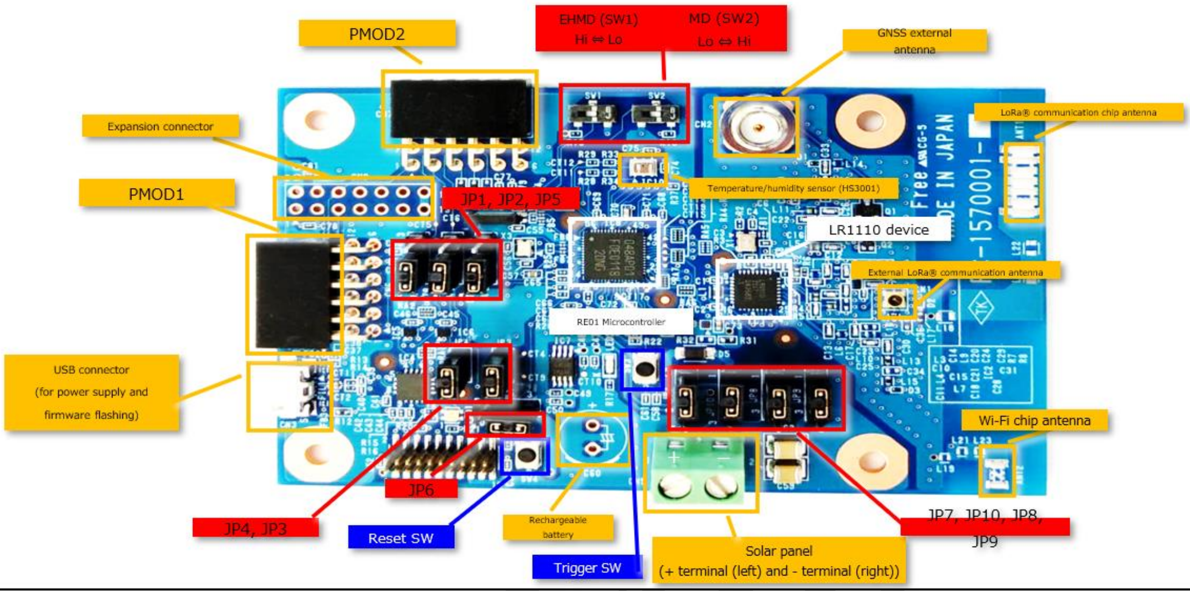


Figure 4 Layout of jumpers and switches

4.1. Board settings

The Zero Carbon board A (edge) and Zero Carbon board B (GW access) operate in the following modes:

- Common to both boards (when USB powered):
  - Zero Carbon board firmware flash mode implemented by Renesas Flash Programmer
  - LoRa®LR1110 device firmware flash mode
- Zero Carbon board A (edge) mode (when powered by USB or solar panel)
- Zero Carbon board B (GW access) mode (when powered by USB)

4.1.1. Common to board A/B: RFP Zero Carbon board firmware flash mode

For details about the board setup, see the following resource:
Zero Carbon LoRa® Evaluation Board Tutorial
"5. Zero Carbon LoRa® Evaluation Board Jumper and Switch Layout Diagram"
"d. Settings when flashing the RE01 from RFP and using a power supply "

For details about how to use Renesas Flash Programmer (RFP), see the following resource:
Zero Carbon LoRa® Evaluation Board Tutorial
"7. Updating the Renesas RE01 Firmware (Common to Zero Carbon boards A and B)"

4.1.2. Common to board A/B: LoRa®LR1110 device firmware flash mode

For details about the board setup, see the following resource:
Zero Carbon LoRa® Evaluation Board Tutorial
"5. Zero Carbon LoRa® Evaluation Board Jumper and Switch Layout Diagram"
"e. Settings when flashing the LR1110 FW (USB communication) and using a power supply"

For details about how to flash the LoRa®LR1110 device firmware, see the following resource:
Zero Carbon LoRa® Evaluation Board Tutorial
"6. Updating the LoRa® LR1110 Firmware (Common to Zero Carbon boards A and B)"

4.1.3. Zero Carbon board A (edge) mode

For details about the board setup, see the following resource:
Zero Carbon LoRa® Evaluation Board Tutorial
"5. Zero Carbon LoRa® Evaluation Board Jumper and Switch Layout Diagram"
When powered by solar panel: "a. Settings when using energy harvesting devices"
When powered by USB: "b. Settings when using USB fast charging"

4.1.4. Zero Carbon board B (GW access) mode

For details about the board setup, see the following resource:
Zero Carbon LoRa® Evaluation Board Tutorial
"5. Zero Carbon LoRa® Evaluation Board Jumper and Switch Layout Diagram"
"f. Settings when using USB to communicate and using a power supply"

4.2. Connecting a solar panel

Connect the solar panel to the connection point shown in Figure 4-2.

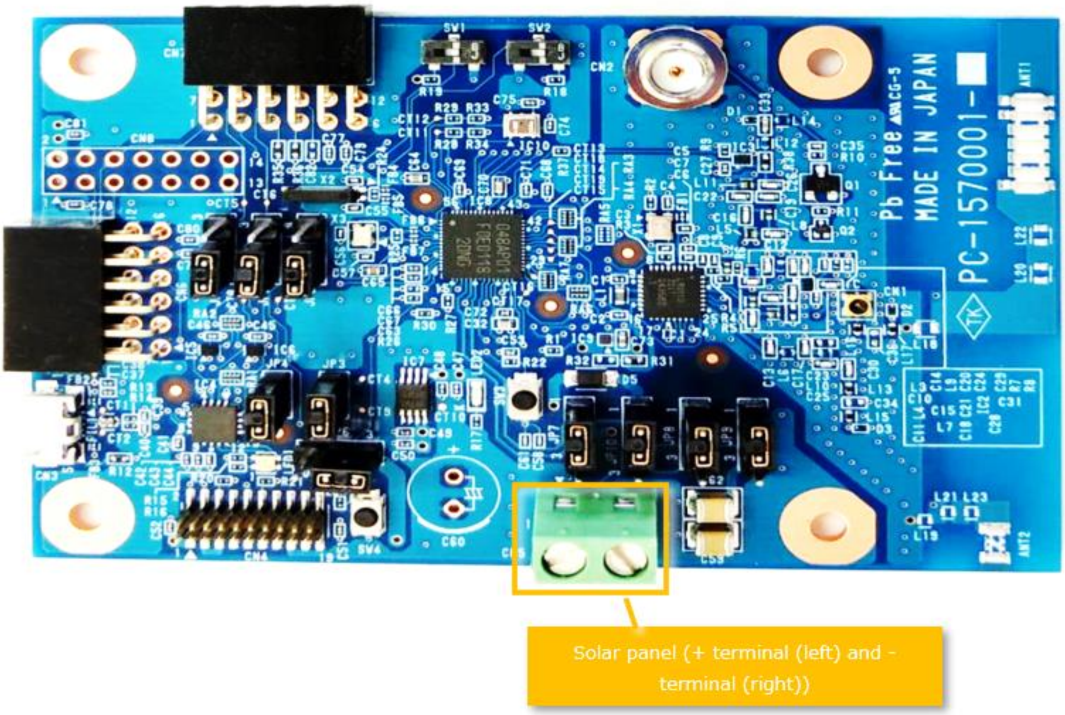


Figure 4-2 Solar panel connection point

4.3. Connecting an external GNSS antenna

Connect the GNSS antenna to the connection point shown in Figure 4-3.

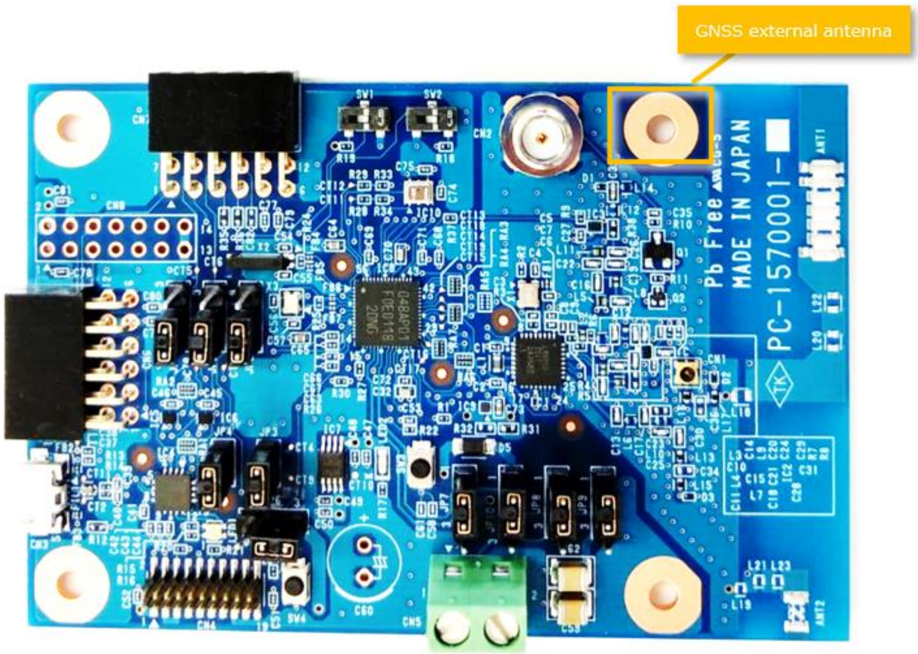


Figure 4-3 GNSS antenna connection point

4.4. Connecting an external LoRa® communication antenna

When using an external LoRa® communication antenna, use an antenna connector adapter cable to connect the antenna to the connection point shown in Figure 4-4.

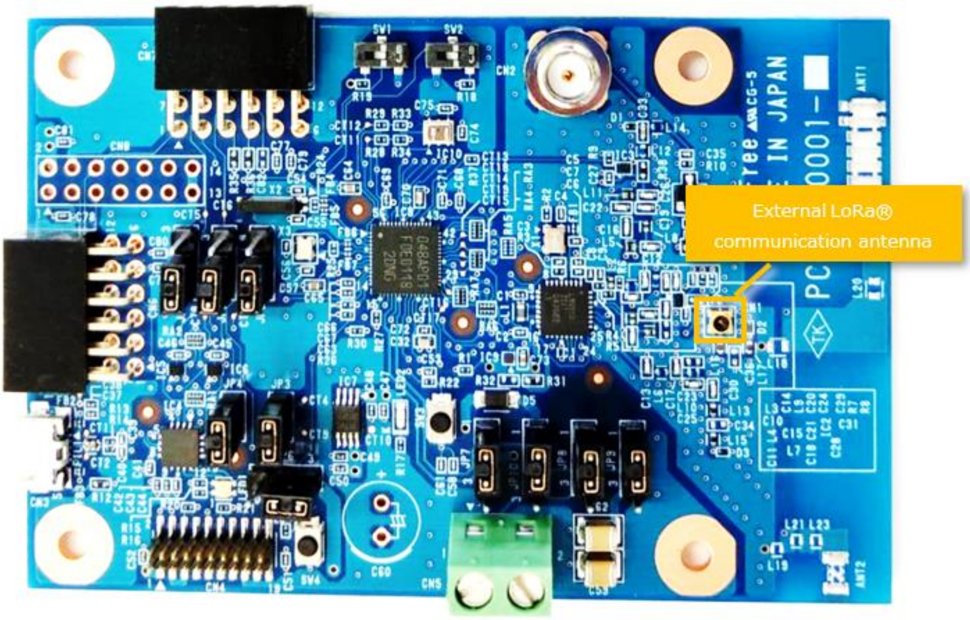


Figure 4-4 External LoRa® communication antenna connection point

4.5. Connecting Pmod modules

Connect Pmod# modules to the Pmod connectors shown in Figure 4-5.

#: Pmod is a standard defined by Diligent for connecting low-frequency, low-I/O pin count peripheral modules to host FPGA controller boards. For details about the Pmod standard, see the Digilent website.

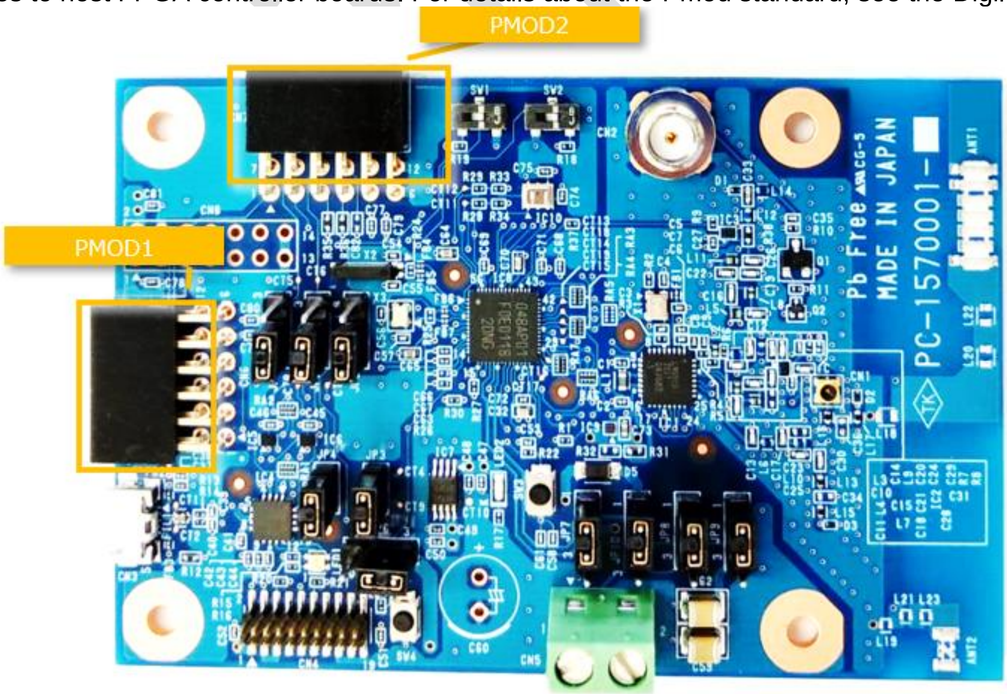


Figure 4-5 Pmod connectors

5. Software Operation

This chapter explains the software specifications of the sample code.

5.1. Folder structure

Figure 5-1 shows the folder structure of the sample code. This sample code was prepared based on "Application Note RE01 256KB".

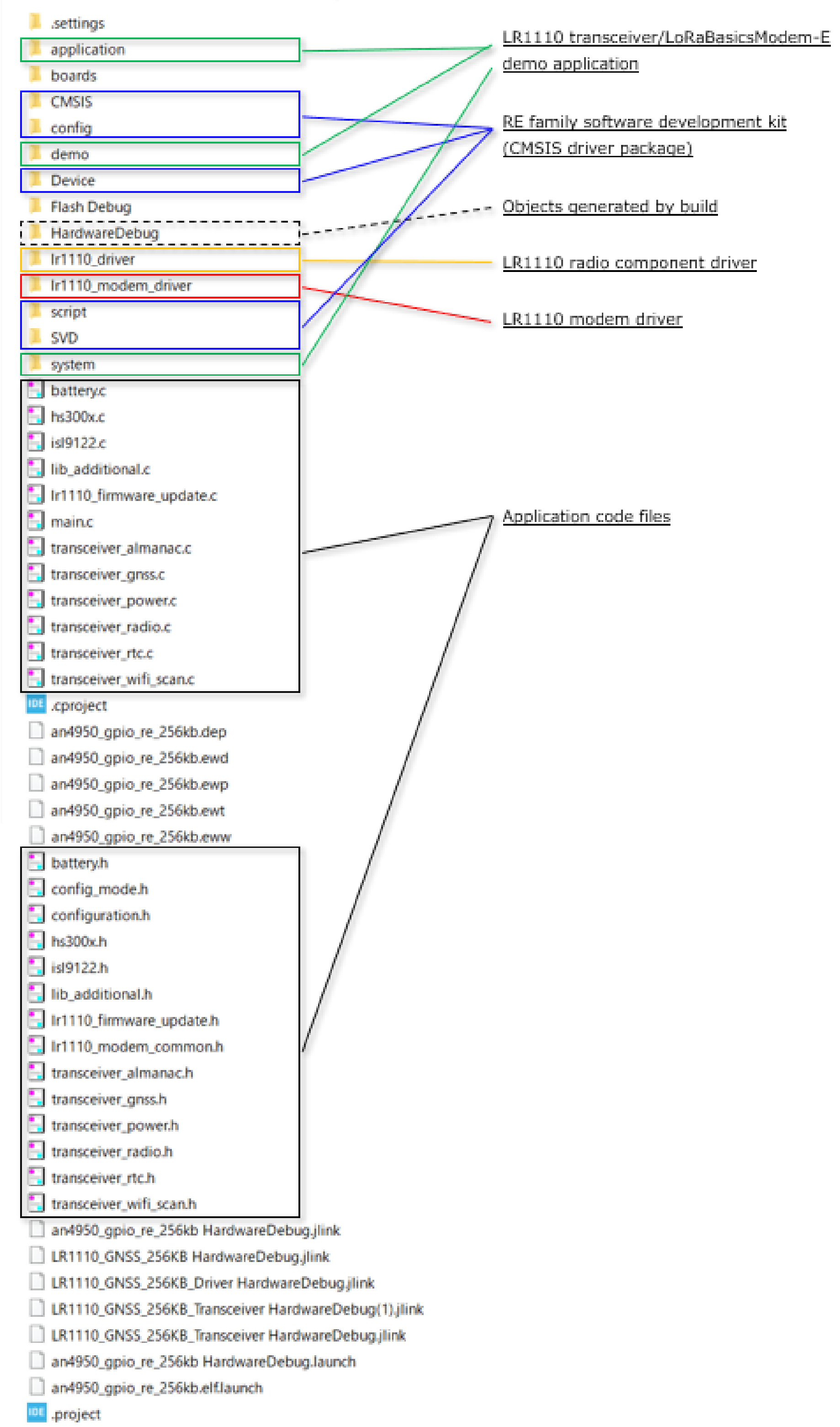


Figure 5-1 Folder structure

5.2. File structure

Table 5-2 lists the application files added to or changed from the "Application Note RE01 256KB" group files.

Table 5-2 File structure

File name	Overview of processing or settings	Remarks
config_mode.h	Definition of Zero Carbon board configuration	Send/receive/update settings, connected antenna/server transmission settings
configuration.h	LR1110 EVK settings	LR1110 device environment settings
main.c	Main processing	Main application group
hs300x.c	Acquisition of HS300x sensor data	Sensor read requests, data acquisition processing
hs300x.h	Definition of HS300x sensor settings	-
lr1110_firmware_update.c	LR1110 firmware update processing	-
lr1110_firmware_update.h	LR1110 firmware update definitions	-
transceiver_almanac.c	Acquisition and setting of almanac data	For LoRa® transceiver
transceiver_almanac.h	Definition of almanac data	For LoRa® transceiver
transceiver_gnss.c	Acquisition and setting of GNSS data	For LoRa® transceiver
transceiver_gnss.h	Definition of GNSS data	For LoRa® transceiver
transceiver_power.c	Application of LR1110 power source settings	For LoRa® transceiver
transceiver_power.h	Definition of LR1110 power source settings	For LoRa® transceiver
transceiver_radio.c	Application of LR1110 initial settings and send/receive settings	For LoRa® transceiver
transceiver_radio.h	Definition of LR1110 initial settings and send/receive settings	For LoRa® transceiver
transceiver_rtc.c	Application of date and time correction	For LoRa® transceiver
transceiver_rtc.h	Definition of date and time correction	For LoRa® transceiver
transceiver_wifi_scan.c	Wi-Fi MAC address scanning	For LoRa® transceiver
transceiver_wifi_scan.h	Settings for Wi-Fi MAC address scanning	For LoRa® transceiver
lib_additional.c	Processing of shared library	-
lib_additional.h	Definition of shared library	-
lr1110_modem_common.h	Common definition of modem drivers for LR1110	-

5.3. Creating the development environment

This section explains how to create the project.

5.3.1. Link destinations

Table 5-3-1 contains links to the resources required to create the development environment.

Table 5-3-1 Link destinations

No.	Target	Link destination
①	ZeroCarbonProject Patch data	https://github.com/ZeroCarbon-LoRaEva/ZeroCarbonProjectPatch
②	Renesas driver package	https://github.com/ZeroCarbon-LoRaEva/re-driver-package
③	LoRa®lr1110 EVK demo application	https://github.com/ZeroCarbon-LoRaEva/lr1110_evk_demo_app
④	LoRa®lr1110 driver	https://github.com/ZeroCarbon-LoRaEva/lr1110_driver/tree/Branch_v3.0.0_kai
⑤	LoRa®lr1110 modem driver	https://github.com/ZeroCarbon-LoRaEva/lr1110_modem_driver/tree/Branch_v2.0.1_kai

5.3.2. Downloading and extracting Github archives

Download the necessary files from the Github repositories in *5.3.1. Link destinations* by selecting Download ZIP from the Code drop-down menu on each page.

The following folders are created when the files are extracted.

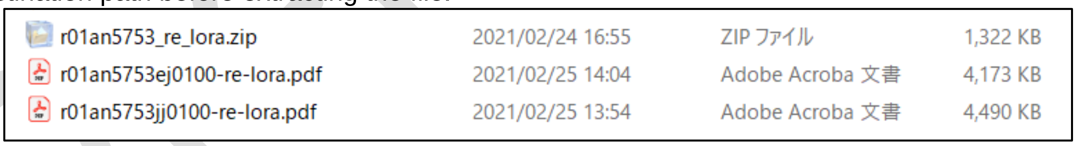
- ① ZeroCarbonProjectPatch-main
- ② re-driver-package-master
- ③ lr1110_evk_demo_app-master
- ④ lr1110_driver-Branch_v3.0.0_kai
- ⑤ lr1110_modem_driver-Branch_v2.0.1_kai

5.3.3. Downloading the base project

Download and extract the file on which the project is based from the Renesas website.

- Download the file from the following URL:
  Application Note RE01 256KB Group Battery Maintenance Free LoRaWAN® Sensor Energy Harvesting

- Unzip the file r01an5753xx0100-re-lora.zip you downloaded.
  Note: A build error will occur if the folder path contains spaces or fullwidth characters. Check the destination path before extracting the file.



- Extract the file r01an5753_re_lora.zip

名前	更新日時	種類	サイズ
.settings	2021/02/20 11:15	ファイル フォルダー	
boards	2021/02/20 11:15	ファイル フォルダー	
CMSIS	2021/02/20 11:15	ファイル フォルダー	
config	2021/02/20 11:15	ファイル フォルダー	
Device	2021/02/20 11:15	ファイル フォルダー	
Flash Debug	2021/02/24 16:52	ファイル フォルダー	
HardwareDebug	2021/02/24 16:54	ファイル フォルダー	
mac	2021/02/20 11:15	ファイル フォルダー	
radio	2021/02/20 11:15	ファイル フォルダー	
Resource	2021/02/20 11:15	ファイル フォルダー	
script	2021/02/20 11:15	ファイル フォルダー	
SVD	2021/02/20 11:15	ファイル フォルダー	
system	2021/02/20 11:15	ファイル フォルダー	
.cproject	2021/02/24 16:53	CPROJECT ファイル	45 KB
.project	2021/01/29 21:23	PROJECT ファイル	1 KB
agt0_timer.c	2021/01/22 16:04	C ファイル	6 KB
agt0_timer.h	2020/10/27 16:08	H ファイル	3 KB
agt1.c	2020/10/27 16:08	C ファイル	7 KB
agt1.h	2020/10/27 16:08	H ファイル	3 KB
Commissioning.h	2021/02/24 16:50	H ファイル	6 KB
error.h	2020/10/27 16:08	H ファイル	3 KB
hs300x.c	2021/01/28 16:35	C ファイル	6 KB
hs300x.h	2021/01/28 17:49	H ファイル	3 KB
lcd.c	2021/01/12 15:48	C ファイル	31 KB
lcd.h	2020/12/21 16:41	H ファイル	5 KB
lvd_lvdbat.c	2021/01/20 19:45	C ファイル	34 KB
lvd_lvdbat.h	2020/12/21 16:41	H ファイル	6 KB
main.c	2021/02/24 13:49	C ファイル	60 KB
main.h	2021/02/24 10:32	H ファイル	13 KB
mip_display.c	2020/12/23 16:32	C ファイル	11 KB

- Rename the folder.
  r01an5753_re_lora → ZeroCarbonProject

5.3.4. Applying patch data

Apply the patch data to the ZeroCarbonProject folder.

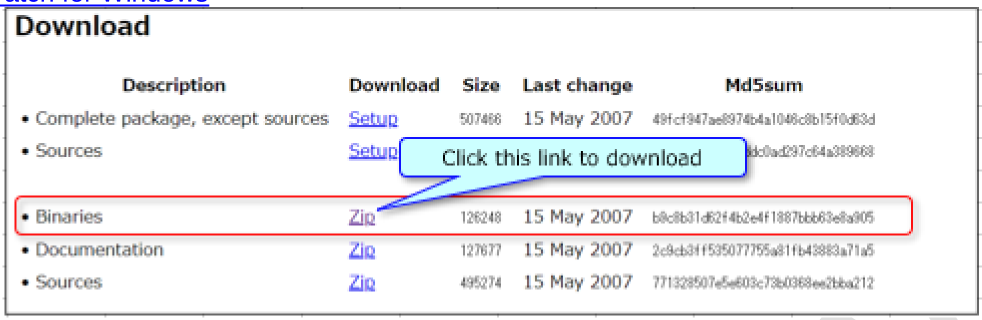
- Download extraction folder: ①ZeroCarbonProjectPatch-main
- Application target folder: ZeroCarbonProject
- Patch data files:
  0001-FileAndFolder-delete.patch
  0002-ZeroCarbon-Custom.patch

Copy the patch data files to the same level as the ZeroCarbonProject folder.

ZeroCarbonProject	2022/03/30 10:55	ファイル フォルダー	
0001-FileAndFolder-delete.patch	2022/03/16 13:59	Patch File	2,611 KB
0002-ZeroCarbon-Custom.patch	2022/03/16 13:59	Patch File	668 KB

1. Prepare the patch command.
   Because Windows has no patch command by default, you need to install it separately.
   You can obtain the patch command for Windows from websites like the following:

[Patch for Windows]

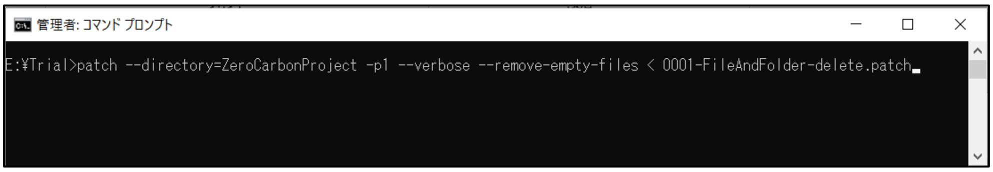


   Extract the downloaded zip file to a folder of your choice.
   Due to Windows constraints, you must execute the patch command from a Command Prompt with administrator privileges.
   Before running the patch command, you must first execute the following command to register the path of the patch.exe file.
   set PATH=%PATH%;"*folder-containing-extracted-patch-command*¥patch-2.5.9-7-bin¥bin"

   Example:
   Folder containing extracted command file:
   E:¥ZeroCarbonProject¥patch-2.5.9-7-bin¥bin
   Path registration command:
   set PATH=%PATH%;"E:¥ZeroCarbonProject¥patch-2.5.9-7-bin¥bin"

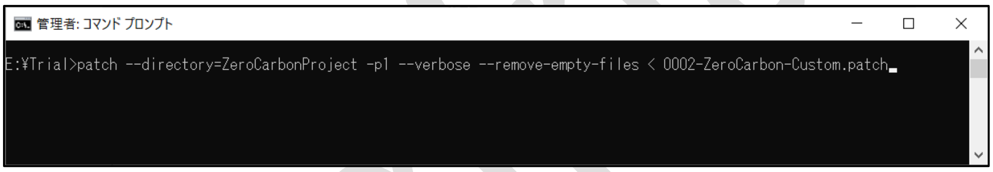
2. Open Command Prompt and use the cd command to change the current folder to the folder containing the ZeroCarbonProject folder.

3. Execute the following command.
patch --directory=ZeroCarbonProject -p1 --verbose --remove-empty-files < 0001-FileAndFolder-delete.patch

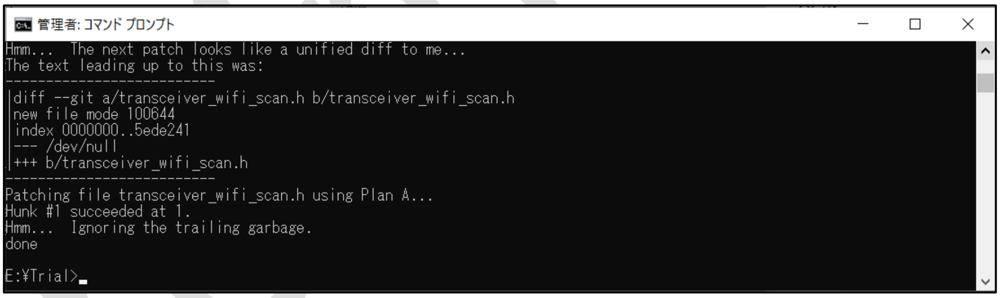


If command execution is successful, the window appears as follows:

patch --directory=ZeroCarbonProject -p1 --verbose --remove-empty-files < 0002-ZeroCarbon-Custom.patch



If command execution is successful, the window appears as follows:



5.3.5. Overwriting with downloaded code

Replace the files and folders in the ZeroCarbonProject folder with the downloaded code.

5.3.5.1. Folder created by extracting downloaded file: ② re-driver-package-master

re-driver-package-master¥SDK_RE01_256KB¥RE01_256KB_DFP
Overwrite the following folders in the ZeroCarbonProject folder by copying the equivalent folders in the preceding folder to the ZeroCarbonProject folder.

- CMSIS
- config
- Device
- script
- SVD

5.3.5.2. Folder created by extracting downloaded file: ③ lr1110_evk_demo_app-master

lr1110_evk_demo_app-master¥embedded
Overwrite the following folders in the ZeroCarbonProject folder by copying the equivalent folders in the preceding folder to the ZeroCarbonProject folder.

- application
- demo
- system

5.3.5.3. Folder created by extracting downloaded file: ④ lr1110_driver-Branch_v3.0.0_kai

lr1110_driver-Branch_v3.0.0_kai
Copy the preceding folder to the ZeroCarbonProject folder, and rename it as follows:

・lr1110_driver

5.3.5.4. Folder created by extracting downloaded file: ⑤lr1110_modem_driver-Branch_v2.0.1_kai

lr1110_modem_driver-Branch_v2.0.1_kai
Copy the preceding folder to the ZeroCarbonProject folder, and rename it as follows:

・lr1110_modem_driver

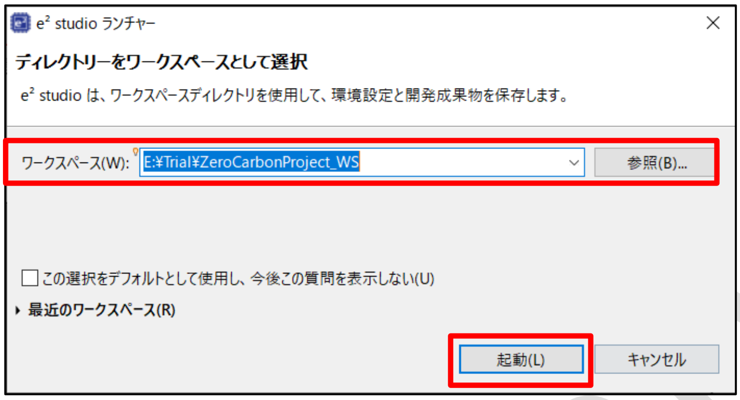
5.3.6. Installing the e² studio integrated development environment

Download and install the e² studio environment from the following section of the Renesas website:
Resources - RE Family Development Environment
https://www.renesas.com/re01-256kb

5.3.7. Importing and building ZeroCarbonProject

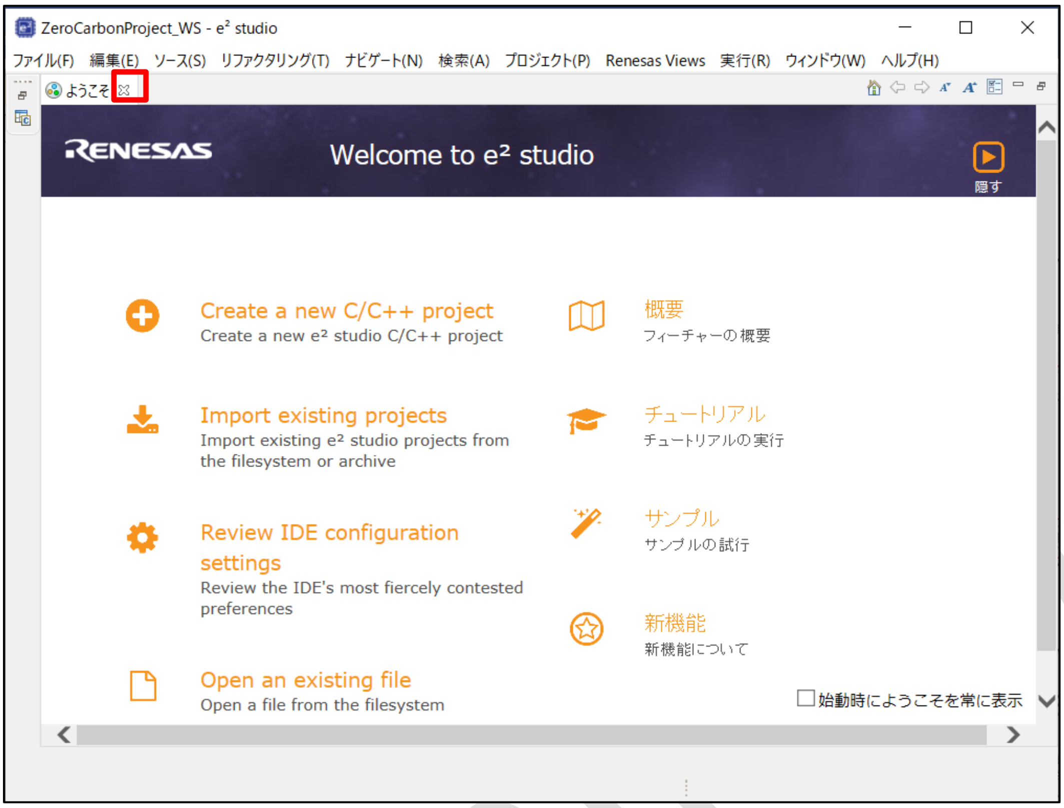
Import ZeroCarbonProject into the e² studio integrated development environment and build the project.

- Start e² studio.
- Specify the workspace directory and then click Launch.

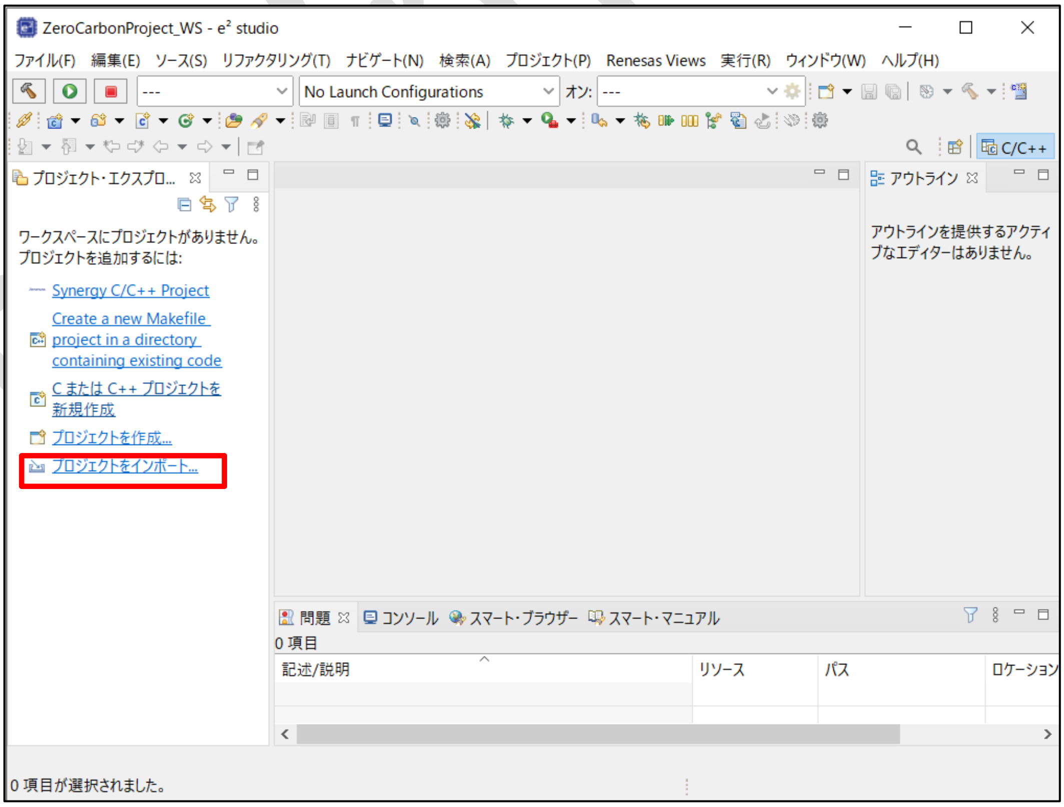


- In the Collect log/usage data dialog box, click the Cancel button.

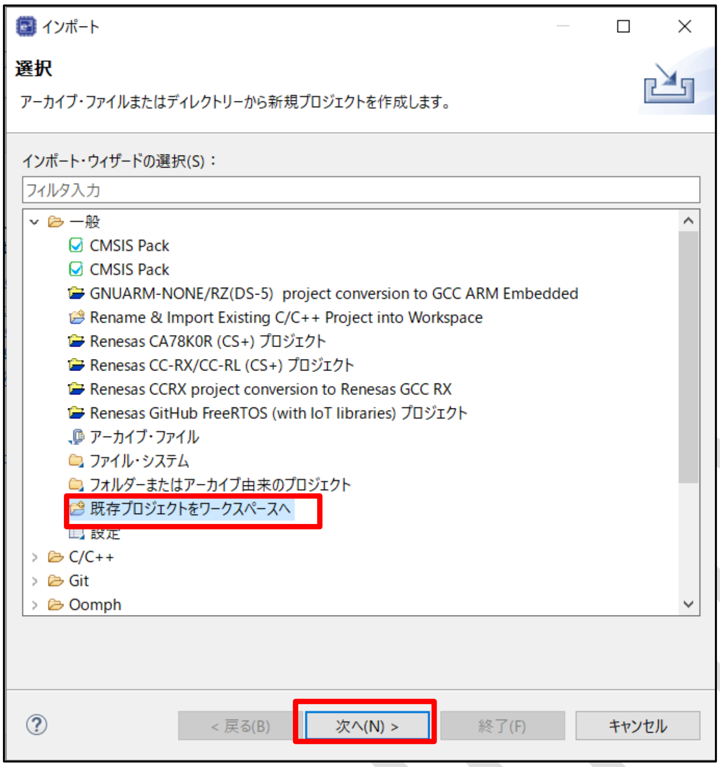
- Click the x on the Welcome tab of the Renesas Welcome to e² studio window.



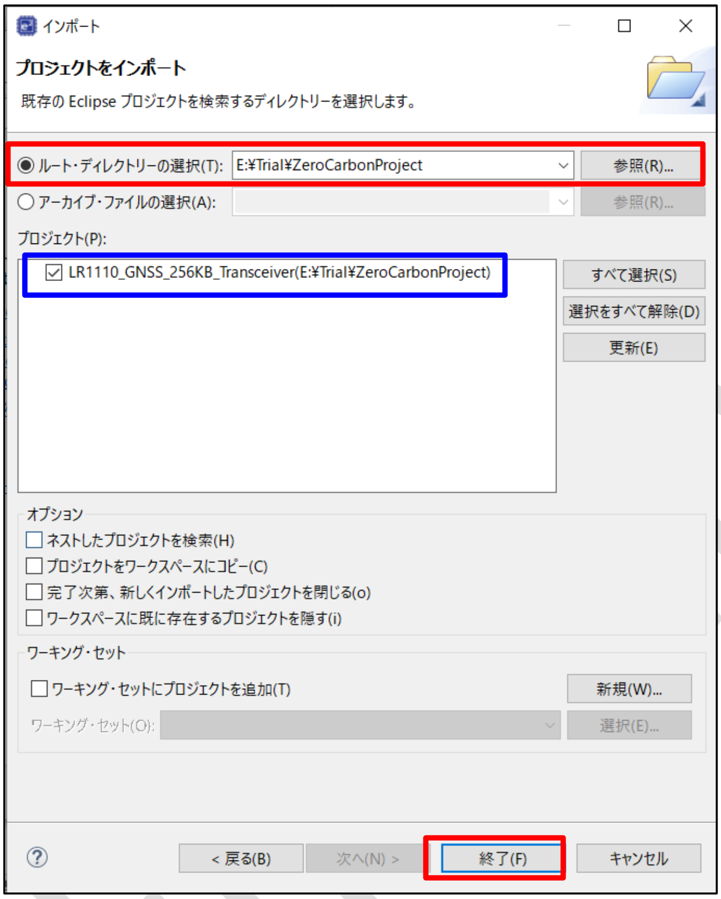
- In the Project Explorer area, click Import Projects.



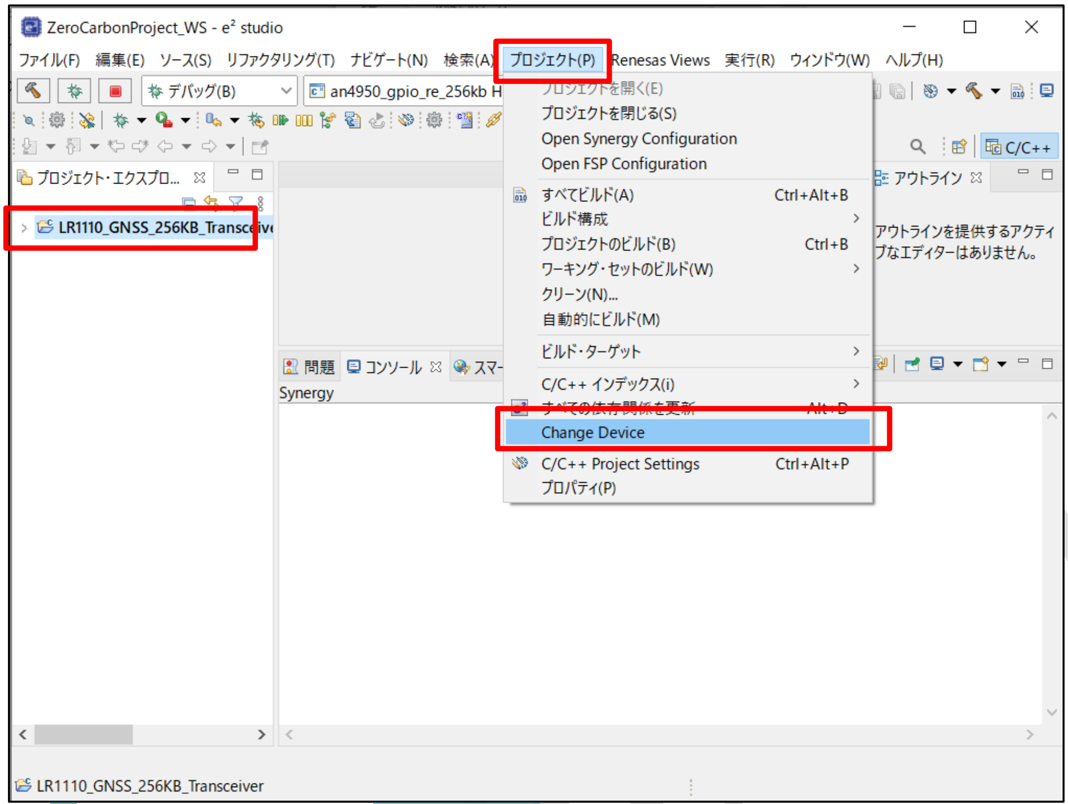
- Under the General node, select Existing Projects into Workspace and then click Next.



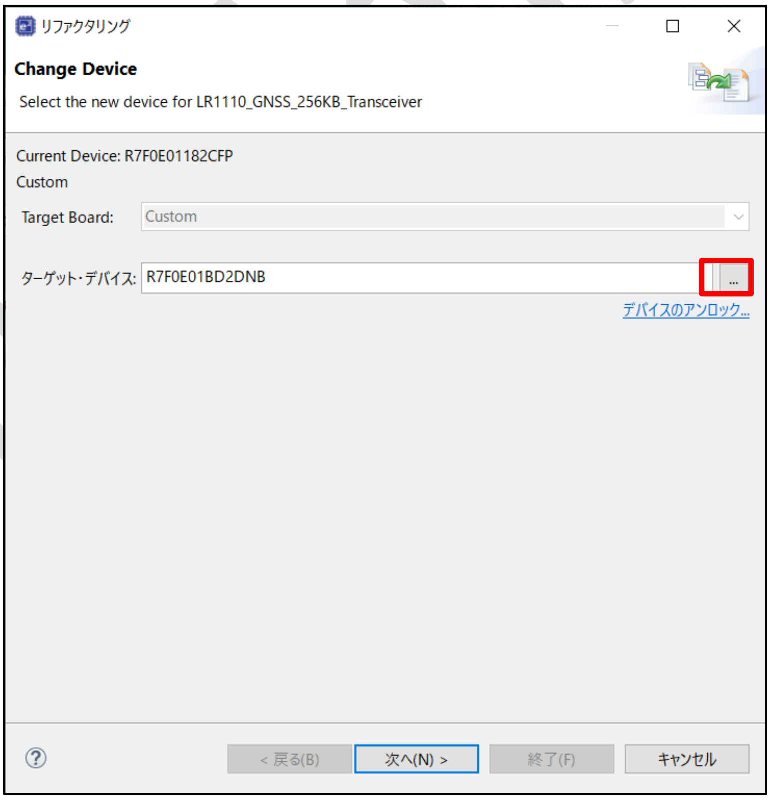
- Click the Browse button beside the Select root directory field, select the project folder you created (which appears as LR1110_GNSS_256KB_Transceiver in the Projects area), and then click the Finish button.



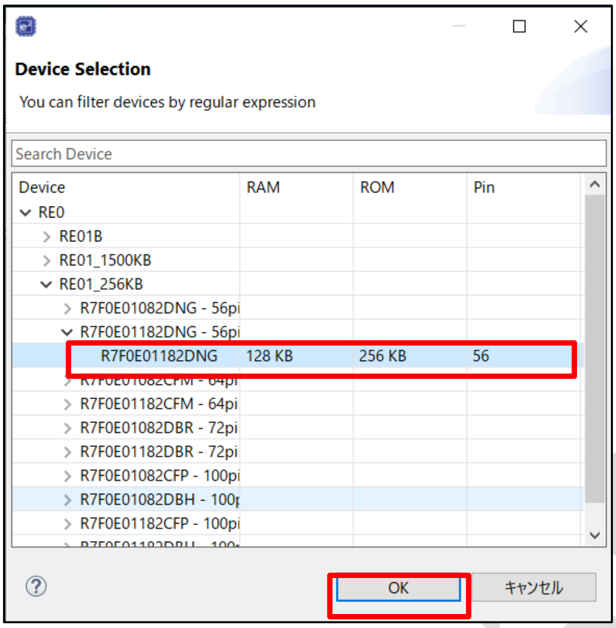
- Select LR1110_GNSS_256KB_Transceiver in the Project Explorer area, and from the Project menu, select Change Device.



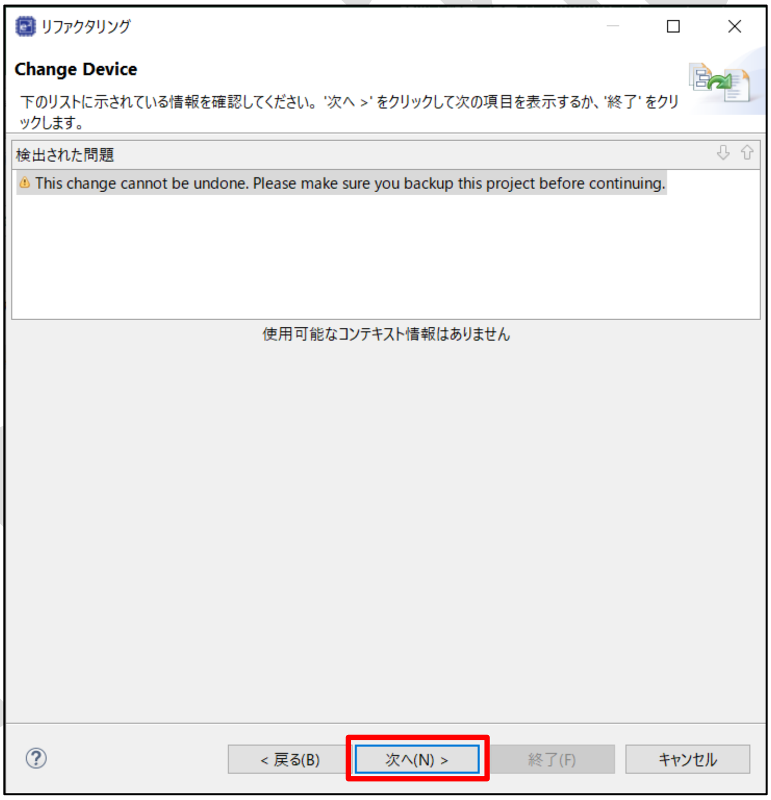
- Click the … button to the right of the Target Device field.



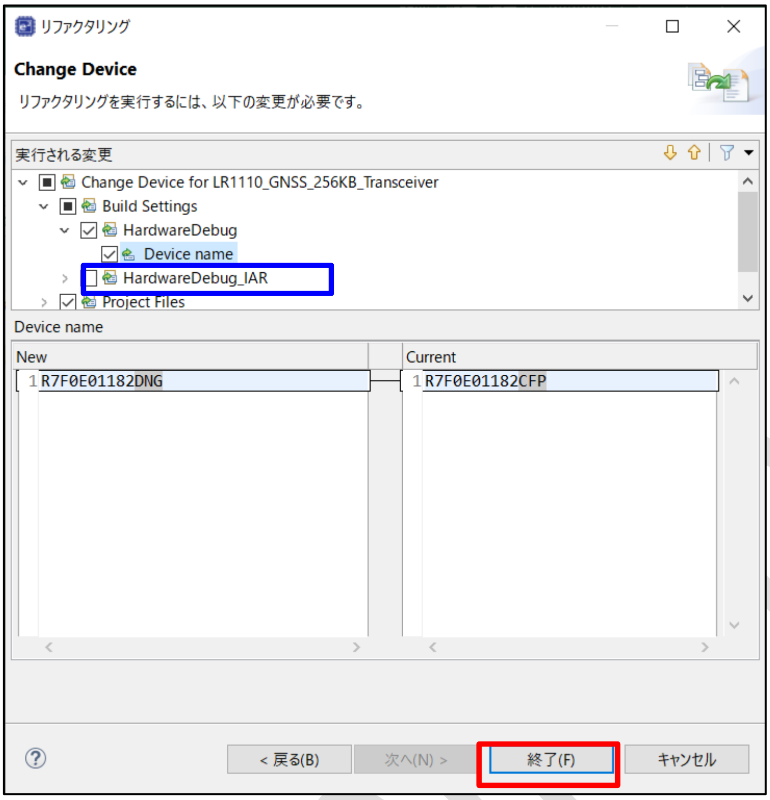
- In the Device Selection dialog box, select R7F0E01182DNG and then click OK.



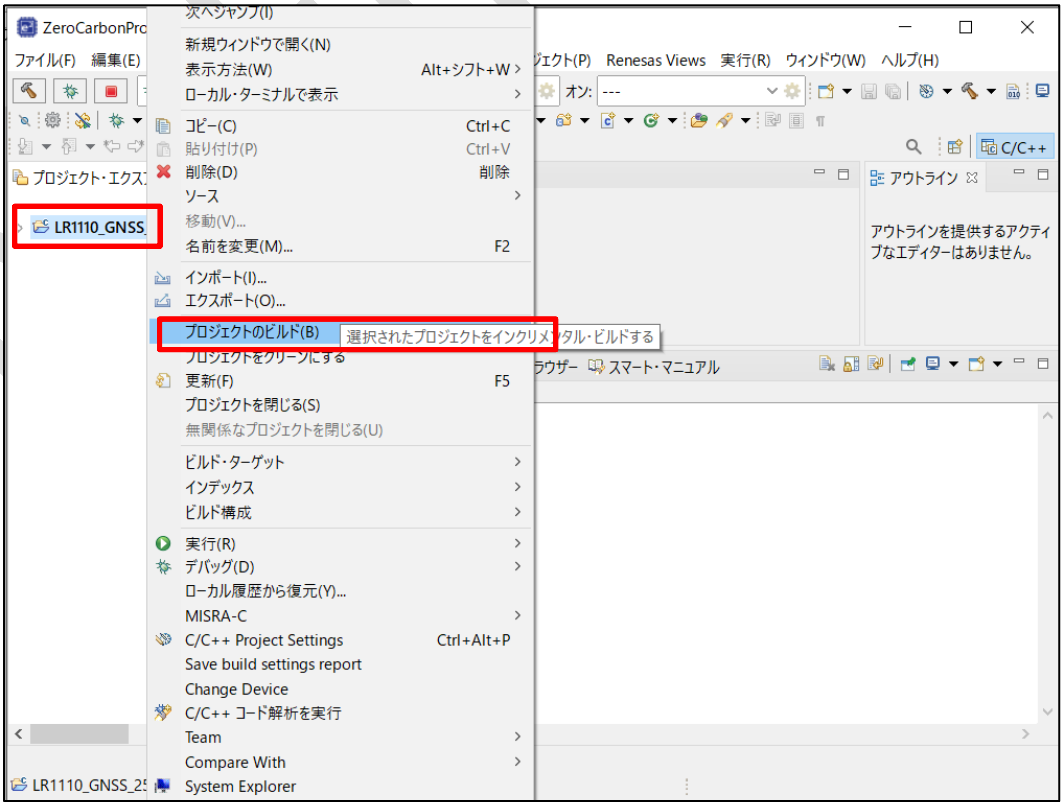
- Click Next.



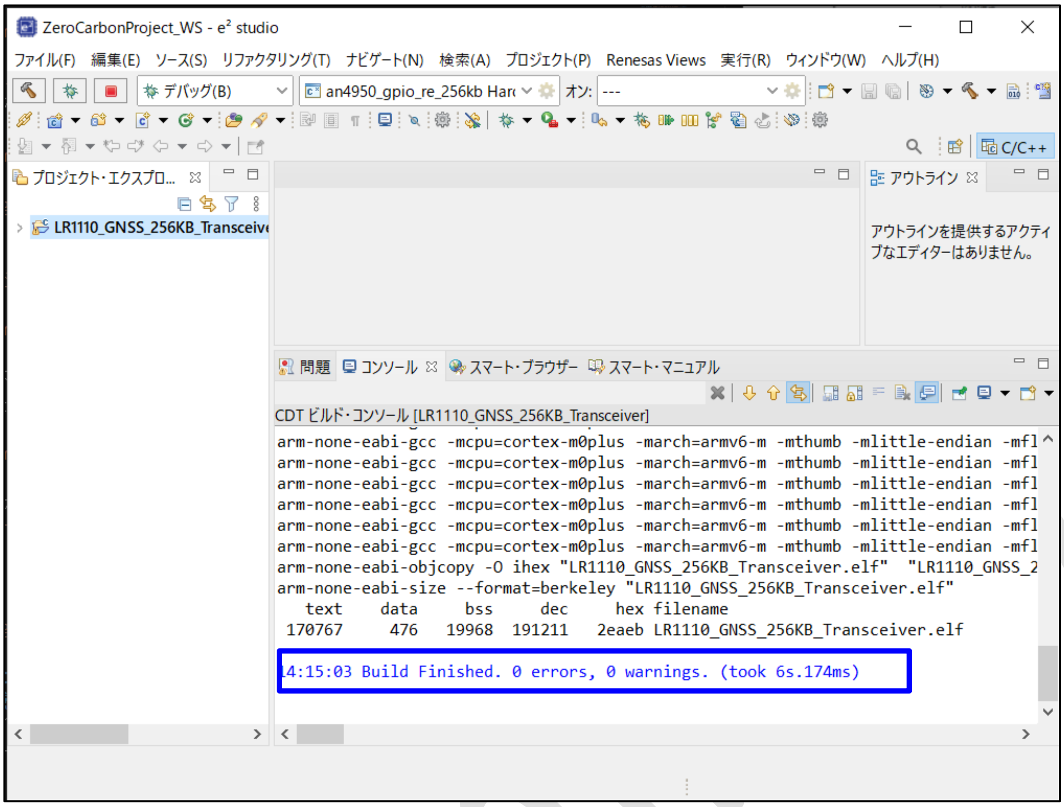
- In the Changes to be performed list, clear the check box beside HardwareDebug_IAR and then click Finish.



- In the Project Explorer area, right-click LR1110_GNSS_256KB_Transceiver and select Build Project from the context menu.



- The build is successful if Build Finished 0 error, 0 warnings appears on the Console tab at the bottom right of the window.



- The .hex file for the project is generated in the following folder:
  ZeroCarbonProject¥HardwareDebug¥LR1110_GNSS_256KB_Transceiver.hex

5.4. Hardware resources

Table 5-4 shows the hardware interrupt used by the sample code.

Table 5-4 Hardware resources

Used for	Interrupt name	Description
Trigger switch	IRQ3_IRQHandler	An interrupt used to wake from standby mode. This interrupt is always enabled.

5.5. List of constants

The following explains the constants used in the sample code.

5.5.1. Board-specific constants

The following table shows the board-specific constant used in the project. This constant is declared in the file ZeroCarbonProject/config_mode.h.

Table 5-6-1 Board-specific constants

Constant name	**Zero Carbon board A (edge)** **Note: This is the default value**	**Zero Carbon board B (GW access)**
TRACKER_RX_TX_UPDATE (for switching between boards A and B)	2	1

5.6. Flowchart

The following flowcharts show the operation of the sample code.

5.6.1. Zero Carbon board A (edge)

Figure 5-6-1 is a flowchart for Zero Carbon board A (edge).

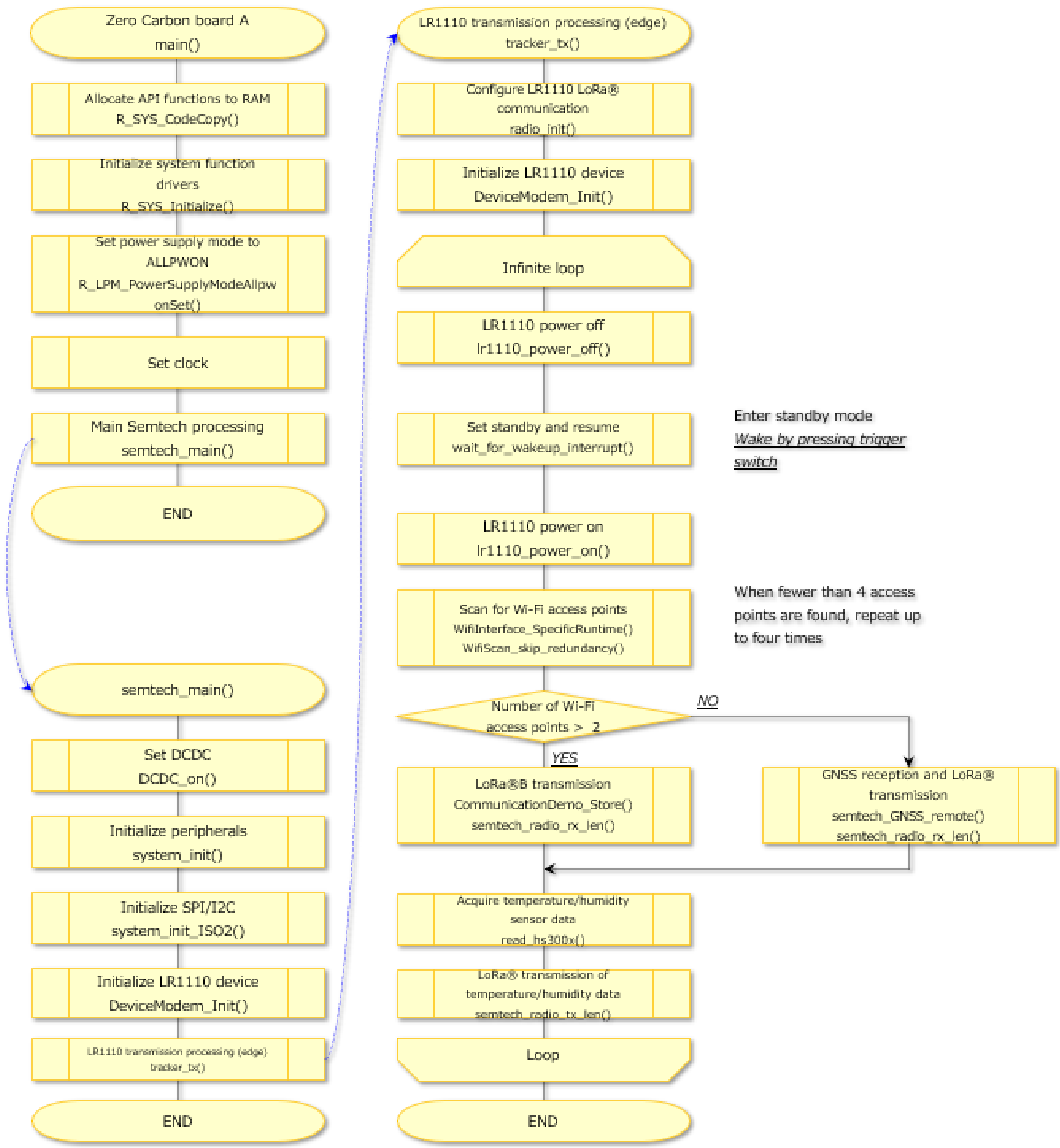


Figure 5-6-1

5.6.2. Zero Carbon board B (GW access)

Figure 5-6-2 is a flowchart for Zero Carbon board B (GW access).

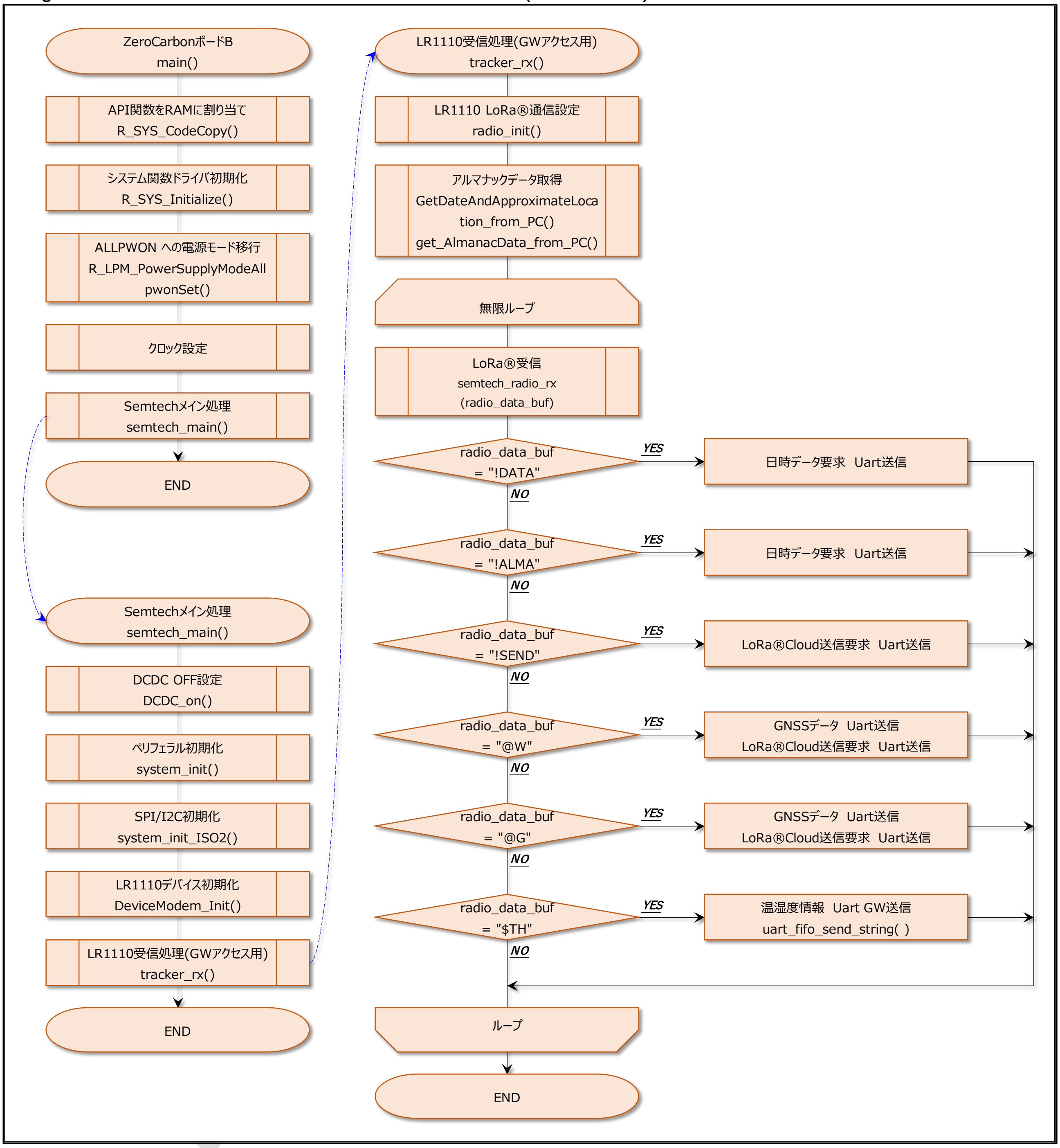


Figure 5-6-2

5.6.3. GW

Figure 5-6-3 is a flowchart for the GW.

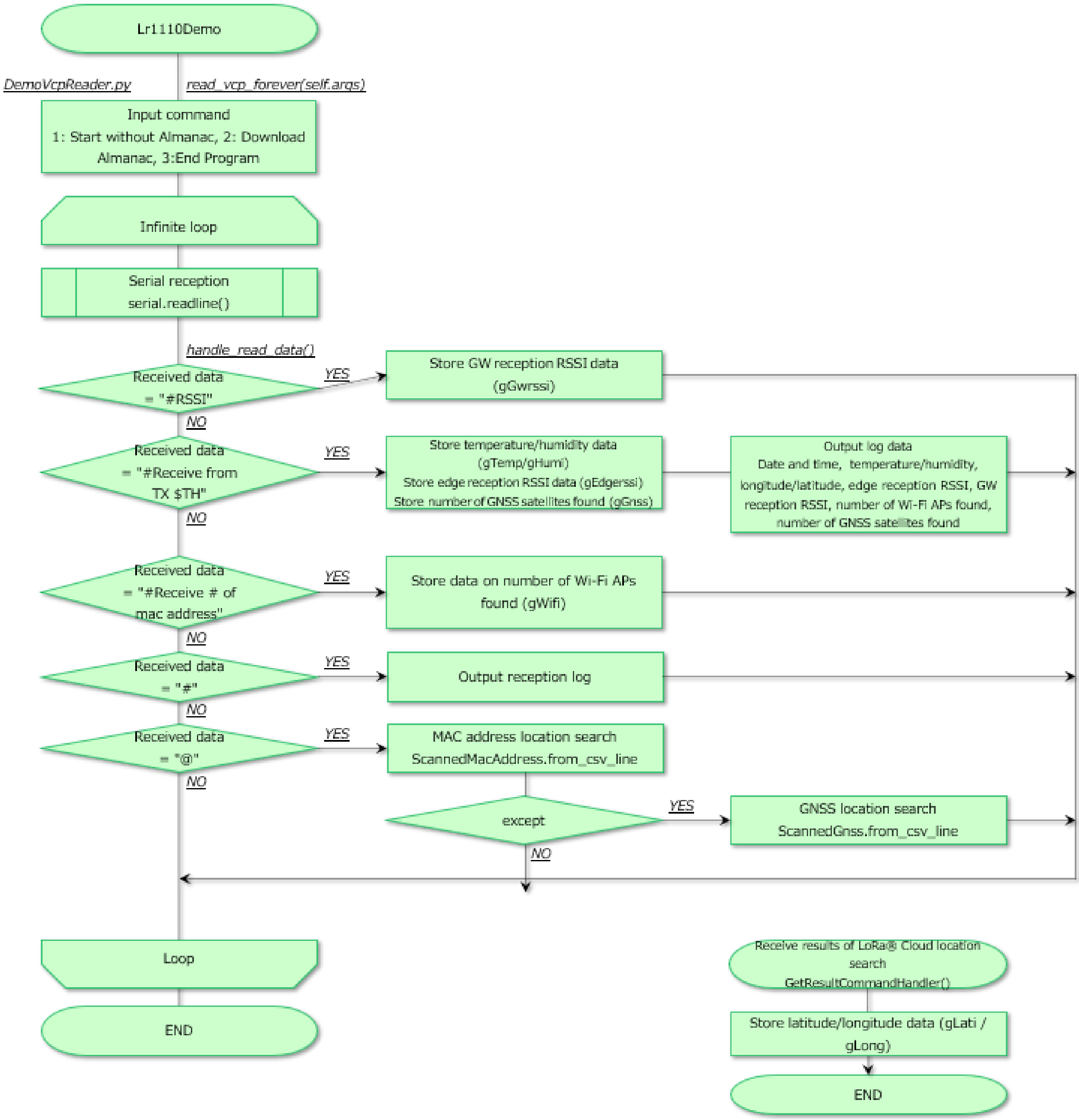


Figure 5-6-3

5.7. Block diagrams

Figure 5-7 illustrates the software layers.

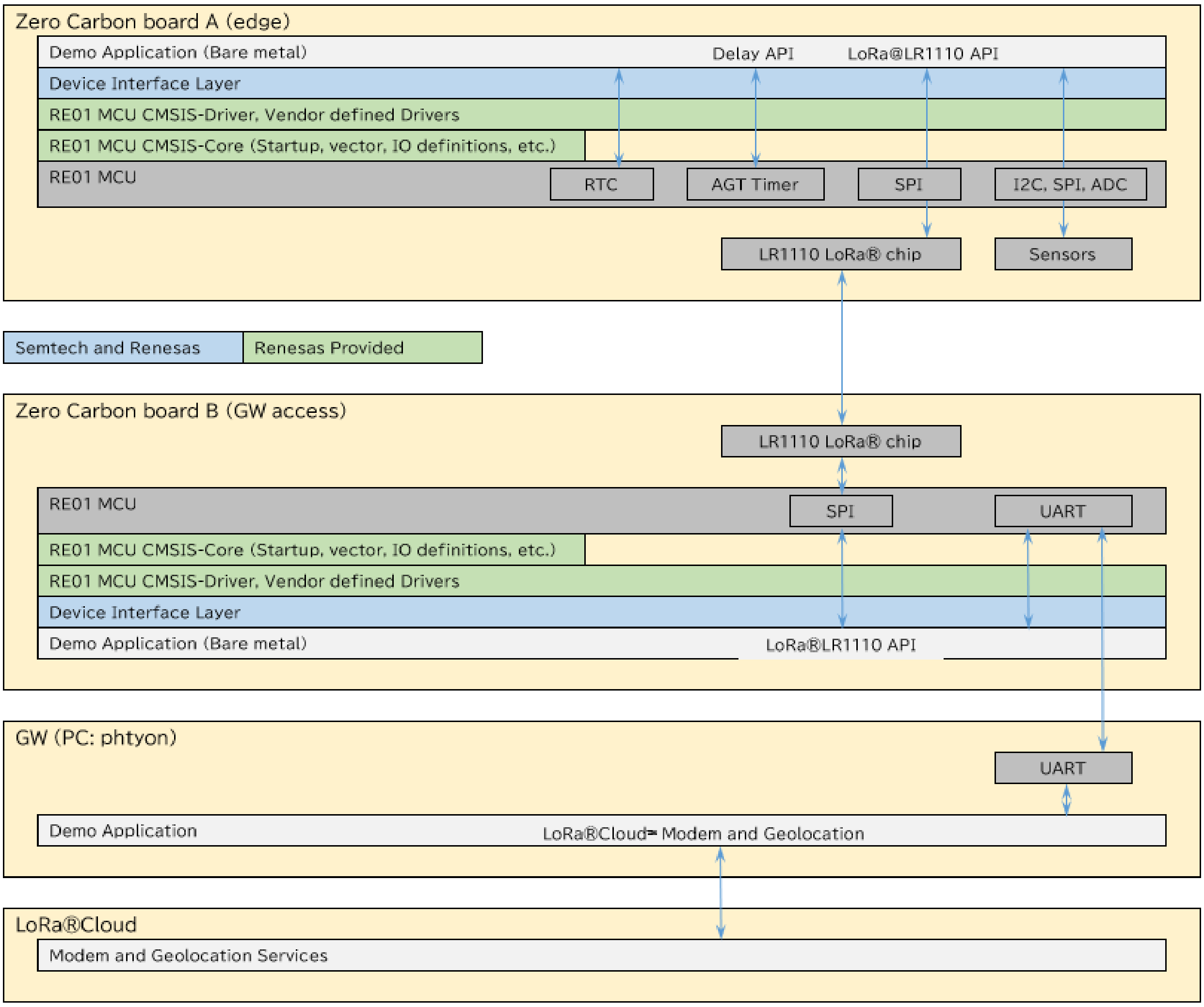


Figure 5-7 Block diagrams

5.8. LoRa® communication settings

Note: Applying the settings in this section incorrectly might result in violation of radio communication laws. Exercise care when applying these settings.

With reference to the following sections, set the LoRa® communication settings of the **Zero Carbon board A (edge)** and **Zero Carbon board B (GW access)**. Use the same settings for both boards.

5.8.1. LoRa® communication packet modulation parameter settings

See the following resource for details on modulation parameter settings.

LR1110 Transceiver User Manual (UserManual_LR1110_V1_2.pdf)
"8.3.1 SetModulationParams"

The blue boxes in the following figure indicate the initial settings of the sample code.

Table 8-4: SetModulationParams Command

Byte	0	1	2	3	4	5
Data from Host	0x02	0x0F	SF	BWL	CR	LowDataRateOptimize
Data to Host	Stat1	Stat2	IrqStatus (31:24)	IrqStatus (23:16)	IrqStatus (15:8)	IrqStatus (7:0)

- *SF* defines the spreading factor (values other than those below are RFU). SF5 and SF6 are compatible with the SX126x device family, but SF6 is not compatible with the SX127x family.:
  - 0x05: SF5
  - 0x06: SF6
  - 0x07:SF7
  - 0x08: SF8
  - 0x09: SF9
  - 0x0A: SF10
  - 0x0B: SF11
  - 0x0C: SF12
- *BWL* defines the LoRa® modulation bandwidth (values other than those below are RFU):
  - 0x03: LoRa_BW_62, LoRa® Bandwidth 62.5 kHz
  - 0x04: LoRa_BW_125, LoRa® Bandwidth 125 kHz
  - 0x05: LoRa_BW_250, LoRa® Bandwidth 250 kHz
  - 0x06: LoRa_BW_500, LoRa® Bandwidth 500 kHz
- *CR* configures the Coding Rate (values other than those below are RFU):
  - 0x01: Short Interleaver CR= 4/5 Overhead Ratio 1.25
  - 0x02: Short Interleaver CR= 4/6 Overhead Ratio 1.5
  - 0x03: Short Interleaver CR= 4/7 Overhead Ratio 1.75
  - 0x04: Short Interleaver CR= 4/8 Overhead Ratio 2
  - 0x05: Long Interleaver CR= 4/5[1] Overhead Ratio 1.25
  - 0x06: Long Interleaver CR= 4/6[1] Overhead Ratio 1.5
  - 0x07: Long Interleaver CR= 4/8[1] Overhead Ratio 2
- *LowDataRateOptimize* reduces the number of bits per symbol:
  - 0x00: LowDataRateOptimize off
  - 0x01: LowDataRateOptimize on

Figure 5-8-1-1 Modulation parameter settings

transceiver_radio.c - sakura 2.4.1.2849

```
int8_t radio_init()
{
//  uint16_t i;
    modem_result=    radio_init_sub();

    modem_result = lr1110_radio_set_pkt_type( &lr1110, LR1110_RADIO_PKT_TYPE_LORA );

    modulation_lora.sf   = LR1110_RADIO_LORA_SF7;
    modulation_lora.bw   = LR1110_RADIO_LORA_BW_125;
    modulation_lora.cr   = LR1110_RADIO_LORA_CR_4_5;
    modulation_lora.ldro = 0;
    modem_result= lr1110_radio_set_lora_mod_params( &lr1110, &modulation_lora );

    packet_lora.preamble_len_in_symb  = 8;
    packet_lora.header_type           = LR1110_RADIO_LORA_PKT_EXPLICIT;  // = DEMO_RADIO_LORA_HDR_DEFAULT;
    packet_lora.crc                   = LR1110_RADIO_LORA_CRC_OFF;        // = DEMO_RADIO_LORA_CRC_DEFAULT;
    packet_lora.iq                    = LR1110_RADIO_LORA_IQ_STANDARD;   // = DEMO_RADIO_LORA_IQ_DEFAULT;
    packet_lora.pld_len_in_bytes = PAYLOAD_LENGTH;
    modem_result = lr1110_radio_set_lora_pkt_params( &lr1110, &packet_lora );

    modem_result=    lr1110_radio_set_rf_freq( &lr1110, RF_FREQUENCY );

    pa_configuration.pa_sel           = LR1110_RADIO_PA_SEL_LP;  // =DEMO_RADIO_PA_SEL_DEFAULT; Low-power Power Amplifier
    pa_configuration.pa_reg_supply    = LR1110_RADIO_PA_REG_SUPPLY_VREG; // = DEMO_RADIO_PA_REG_SUPPLY_DEFAULT;  Power amplifier supplied by the main regulator
    pa_configuration.pa_duty_cycle    = DEMO_RADIO_PA_DUTY_CYCLE_DEFAULT; // = 4
//  pa_configuration.pa_duty_cycle    = DEMO_RADIO_PA_DUTY_CYCLE_DOWN; // = 2
    pa_configuration.pa_hp_sel        = DEMO_RADIO_PA_HP_SEL_DEFAULT; // = 0
    modem_result = lr1110_radio_set_pa_cfg( &lr1110, &pa_configuration );

//  modem_result=    lr1110_radio_set_tx_params( &lr1110, DEMO_RADIO_TX_POWER_DEFAULT, LR1110_RADIO_RAMP_240_US );
    modem_result=    lr1110_radio_set_tx_params( &lr1110, DEMO_RADIO_TX_POWER_DOWN,    LR1110_RADIO_RAMP_80_US );
    modem_result =     lr1110_system_set_dio_irq_params(&lr1110,
     LR1110_SYSTEM_IRQ_GNSS_SCAN_DONE | LR1110_SYSTEM_IRQ_TX_DONE | LR1110_SYSTEM_IRQ_RX_DONE | LR1110_SYSTEM_IRQ_TIMEOUT, 0 );
    modem_result =    lr1110_system_clear_irq_status( &lr1110, LR1110_SYSTEM_IRQ_ALL_MASK );

    return 0;
}
```

Figure 5-8-1-2 Location of modulation parameter settings

5.8.2. Power amplifier configuration settings

See the following resource for details on power amplifier configuration settings:
LR1110 Transceiver User Manual (UserManual_LR1110_V1_4.pdf)
"9.5.1 SetPaConfig"
The blue boxes in the following figure indicate the initial settings of the sample code.

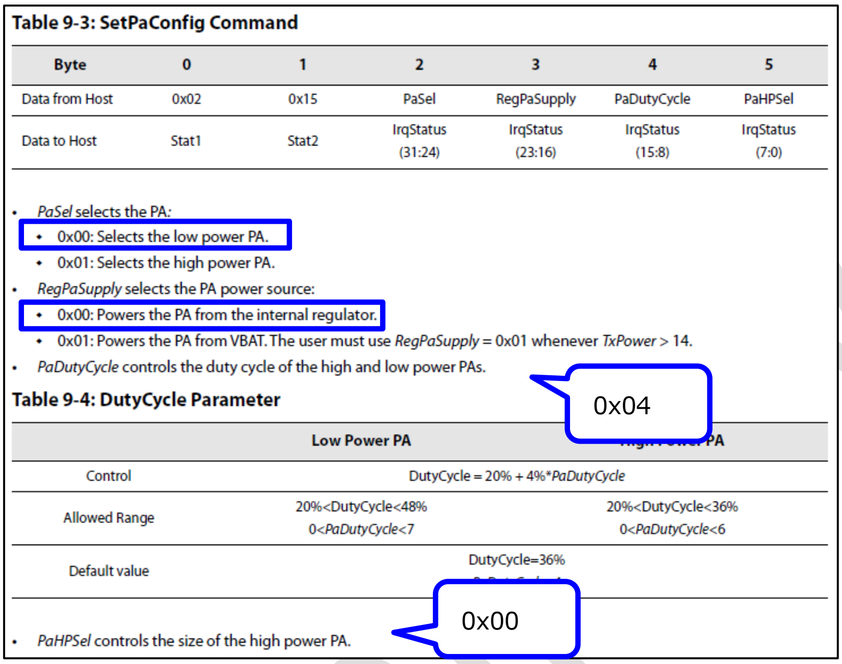


Table 9-3: SetPaConfig Command

Byte	0	1	2	3	4	5
Data from Host	0x02	0x15	PaSel	RegPaSupply	PaDutyCycle	PaHPSel
Data to Host	Stat1	Stat2	IrqStatus (31:24)	IrqStatus (23:16)	IrqStatus (15:8)	IrqStatus (7:0)

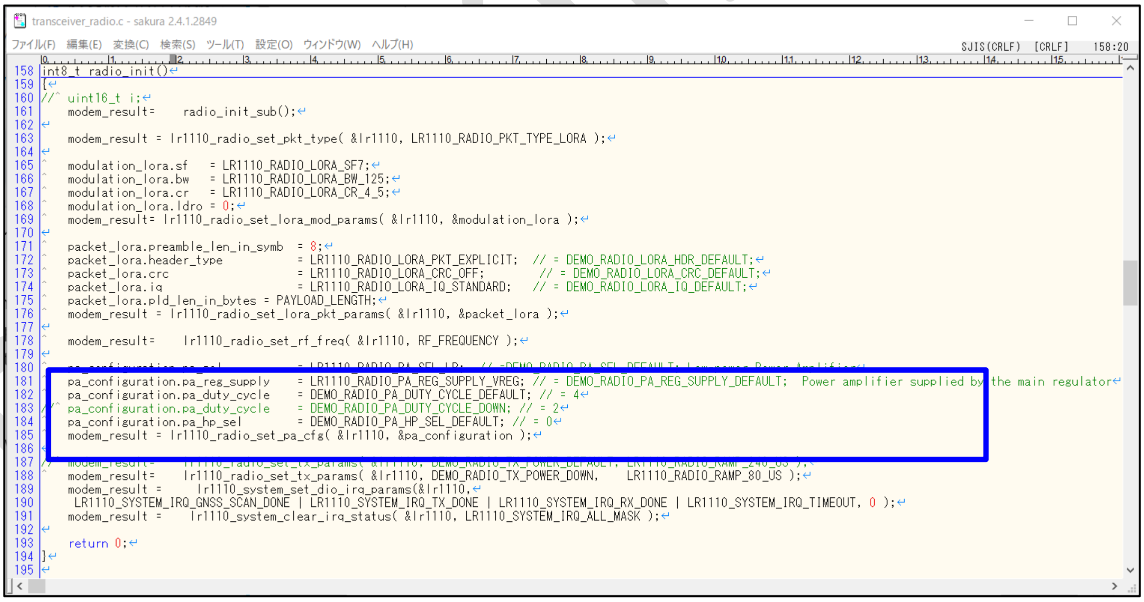
- *PaSel* selects the PA:
  - 0x00: Selects the low power PA.
  - 0x01: Selects the high power PA.
- *RegPaSupply* selects the PA power source:
  - 0x00: Powers the PA from the internal regulator.
  - 0x01: Powers the PA from VBAT. The user must use *RegPaSupply* = 0x01 whenever *TxPower* > 14.
- *PaDutyCycle* controls the duty cycle of the high and low power PAs.

Table 9-4: DutyCycle Parameter

	Low Power PA	High Power PA
Control	DutyCycle = 20% + 4%**PaDutyCycle*	
Allowed Range	20%<DutyCycle<48% 0<*PaDutyCycle*<7	20%<DutyCycle<36% 0<*PaDutyCycle*<6
Default value	DutyCycle=36%	

- *PaHPSel* controls the size of the high power PA.

Figure 5-8-2-1 Power amplifier configuration settings




```
int8_t radio_init()
{
//  uint16_t i;
    modem_result=    radio_init_sub();

    modem_result = lr1110_radio_set_pkt_type( &lr1110, LR1110_RADIO_PKT_TYPE_LORA );

    modulation_lora.sf   = LR1110_RADIO_LORA_SF7;
    modulation_lora.bw   = LR1110_RADIO_LORA_BW_125;
    modulation_lora.cr   = LR1110_RADIO_LORA_CR_4_5;
    modulation_lora.ldro = 0;
    modem_result= lr1110_radio_set_lora_mod_params( &lr1110, &modulation_lora );

    packet_lora.preamble_len_in_symb  = 8;
    packet_lora.header_type           = LR1110_RADIO_LORA_PKT_EXPLICIT;  // = DEMO_RADIO_LORA_HDR_DEFAULT;
    packet_lora.crc                   = LR1110_RADIO_LORA_CRC_OFF;        // = DEMO_RADIO_LORA_CRC_DEFAULT;
    packet_lora.iq                    = LR1110_RADIO_LORA_IQ_STANDARD;   // = DEMO_RADIO_LORA_IQ_DEFAULT;
    packet_lora.pld_len_in_bytes = PAYLOAD_LENGTH;
    modem_result = lr1110_radio_set_lora_pkt_params( &lr1110, &packet_lora );

    modem_result=    lr1110_radio_set_rf_freq( &lr1110, RF_FREQUENCY );

    pa_configuration.pa_sel           = LR1110_RADIO_PA_SEL_LP;  // =DEMO_RADIO_PA_SEL_DEFAULT; Low-power Power Amplifier
    pa_configuration.pa_reg_supply    = LR1110_RADIO_PA_REG_SUPPLY_VREG; // = DEMO_RADIO_PA_REG_SUPPLY_DEFAULT;  Power amplifier supplied by the main regulator
    pa_configuration.pa_duty_cycle    = DEMO_RADIO_PA_DUTY_CYCLE_DEFAULT; // = 4
//  pa_configuration.pa_duty_cycle    = DEMO_RADIO_PA_DUTY_CYCLE_DOWN; // = 2
    pa_configuration.pa_hp_sel        = DEMO_RADIO_PA_HP_SEL_DEFAULT; // = 0
    modem_result = lr1110_radio_set_pa_cfg( &lr1110, &pa_configuration );

//  modem_result=    lr1110_radio_set_tx_params( &lr1110, DEMO_RADIO_TX_POWER_DEFAULT, LR1110_RADIO_RAMP_240_US );
    modem_result=    lr1110_radio_set_tx_params( &lr1110, DEMO_RADIO_TX_POWER_DOWN,    LR1110_RADIO_RAMP_80_US );
    modem_result =     lr1110_system_set_dio_irq_params(&lr1110,
     LR1110_SYSTEM_IRQ_GNSS_SCAN_DONE | LR1110_SYSTEM_IRQ_TX_DONE | LR1110_SYSTEM_IRQ_RX_DONE | LR1110_SYSTEM_IRQ_TIMEOUT, 0 );
    modem_result =    lr1110_system_clear_irq_status( &lr1110, LR1110_SYSTEM_IRQ_ALL_MASK );

    return 0;
}
```

Figure 5-8-2-2 Location of power amplifier configuration settings

5.8.3. TX power and power amplifier ramping time parameter settings

See the following resource for details on power amplifier configuration settings.
LR1110 Transceiver User Manual (UserManual_LR1110_V1_2.pdf)
"9.5.2 SetTxParams"

The blue boxes in the following figure indicate the initial settings of the sample code.

Table 9-5: SetTxParams Command

Byte	0	1	2	3
Data from Host	0x02	0x11	TxPower	RampTime
Data to Host	Stat1	Stat2	IrqStatus(31:24)	IrqStatus(23:16)

13

- *TxPower* defines the output power in dBm in a range of:
  - - 17 dBm (0xEF) to +14 dBm (0x0E) by steps of 1 dB if the hig[...]cted.
  - - 9 dBm (0xF7) to +22 dBm(0x16) by steps of 1 dB if the high power PA is selected.
  - If *TxPower* > +14 dBm, the user must select the VBAT supply for the PA using the *SetPaConfig* command.
- *RampTime* defines the PA power ramping time, which can be from 16 to 304 µs according to the following table:

Table 9-6: RampTime Values

RampTime	Value	Ramp Time in µs
SET_RAMP_16U	0x00	16
SET_RAMP_32U	0x01	32
SET_RAMP_48U	0x02	48
SET_RAMP_64U	0x03	64
SET_RAMP_80U	0x04	80
SET_RAMP_96U	0x05	96
SET_RAMP_112U	0x06	112
SET_RAMP_128U	0x07	128
SET_RAMP_144U	0x08	144
SET_RAMP_160U	0x09	160
SET_RAMP_176U	0x0A	176
SET_RAMP_192U	0x0B	192
SET_RAMP_208U	0x0C	208
SET_RAMP_240U	0x0D	240
SET_RAMP_272U	0x0E	272
SET_RAMP_304U	0x0F	304

Figure 5-8-3-1 TX power and power amplifier ramping time parameter settings

transceiver_radio.c - sakura 2.4.1.2849

```
int8_t radio_init()
{
//  uint16_t i;
    modem_result=    radio_init_sub();

    modem_result = lr1110_radio_set_pkt_type( &lr1110, LR1110_RADIO_PKT_TYPE_LORA );

    modulation_lora.sf    = LR1110_RADIO_LORA_SF7;
    modulation_lora.bw    = LR1110_RADIO_LORA_BW_125;
    modulation_lora.cr    = LR1110_RADIO_LORA_CR_4_5;
    modulation_lora.ldro = 0;
    modem_result= lr1110_radio_set_lora_mod_params( &lr1110, &modulation_lora );

    packet_lora.preamble_len_in_symb  = 8;
    packet_lora.header_type           = LR1110_RADIO_LORA_PKT_EXPLICIT;  // = DEMO_RADIO_LORA_HDR_DEFAULT;
    packet_lora.crc                   = LR1110_RADIO_LORA_CRC_OFF;        // = DEMO_RADIO_LORA_CRC_DEFAULT;
    packet_lora.iq                    = LR1110_RADIO_LORA_IQ_STANDARD;   // = DEMO_RADIO_LORA_IQ_DEFAULT;
    packet_lora.pld_len_in_bytes = PAYLOAD_LENGTH;
    modem_result = lr1110_radio_set_lora_pkt_params( &lr1110, &packet_lora );

    modem_result=    lr1110_radio_set_rf_freq( &lr1110, RF_FREQUENCY );

    pa_configuration.pa_sel           = LR1110_RADIO_PA_SEL_LP;  // =DEMO_RADIO_PA_SEL_DEFAULT; Low-power Power Amplifier
    pa_configuration.pa_reg_supply    = LR1110_RADIO_PA_REG_SUPPLY_VREG; // = DEMO_RADIO_PA_REG_SUPPLY_DEFAULT;  Power amplifier supplied by the main regulator
    pa_configuration.pa_duty_cycle    = DEMO_RADIO_PA_DUTY_CYCLE_DEFAULT; // = 4
//  pa_configuration.pa_duty_cycle    = DEMO_RADIO_PA_DUTY_CYCLE_DOWN; // = 2
    pa_configuration.pa_hp_sel        = DEMO_RADIO_PA_HP_SEL_DEFAULT; // = 0
    modem_result = lr1110_radio_set_pa_cfg( &lr1110, &pa_configuration );

//  modem_result=    lr1110_radio_set_tx_params( &lr1110, DEMO_RADIO_TX_POWER_DEFAULT, LR1110_RADIO_RAMP_240_US );
    modem_result=    lr1110_radio_set_tx_params( &lr1110, DEMO_RADIO_TX_POWER_DOWN,    LR1110_RADIO_RAMP_80_US );
    modem_result =    lr1110_system_set_dio_irq_params(&lr1110,
     LR1110_SYSTEM_IRQ_GNSS_SCAN_DONE | LR1110_SYSTEM_IRQ_TX_DONE | LR1110_SYSTEM_IRQ_RX_DONE | LR1110_SYSTEM_IRQ_TIMEOUT, 0 );
    modem_result =    lr1110_system_clear_irq_status( &lr1110, LR1110_SYSTEM_IRQ_ALL_MASK );

    return 0;
}
```

Figure 5-8-3-2 Location of TX power and power amplifier ramping time parameter settings

5.8.4. Frequency settings

See the following resource for details on frequency settings:
LR1110 Transceiver User Manual (UserManual_LR1110_V1_2.pdf)
"7.2.1 SetRfFrequency"

The frequency settings in this section conform to Japanese standards as explained at the following URL:
https://www.arib.or.jp/kikaku/kikaku_tushin/desc/std-t108.html

The blue box in the following figure indicates the initial settings of the sample code.

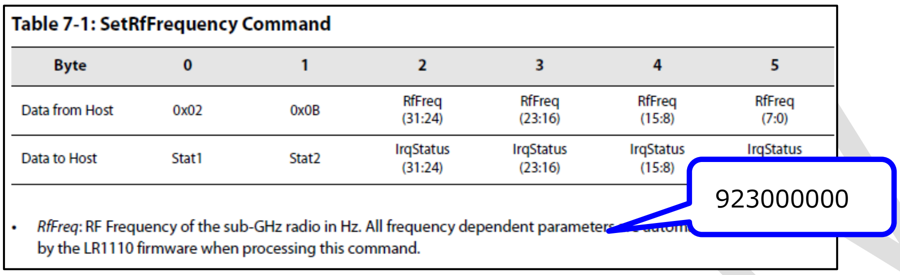


Table 7-1: SetRfFrequency Command

Byte	0	1	2	3	4	5
Data from Host	0x02	0x0B	RfFreq (31:24)	RfFreq (23:16)	RfFreq (15:8)	RfFreq (7:0)
Data to Host	Stat1	Stat2	IrqStatus (31:24)	IrqStatus (23:16)	IrqStatus (15:8)	IrqStatus

- *RfFreq*: RF Frequency of the sub-GHz radio in Hz. All frequency dependent parameters … by the LR1110 firmware when processing this command.

Figure 5-8-4-1 Frequency settings

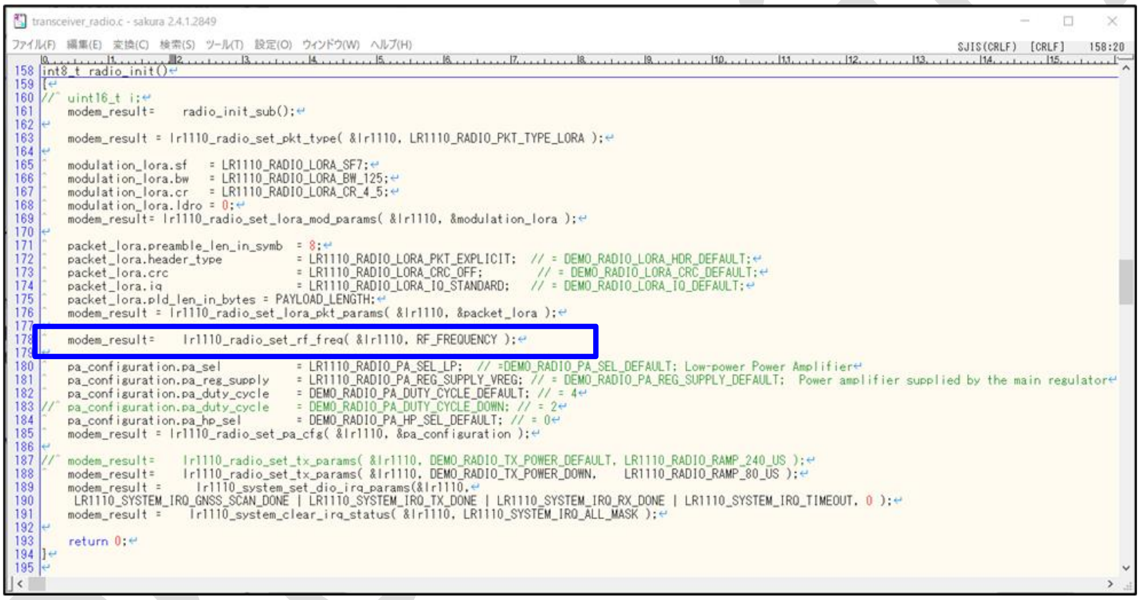


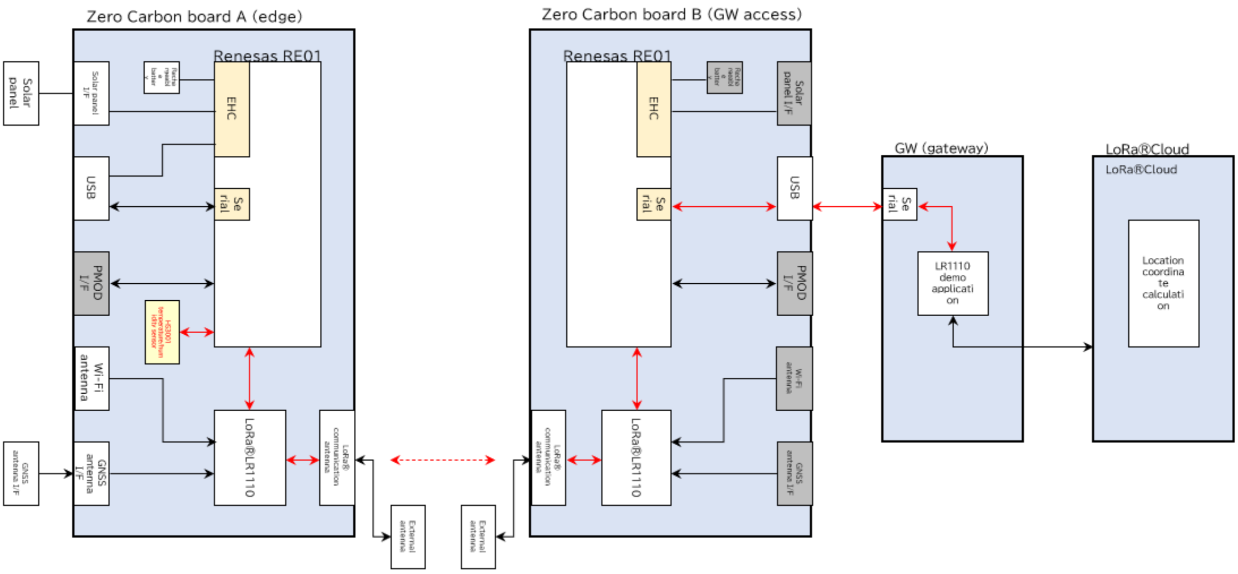
Figure 5-8-4-2 Location of frequency settings

5.9. Zero Carbon board A (edge) with additional sensor

The following explains the steps required on the Zero Carbon board A (edge), Zero Carbon board B (GW access) and GW in a system where a sensor is added to the Zero Carbon board A (edge).

Note: The following uses the example of the HS3001 (I^2C communication temperature and humidity sensor) that the Zero Carbon board currently incorporates.

In the following overall system diagram, the output of the HS3001 (temperature and humidity sensor) is passed to the gateway by serial communication via the LR1110 (the route shown in red in the following figure).



Development languages:

- Zero Carbon board A (edge) : c
- Zero Carbon board B (GW access) : c
- GW : python

5.9.1. On the Zero Carbon board A (edge)

The software acquires the output of the HS3001 temperature and humidity sensor and uses LoRa® communication to send the data to the Zero Carbon board B (GW access).

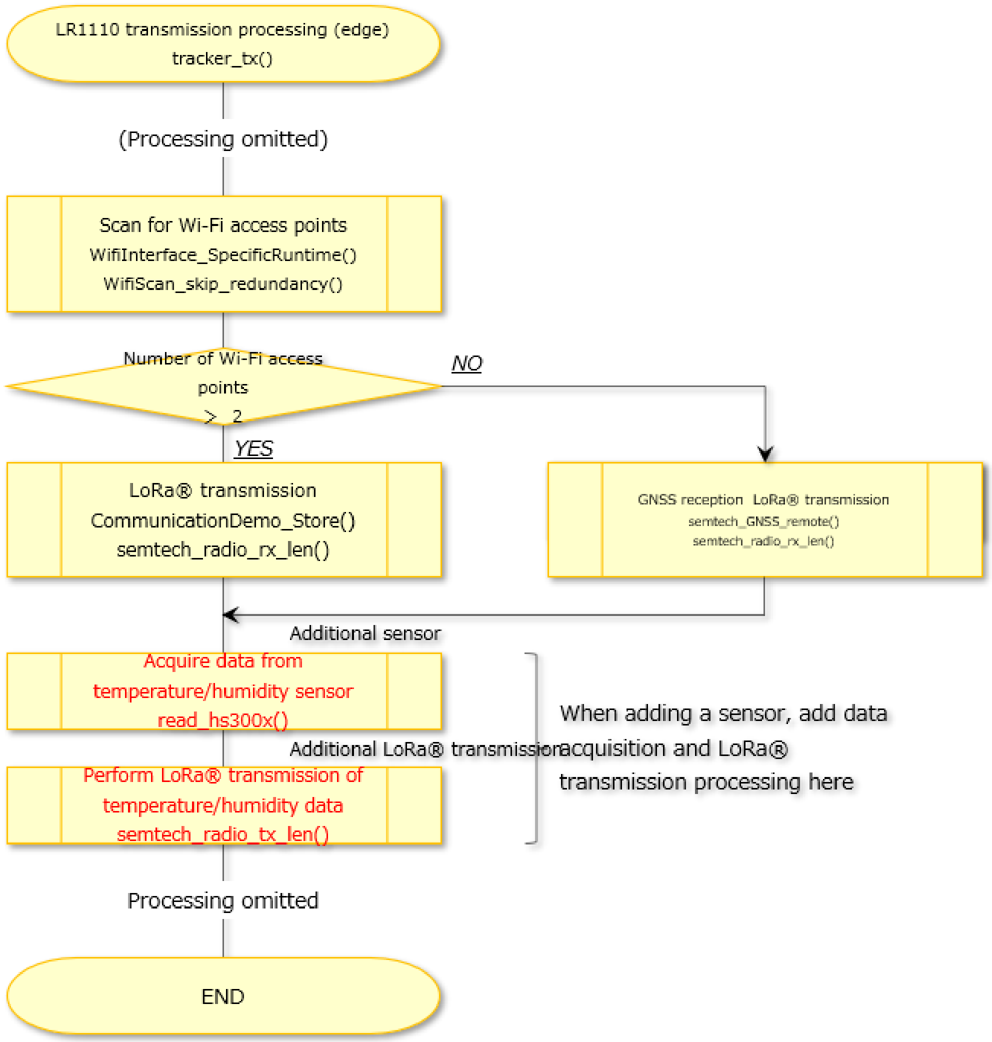


Figure 5-9-1-1

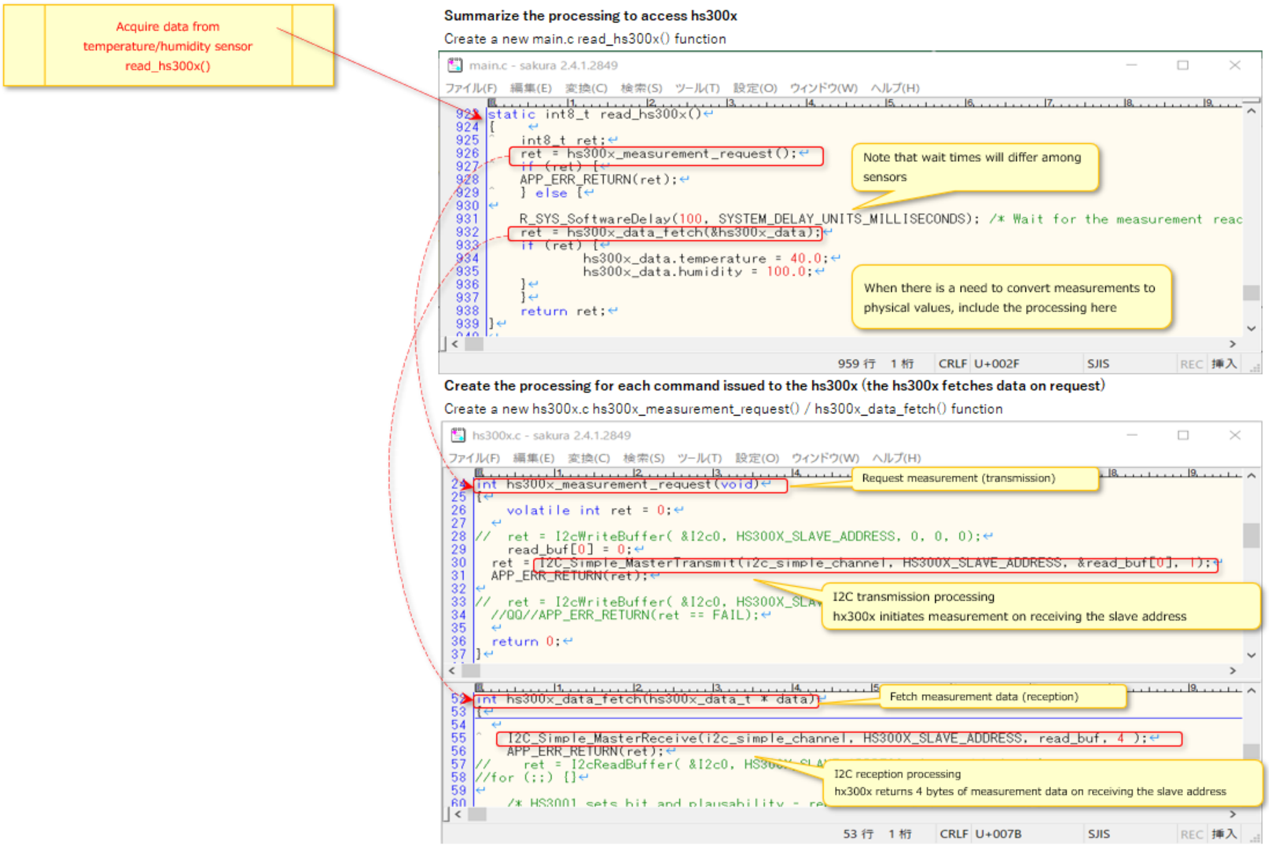


Figure 5-9-1-2

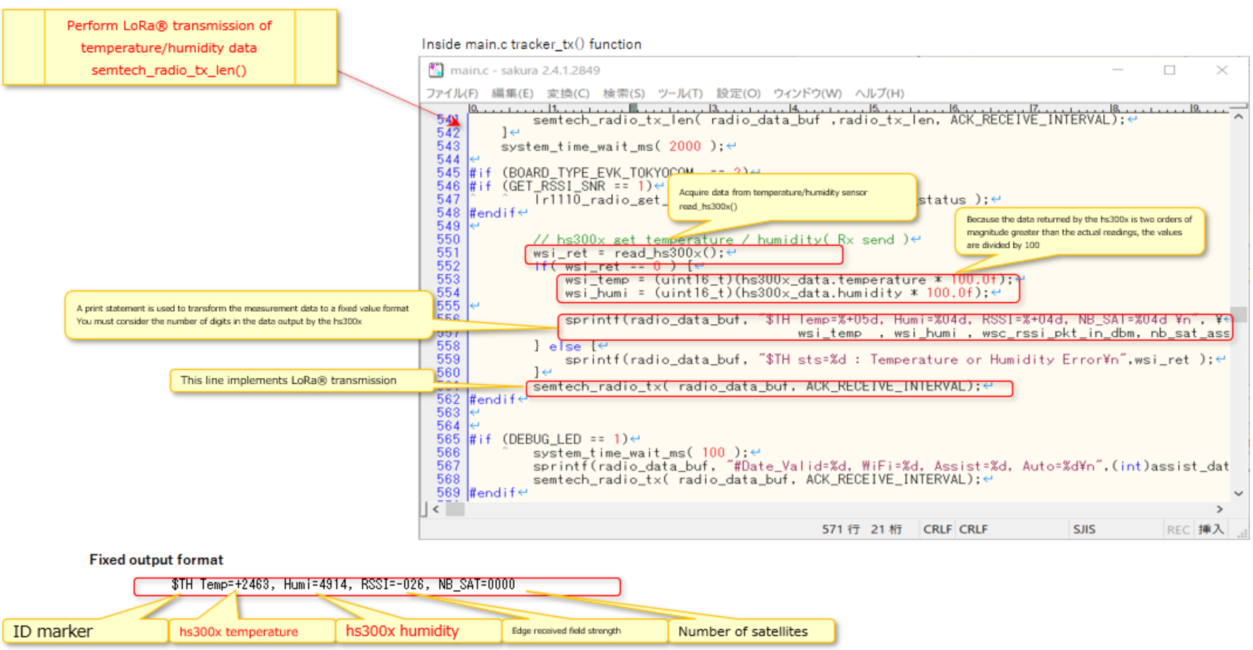


Figure 5-9-1-3

5.9.2. On the Zero Carbon board B (GW access)

The software uses UART communication to send the temperature and humidity data of the HS3001 sensor received by LoRa® communication to the GW.

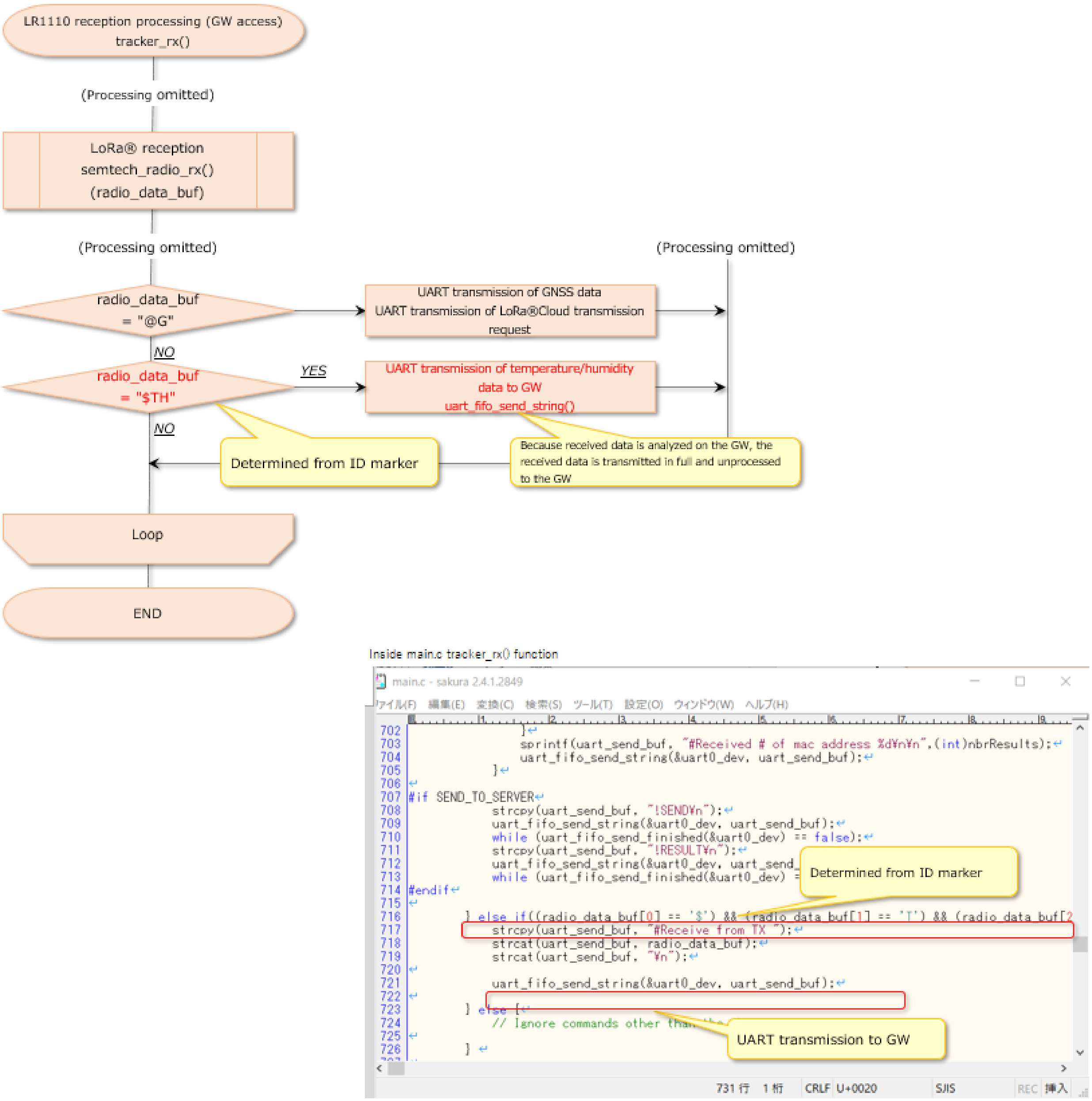


Figure 5-9-2

5.9.3. On the GW

The software stores the temperature and humidity data of the HS3001 sensor received by UART communication in variables and outputs the values as log data.

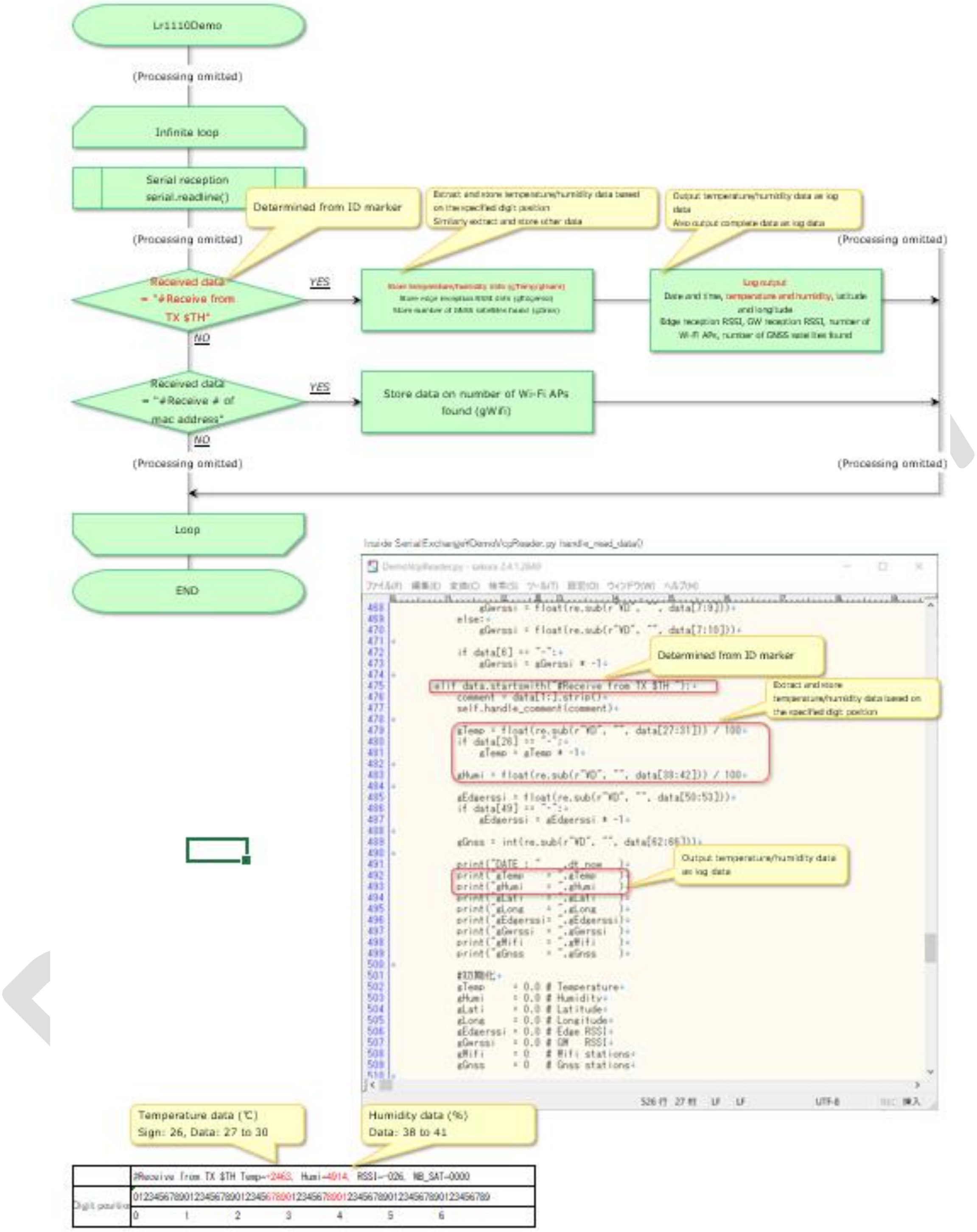


Figure 5-9-3-1

The log output is as follows:

Execution results

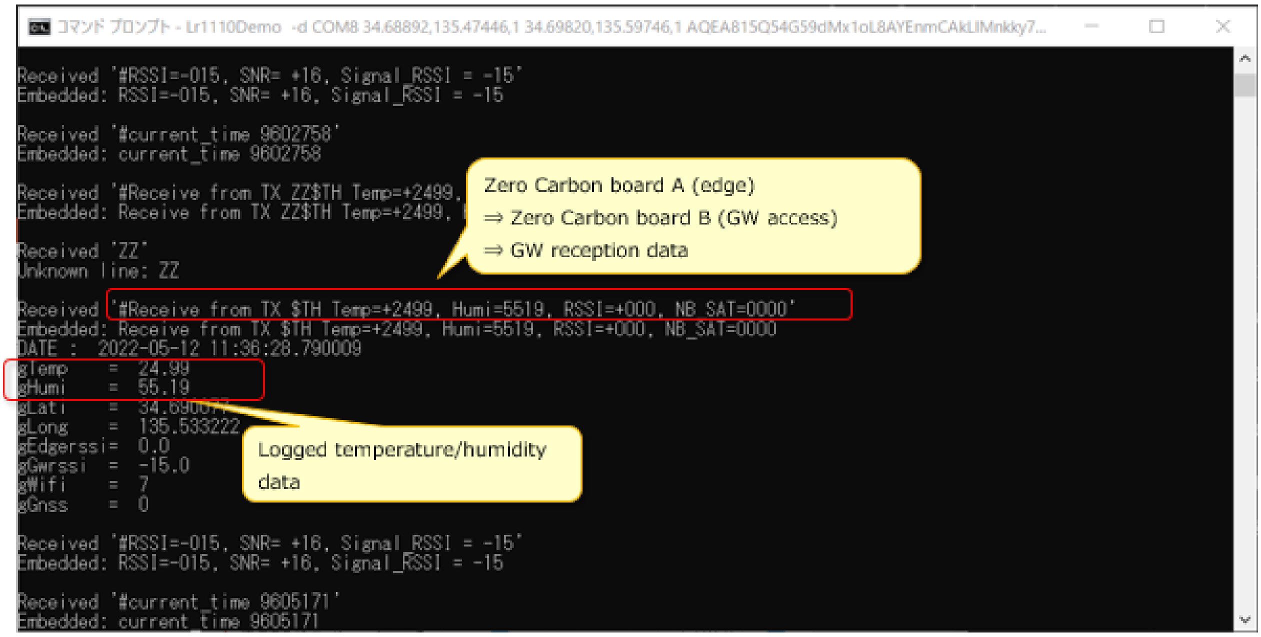


Figure 5-9-3-2

6. Debugging (when using E2Lite)

This chapter explains how to debug the software using Renesas' E2 Emulator Lite (hereinafter *E2Lite*).

6.1. Debugging in e² studio

- Step1: Connecting the Zero Carbon board A (edge) and the E2Lite

Connect a flat cable to connectors indicated by the red boxes in Figure 6-1-1, paying attention to the orientation of the pins.

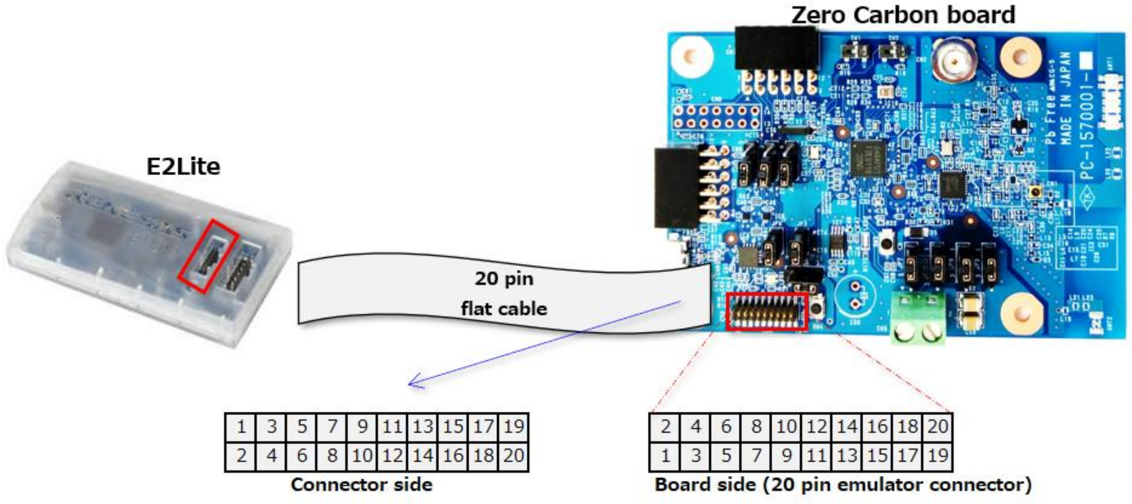
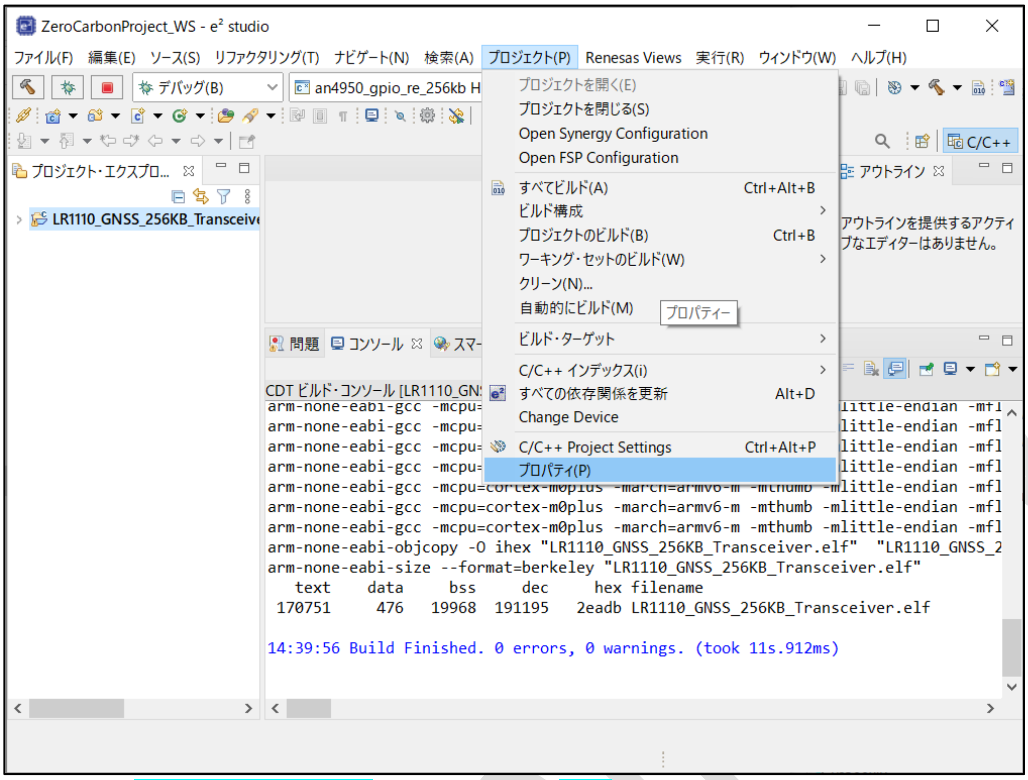


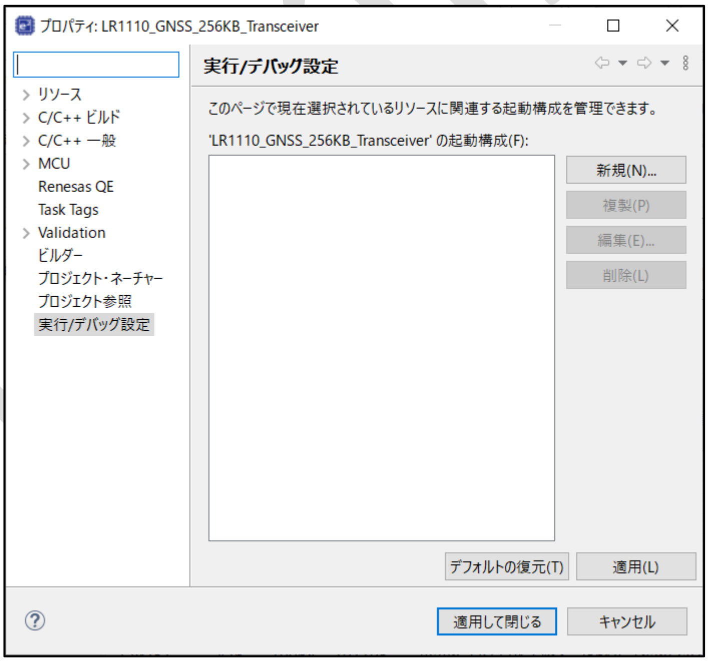
Figure 6-1-1

- Step 2: Run/debug settings

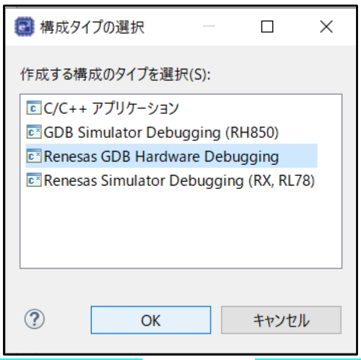
  From the Project menu, select Properties.



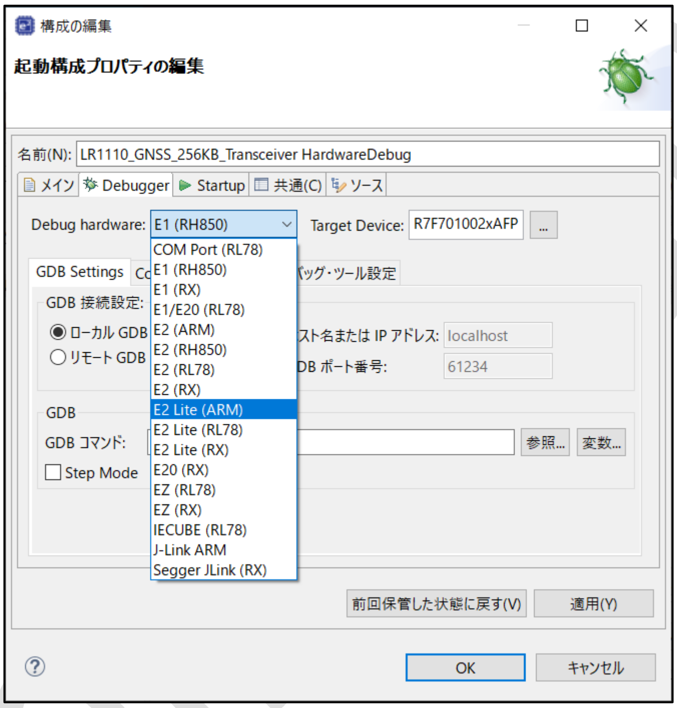
Select Run/Debug Settings, and then click New.



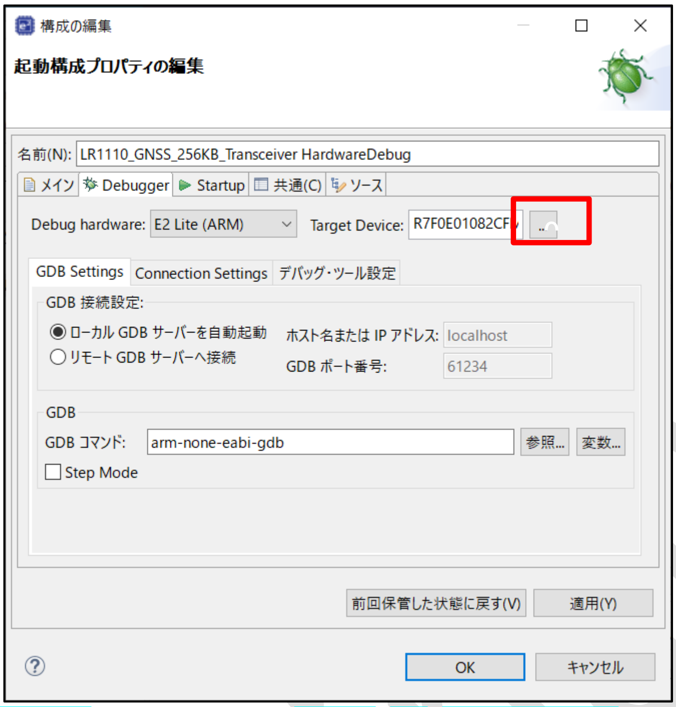
Select Renesas GDB Hardware Debugging, and then click OK.



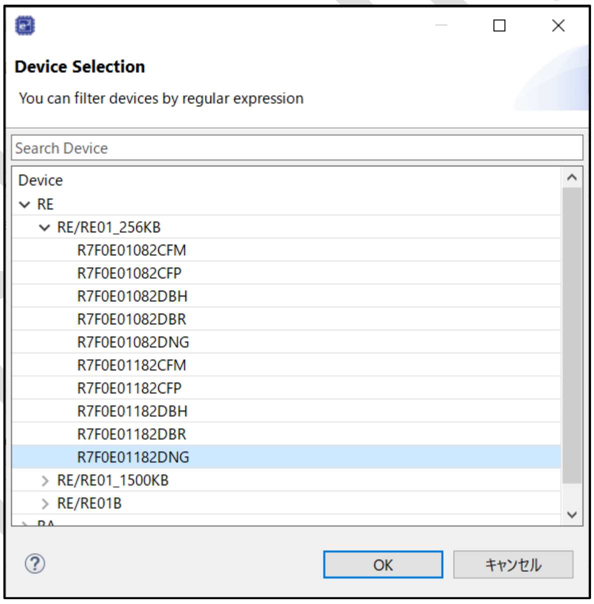
On the Debugger tab, select E2lite (ARM) from the Debug hardware drop-down list.



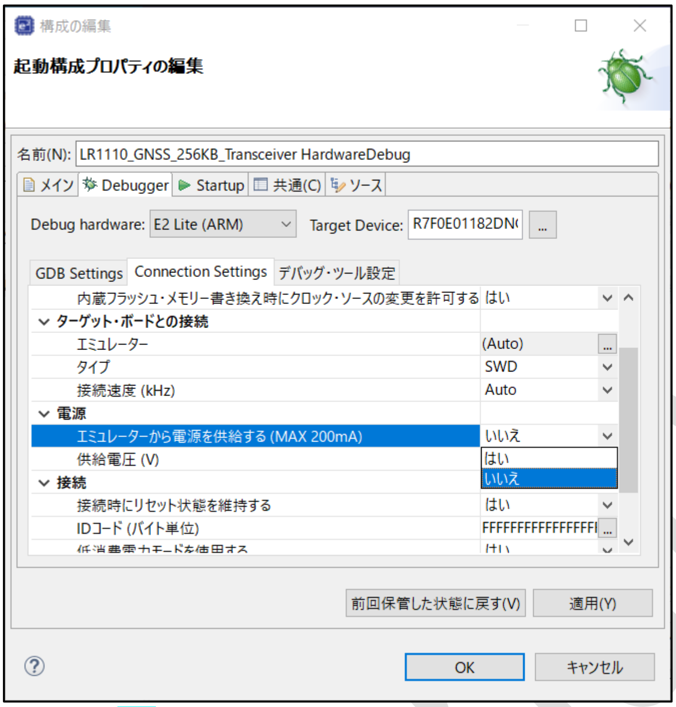
Click the ··· button beside the Target Device field.



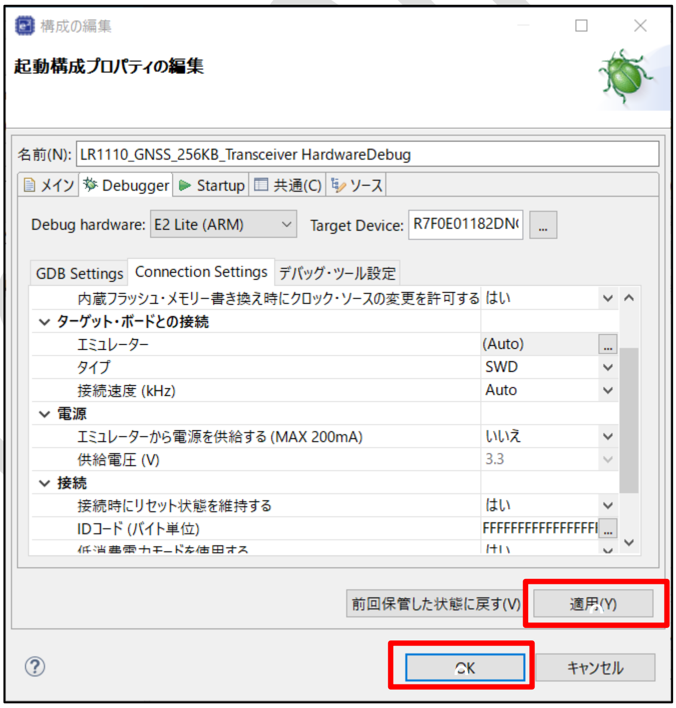
In the Device Selection dialog box, click Device, RE, RE/RE_256KB, and R7F0E01182DNG, and then click OK.



On the Connection Settings tab, select No for the Power setting Power Target from the Emulator (MAX 200mA).



Click Apply, and then click OK.



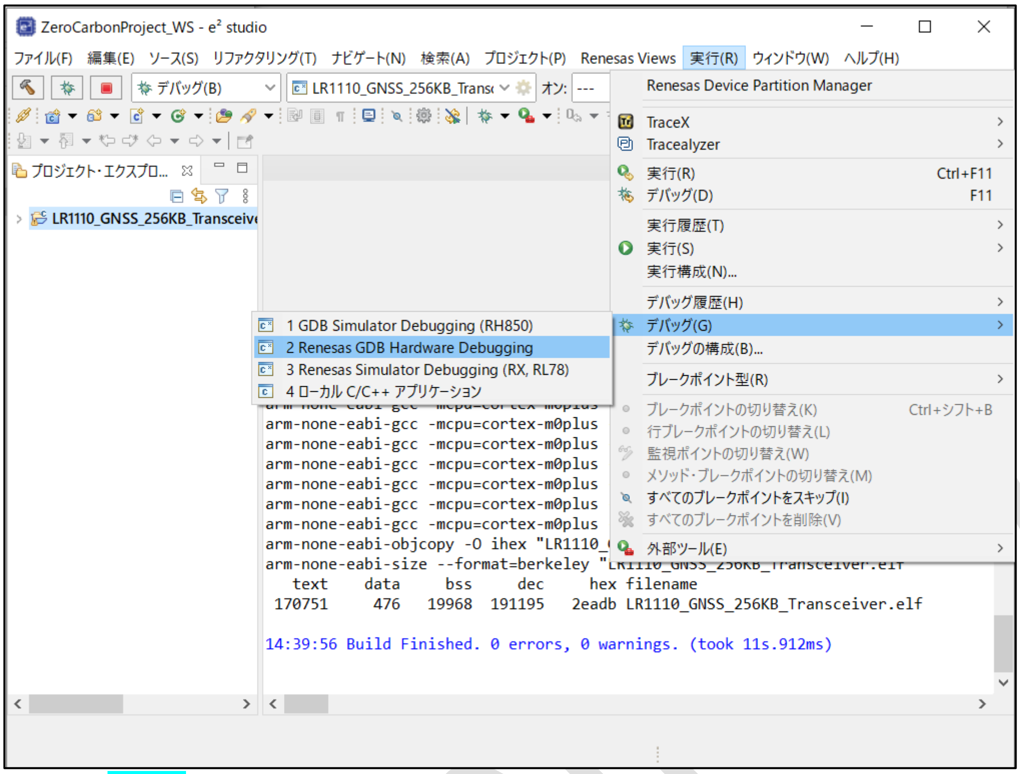
Click Apply, and then click OK. This step is now complete.

- Step 3: Zero Carbon board A (edge) jumper and switch settings

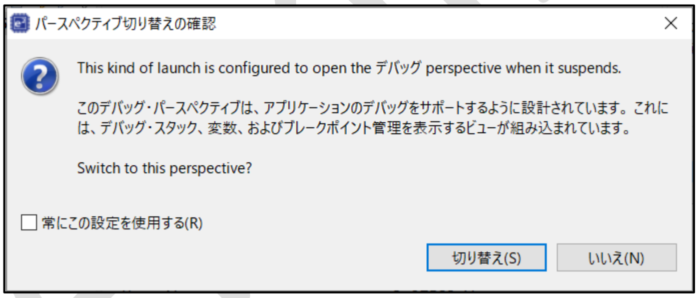
  For details about the board setup when using a USB power supply, see the following resource:
  Zero Carbon LoRa® Evaluation Board Tutorial
  "5. Zero Carbon LoRa® Evaluation Board Jumper and Switch Layout Diagram"
  When powered by USB: "b. Settings when using USB fast charging"
  Note: Because the voltage supplied by energy harvesting devices is unstable, you must power the Zero Carbon board A (edge) with a USB power supply.

- Step 4: Starting the debugger

From the Run menu, select Debug and then Renesas GDB Hardware Debugging.



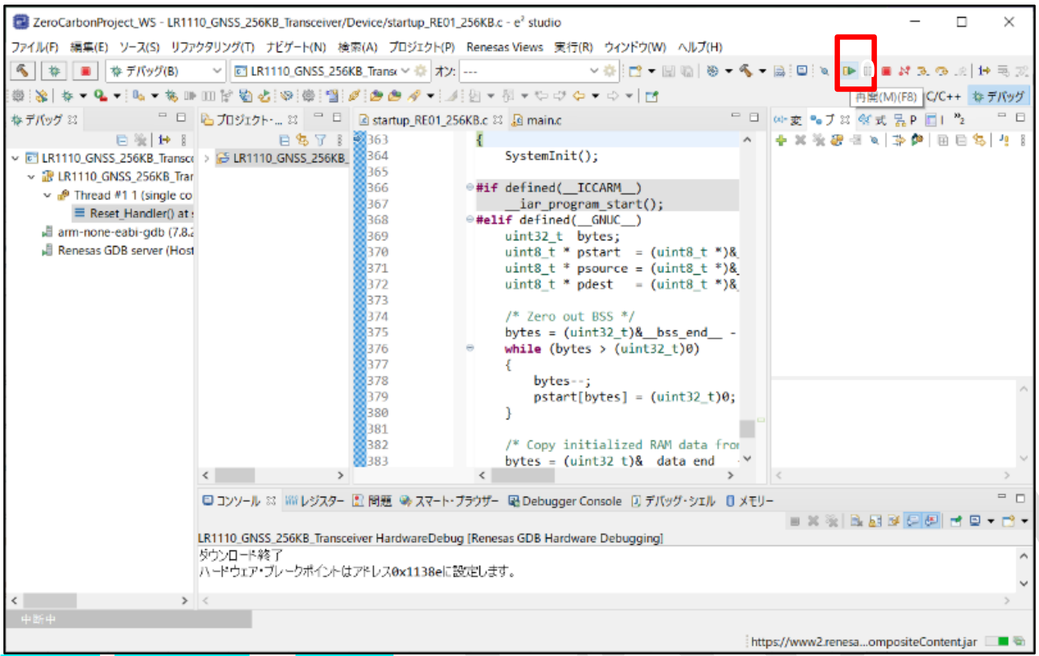
Click the Switch button.



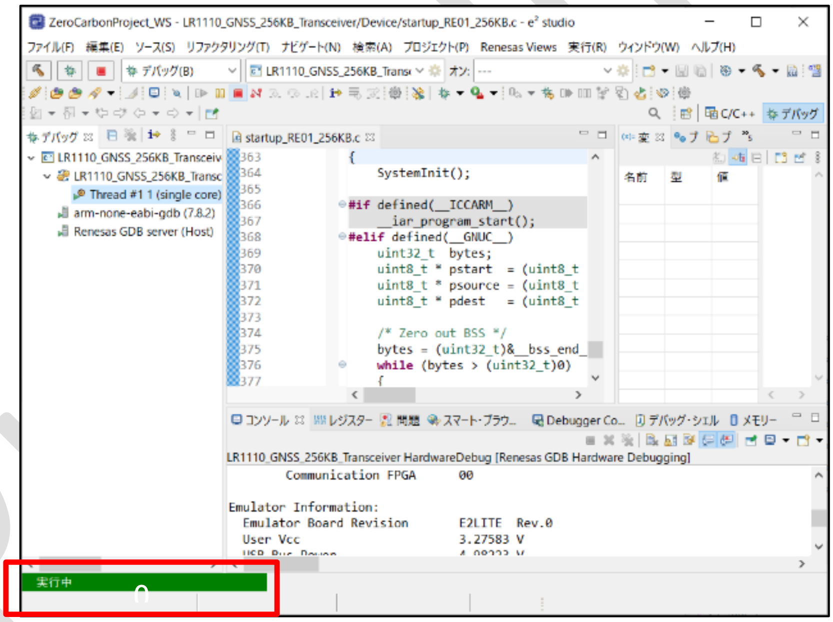
Note: If an error message like the following appears, disconnect the USB cable from the E2Lite and the Zero Carbon board A (edge). Then, reconnect the cable, first to the E2Lite and then to the Zero Carbon board A (edge).

- Step 5: Start debugging

Press the F8 key or click the Resume button shown in the red box in the following figure.



Running, Suspended, or Standby appears in the status bar according to the status of the debug process.

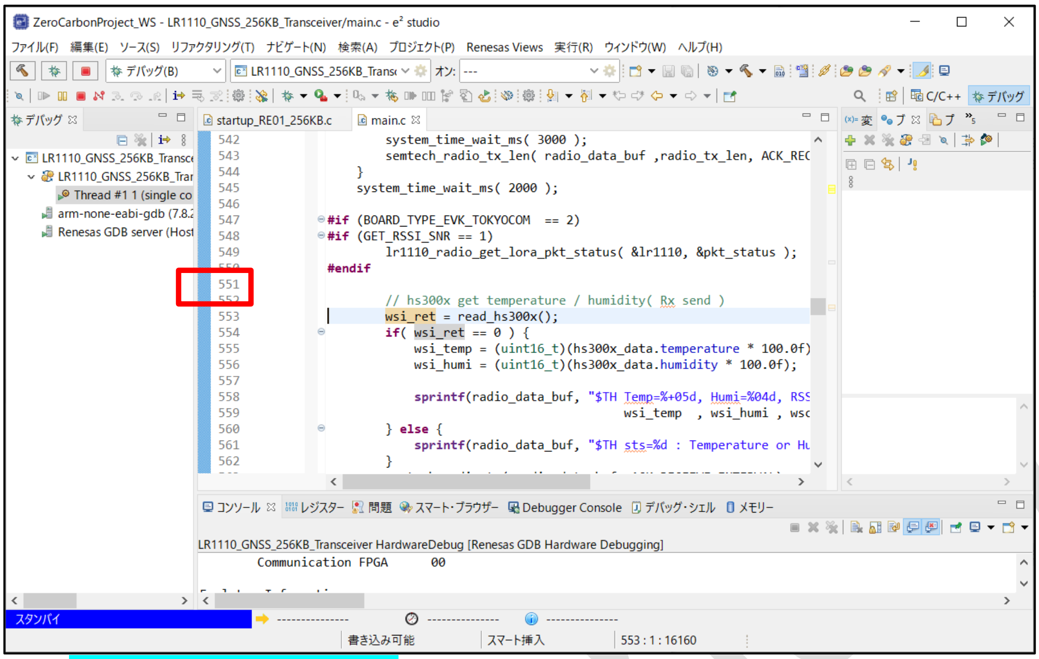


The process will sometimes stop at a hardware breakpoint during the first run. If this occurs, click the Resume button again.

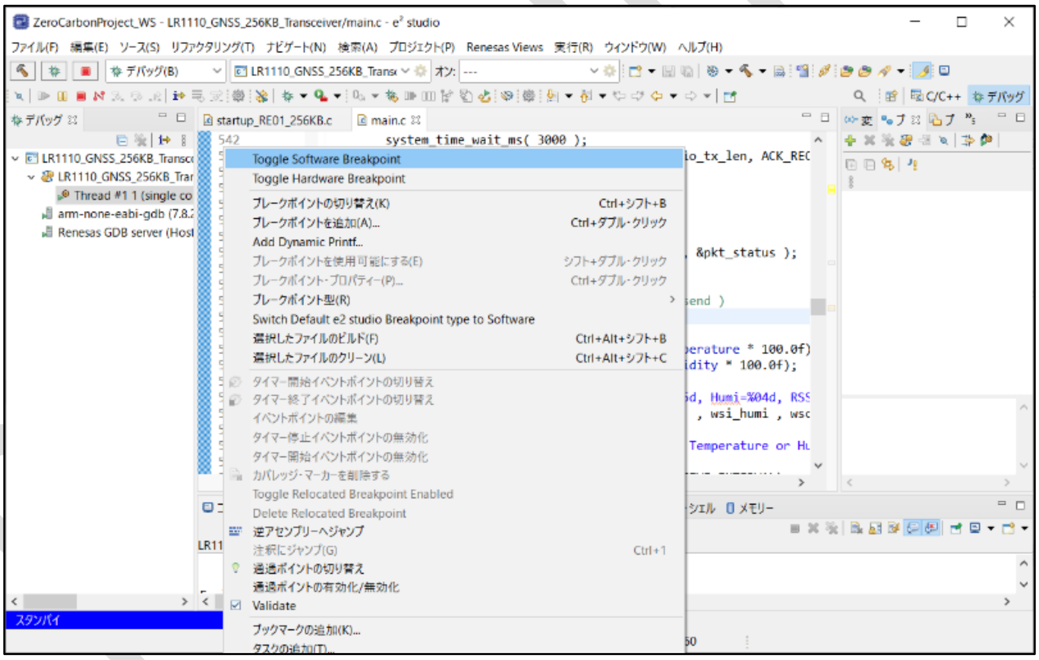
Press the trigger switch on the Zero Carbon board A (edge) and confirm that it works.

- Step 6: Setting a breakpoint

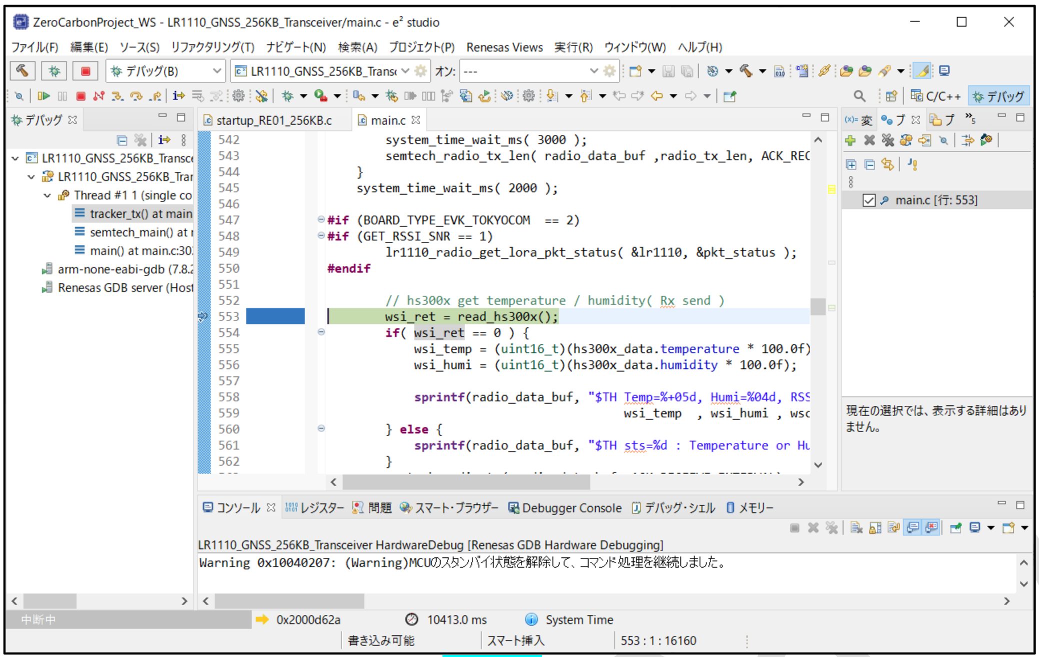
  Right-click the left of the line of source code where you want to place a break, as indicated by the red box.



Click Toggle Software Breakpoint.



When you press the trigger switch to run the code, execution stops at the specified break point.

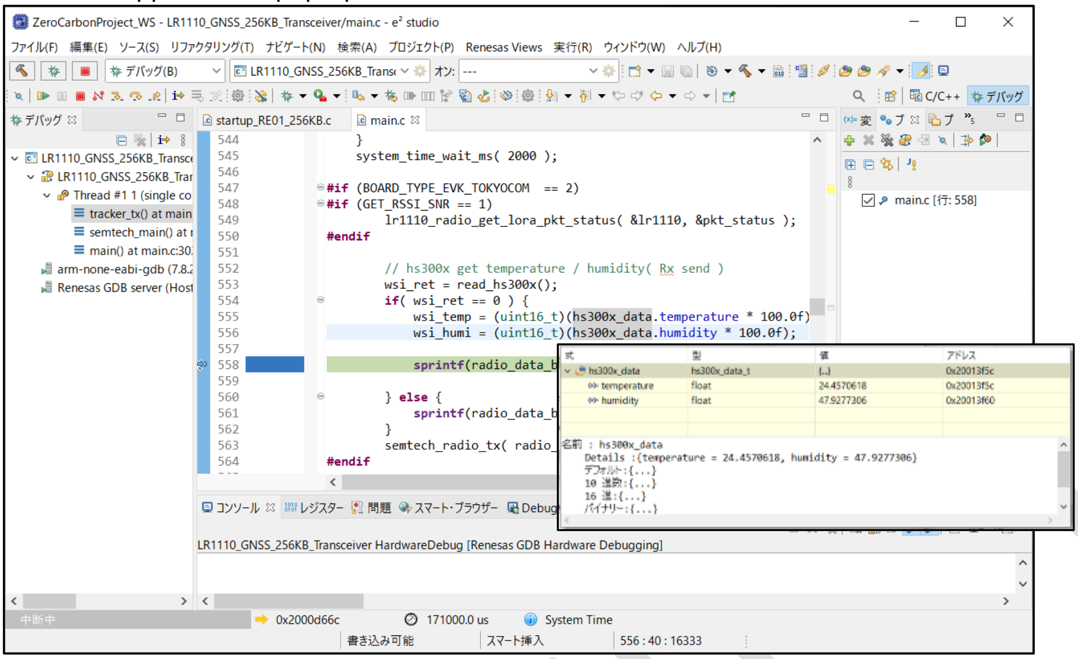


To resume code execution, click the Resume button.

To remove the breakpoint, right-click the location of the breakpoint and then click Toggle Software Breakpoint.
You can also clear a breakpoint by clearing the check box in the Breakpoint window displayed by pressing ALT + Shift + Q, B.

- Step 7: Checking variable values

  Stop execution by setting a breakpoint in the source code where you want to check the value of a variable, and align the mouse cursor with the variable you want to check. The contents of the variable appears in a pop-up window as follows:



7. Acquiring a Manage Token from LoRa® Cloud

The following explains how to acquire a Manage Token from LoRa® Cloud.

7.1. Acquiring a Manage Token

See the following resource:
Zero Carbon LoRa® Evaluation Board Tutorial
"3. Setting up a LoRa® Cloud Account"

8. Current Measurement Method and Current Consumption

8.1. Current measurement method

The following shows how to measure the power consumption of the Zero Carbon board A (edge).
Figure 8-1-1 shows an overall view of the connections among devices.

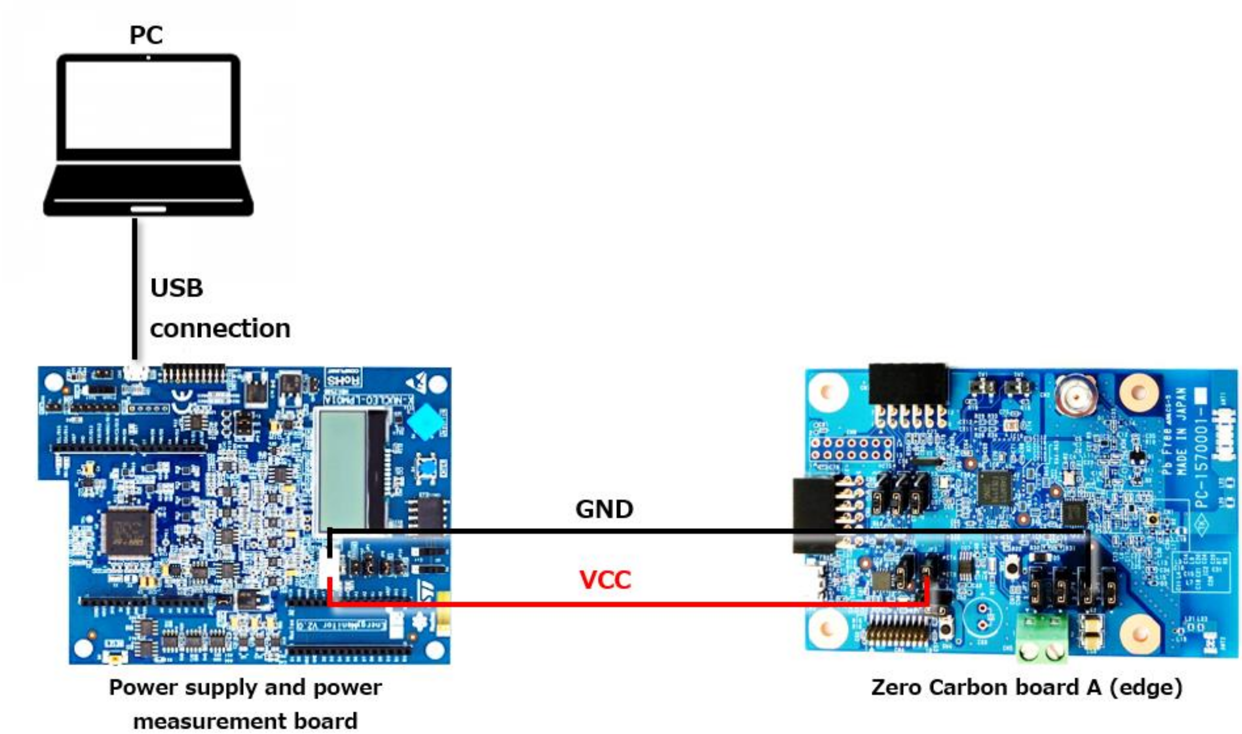


Figure 8-1-1

The power supply and power measurement board requires the STM32CubeMonitor-Power software together with an ultralow power consumption tool and accompanying software.

For information about how to set up and use this system, visit the following URL:
https://www.st.com/resource/en/user_manual/um2202-stm32cubemonitorpower-software-tool-for-power-and-ultralowpower-measurements- stmicroelectronics.pdf

For details about the power supply and power measurement board (X-NUCLEO-LPM01A), visit the following URL:
https://www.st.com/content/st_com/ja/products/evaluation-tools/product-evaluation-tools/stm32-nucleo-expansion-boards/x-nucleo-lpm01a.html

Figure 8-1-2 and Table 8-1-1 show the settings for the Zero Carbon board A (edge).

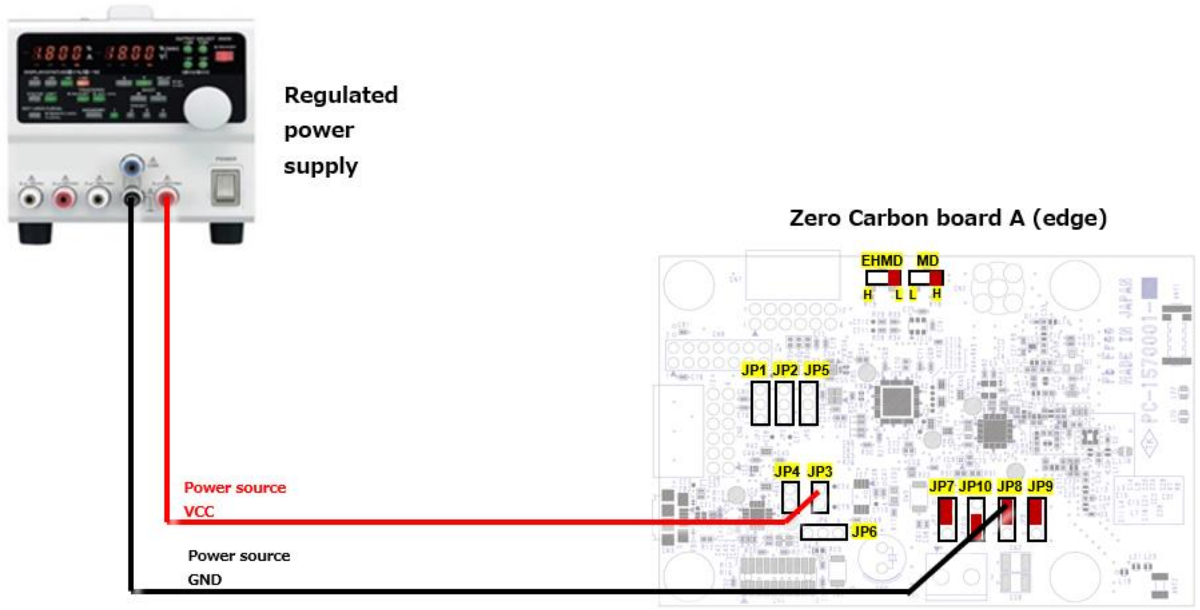


Figure 8-1-2

Table 8-1-1

JP/SW	State
JP1	Open
JP2	Open
JP3	Connect VCC power source to pin 1
JP4	Open
JP5	Open
JP6	Open
JP7	1-2
JP8	Connect GND of power source to pin 1 1-2
JP9	1-2
JP10	2-3
SW1(EHMD)	Low
SW2(MD)	High

8.2. Current consumption

The sample code conducts a Wi-Fi scan. If the Wi-Fi scan is unable to obtain enough Wi-Fi Mac addresses (> 4) to determine location, the sample code updates the GNSS almanac data and performs a GNSS scan. You might encounter this scenario when using the system in mountainous areas or in the middle of the ocean where Wi-Fi is out of range.

You can select whether to update almanac data (Assisted Mode/Autonomous Mode). Updating almanac data (Assisted Mode) yields an approximate 7dB improvement in GNSS reception sensitivity (for details, see the SEMTECH Application Notes).

- **Results of Wi-Fi tracking current measurement**

Total 64 mJ (26mC@2.5V)

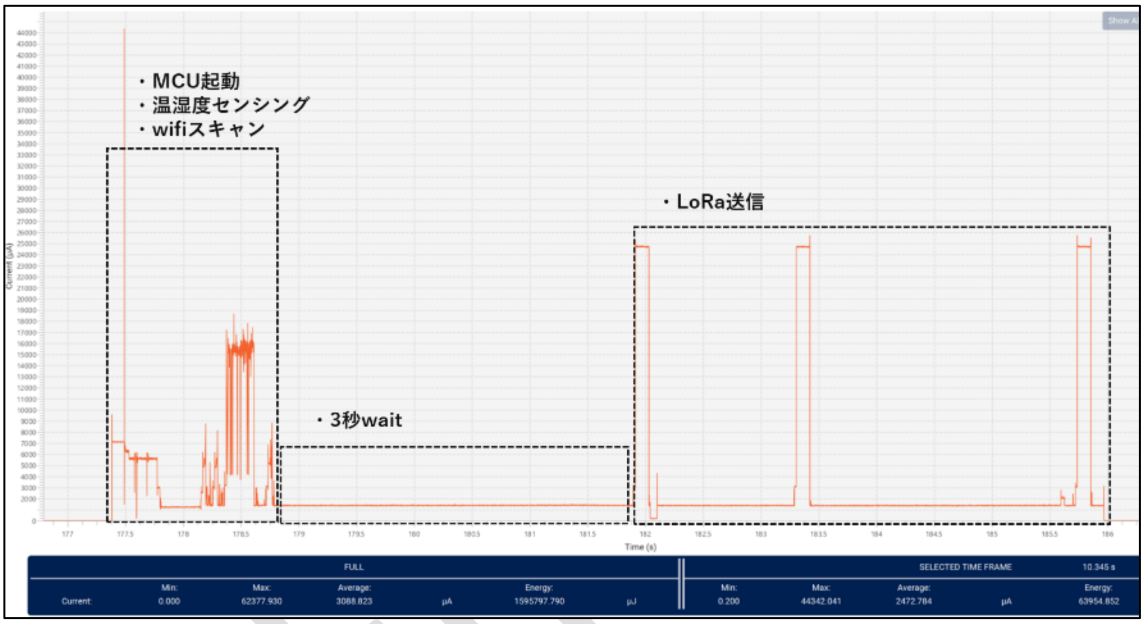


Figure 8-2-1

- **Results of GNSS tracking current measurement**

Total 503 mJ (201mC@2.5V)

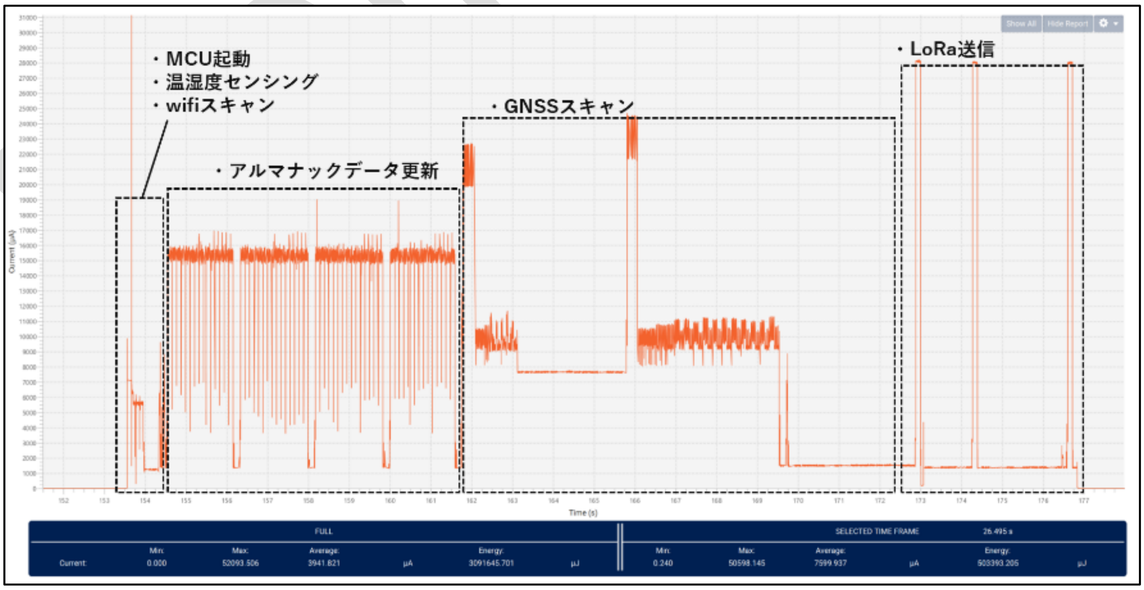


Figure 8-2-2

• **Balance between energy harvested and consumed**

Solar battery	Size [mm]	Thickness [mm]	Mass [g]	Luminance [lux] (approx.)	Generated current [uA] (values on datasheet)	Charging time [minutes] required to implement one Wi-Fi tracking cycle (26mC)	Charging time [minutes] required to implement one GNSS tracking cycle (201mC)
Solar film For indoor/outdoor use BCS4430B6 (TDK)	44 × 30	0.18	0.2	200 (indoors) (typical room)	30	14.4	Not relevant due to lack of GNSS reception indoors
				500 (indoors) (bright room)	80	5.4	Not relevant due to lack of GNSS reception indoors
				3,000 (outdoors) (full shade)	500	0.9	6.7
				5,000 (outdoors) (full shade)	640	0.7	5.2
Solar panel Indoor luminance specifications AM-1815 (Panasonic)	58.1 × 48.6	1.1	7.8	200 (indoors) (typical room)	45.7	9.5	Not relevant due to lack of GNSS reception indoors
Solar panel Outdoor luminance specifications AM-5812 (Panasonic)	59.0 × 28.7	1.6	4.6	50,000 (outdoors) (bright overcast sky)	8900	0.05	0.38

9. Troubleshooting

Table 9 lists problems that might occur and the action you need to take when they do.

Table 9 Troubleshooting

Related section	Problem	Solution
2.1	The GW application fails to start	If the version of Python is earlier than 3.5, upgrade to Python version 3.5 or later.
		If multiple instances of Python are installed, you might not have set the path of the instance you installed most recently. See *11. Troubleshooting* in the Zero Carbon LoRa® Evaluation Board Tutorial.
		The port number of the PC port to which the Zero Carbon board B (GW access) is connected is incorrectly set. With board B connected to the port, check the port number in the Ports (COM & LPT) node of Device Manager.
	A solar powered Zero Carbon board A (edge) does not boot	The microcontroller requires a start-up voltage of approximately 2.6 volts. Either wait a while for the battery to charge, or use USB fast charging to charge the battery before reconnecting the solar panel.
5.3.4	The Patch command fails	Run the command as a user with administrator privileges.
		Place the Patch data file at the same level as the ZeroCarbon folder in the folder structure.
5.3.7	Build does not complete successfully	The Patch command might have failed. Try again by repeating the steps from 5.3.3 onward.
		The code file downloaded in 5.3.2 might be the wrong version. Download the specified version of the code file and repeat the steps from 5.3.3 onward.
6.1	Zero Carbon board A (edge) does not connect to E2Lite	When connecting the E2lite to a PC, connect the USB cable to E2Lite first, and then connect the power supply USB cable to the Zero Carbon board A (edge). Alternatively, check the orientation of the flat cable that connects the Zero Carbon board A (edge) to the E2Lite.
-	The program code does not use GNSS to estimate location	GNSS reception is used to estimate location when a Wi-Fi scan finds fewer than three access points. Either shield the Wi-Fi antenna or modify the code for the Zero Carbon board A (edge) to perform GNSS reception only.
-	The trigger switch does not function	The Zero Carbon board A (edge) and Zero Carbon board B (GW access) might have been flashed with the wrong firmware. Alternatively, the Zero Carbon board B (GW access) that connects to the GW might have the wrong firmware. Review the setup again. We recommend that you label the Zero Carbon board A (edge) and Zero Carbon board B (GW access) to ensure the correct firmware is flashed to the correct board.
-	Renesas Knowledge Base (FAQ)	For details about the RE family of microcontrollers, visit the following website: https://ja-support.renesas.com/knowledgeBase#31135

10. Precautions for Use

Note the following when using the Zero Carbon LoRa® Evaluation Board (model name: PC-1570001):

- The PC-1570001 is a board that embodies the reference design provided by Renesas' Zero Carbon Solution# concept. Because its use case lies solely in evaluation, we can make no guarantees regarding its operation or circuit design. The schematics and bill of materials shown in P38 onward of the User's Guide are those of the Zero Carbon Solution#.
- The circuits and other related information described in resources related to the PC-1570001 board are intended only as examples of the operation and application of semiconductor products.
  It is the responsibility of the customer to evaluate this information thoroughly when designing their equipment and systems.
  Renesas accepts no responsibility for damages resulting from the information in resources related to the PC-1570001 board. This includes damages incurred by the customer or any third party (the same applies hereinafter).
- The PC-1570001 does not represent an ideal reference design for the final product, nor does it satisfy regulatory standards that apply to the final product.
- Tachibana Electronic Solutions makes no warranty and assumes no responsibility for any infringement of patents, copyrights, or other intellectual property rights of third parties or disputes arising from the use of the product data, diagrams, tables, programs, algorithms, application circuit examples, and other information described in related documents.
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- Do not, in whole or part, alter, modify, reproduce, reverse engineer, or otherwise improperly use the PC-1570001. Tachibana Electronic Solutions is not liable for any damages caused by any such modification, alteration, reproduction, or reverse engineering.
- The PC-1570001 is not intended for use in equipment or systems that might directly endanger life or limb (such as life-support equipment and items implanted in the human body) or cause significant property damage (such as space equipment, submarine repeaters, nuclear power control systems, aircraft control systems, core plant systems, and military equipment), nor do we anticipate its use in such applications. Tachibana Electronic Solutions is not liable for any damage caused by use of our products for unanticipated applications.
- The PC-1570001 and its technology must not be used in equipment or systems whose manufacture, use, or sale is prohibited by domestic or foreign laws and regulations. When exporting, selling, or transferring our products or technology, ensure that you comply with the Foreign Exchange and Foreign Trade Law and other applicable export control laws and regulations of Japan and other countries, and follow the necessary procedures.
- If the customer resells or otherwise transfers the PC-1570001 to a third party, the customer is responsible for notifying the third party in advance of these terms and conditions.
- Reproduction or duplication of resources related to the PC-1570001 board, in whole or in part, is prohibited without our prior written consent.
- The PC-1570001 can generate, use, and emit RF energy that can cause harmful interference to radio communications. It can also be affected by EMC considerations.
- Cautionary note regarding the sample program
  The sample program is a product of the open-source community. Conditions of use and compensation are defined by the GitHub website, and any support requests can be submitted to the GitHub community.

#: Zero Carbon Solution:
https://www.semtech.com/company/press/semtech-ryoden-and-renesas-electronics-launch-zero-carbon-solution-with-the-lora-edge-platform-and-a-re-microcontroller

11. Disclaimer

By using the evaluation board (model name: PC-1570001), the customer agrees to the following terms and conditions:

- The PC-1570001 is not guaranteed to be free of defects. Any risk related to the results and performance of the PC-1570001 is borne entirely by the customer.
- The PC-1570001 is provided as-is without warranty of any kind, either express or implied.
- Such warranties include, but are not limited to, implied warranties of fitness for a particular purpose, salability, and non-infringement of authority and intellectual property rights. Tachibana Electronic Solutions expressly disclaims all such warranties.
- Tachibana Electronic Solutions does not consider the PC-1570001 to be a finished product. For this reason, the PC-1570001 might not yet comply with some requirements applicable to finished products, such as recycling, restricted substances, and electromagnetic compatibility regulations.
- It is entirely the responsibility of the customer to ensure compliance with all regulations that apply in the customer's locale.
- Neither Tachibana Electronic Solutions nor its affiliates are liable for any lost profits, loss of data, loss of contract opportunities, loss of business, loss of reputation or goodwill, economic losses, or costs associated with reprogramming or recalls (whether these losses are direct or indirect). Neither Tachibana Electronic Solutions nor its affiliates are liable for any other special, incidental, or consequential damages, either direct or indirect, arising out of or in any way connected with the use of the PC-1570001, even if we have been advised of the possibility of such damages.
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Revision History

Rev.	Publication date	Revisions	
		Pages	Description
1.00	Apr. 28, 2022	-	First publication

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