Zero Carbon LoRa® Evaluation Board (PC-1570001)

User's Manual

Introduction

The Zero Carbon LoRa® Evaluation Board offers LoRa communication and indoor/outdoor location tracking using the SEMTECH LR1110 and temperature and humidity sensing using Renesas' HS3001, under the control of a RE01 ultra-low power microcontroller based on Renesas proprietary SOTB™ process. Power can be supplied by USB, with the option of energy harvesting# using the RE01's energy harvesting controller.

#: Energy harvesting elements (such as solar panels) must be purchased separately.

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
LR1110 Transceiver User Manual

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.

Contents

1. Overview

This document explains how to use the Zero Carbon LoRa® Evaluation Board from a hardware perspective.

Sample programs are available from the GitHub repository.

Note: The sample programs are a product of the open-source community. For this reason, Tachibana Electronic Solutions can offer no support in relation to the sample programs. We appreciate your understanding. Conditions of use and compensation are defined by the GitHub website, and any support requests can be submitted to the GitHub community.

■ Product and model names

Product name: Zero Carbon LoRa® Evaluation Board

Model name: PC-1570001

■ Key features

• Support for indoor/outdoor location tracking and LoRa communication

• The RE01 microcontroller, a small solar panel, and the on-board rechargeable battery constitute a full system

• Support for multiple power supply methods

1.1 Package contents

Table 1-1 lists everything that comes with the Zero Carbon LoRa® Evaluation Board. It does not come with the debuggers used during software development (such as E2 and J-link) or the environmental energy harvesting elements (such as solar panels) used when evaluating energy harvesting.

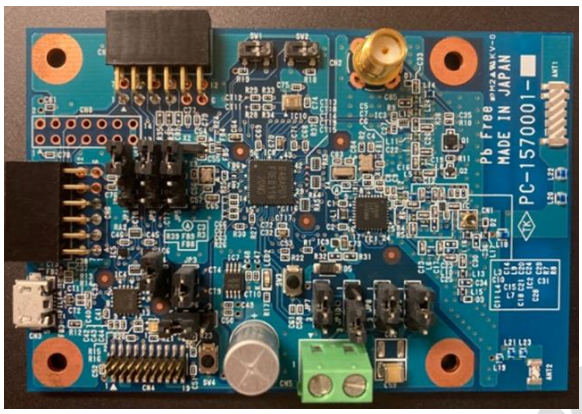
Table 1-1: Package contents

No.	Item	
1	Main board	Model name PC-1570001
2	Instructions	

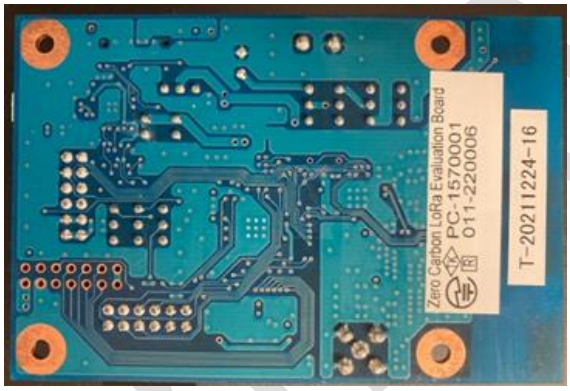
For information about component selection when evaluating energy harvesting, see RE01 1500KB, 256KB Group Battery Maintenance Free Energy Harvesting System Power Management (R01NA4837).

1.2 Visual appearance

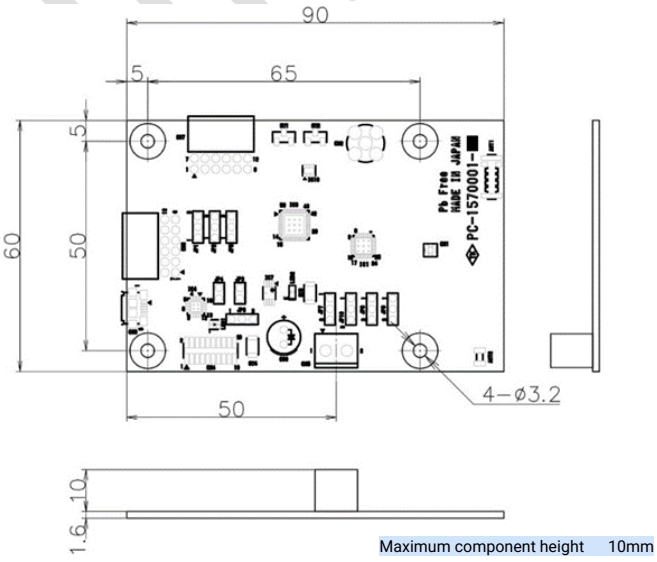
Figure **1**-**1** shows the visual appearance of the Zero Carbon LoRa® Evaluation Board. The board size is 60 × 90 mm.



Board (bottom)



Board (top)



Dimensions

Figure 1-1: Visual appearance

1.3 Component layout

Figure 1-2 shows the layout of the components on the Zero Carbon LoRa® Evaluation Board.

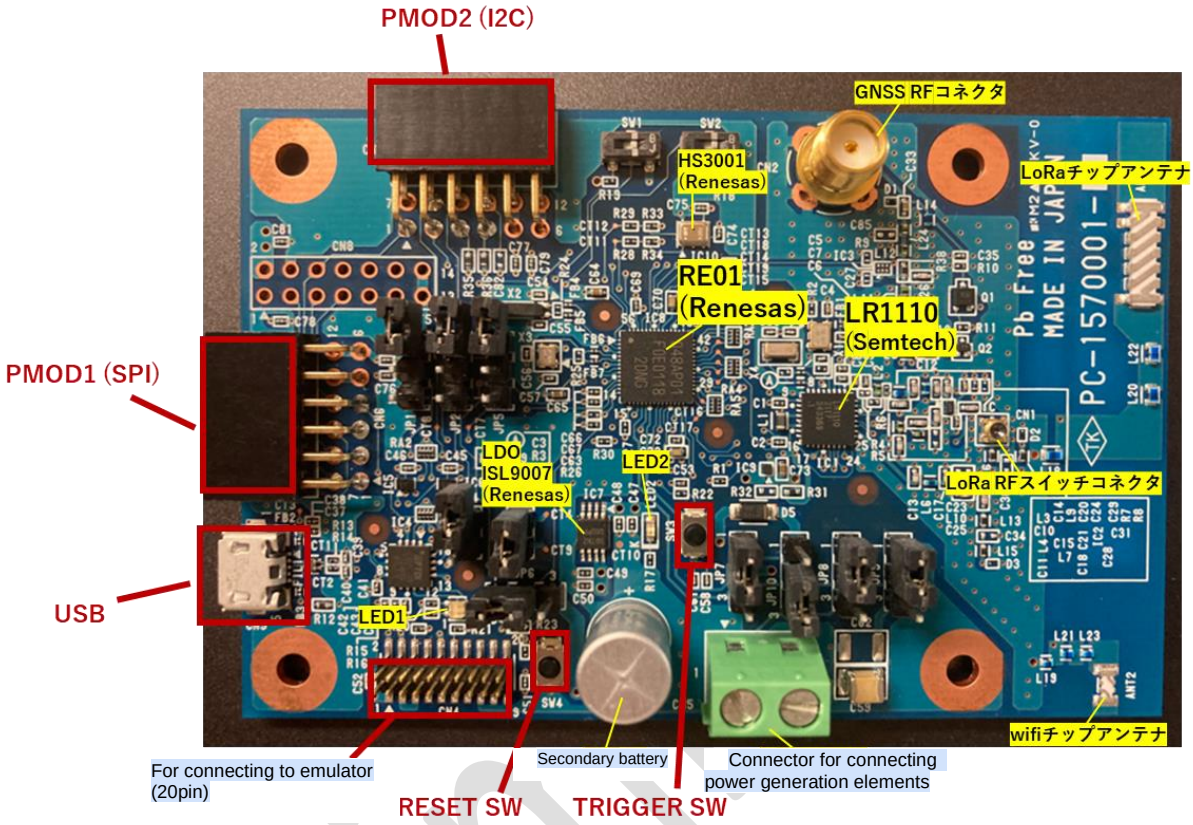


Figure 1-2 Component layout

2. Specifications

Table 2-1 shows the specifications of the Zero Carbon LoRa® Evaluation Board.

Item	Description
CPU	Arm Cortex-M0+ core, Max. 64MHz
Internal voltage regulator	Output voltage 3.3V (under USB CN4 supply)
Primary external oscillator	32MHz crystal oscillator
Secondary external oscillator	32.768kHz crystal oscillator
LoRa external oscillator	32MHz TCXO
Power supply modes	• External power supply mode (1.8V to 3.6V) • Energy harvesting mode • USB power mode
Memory	SRAM 128KB, Program Flash 256 KB
Interface	PMOD1: SPI × 1ch, PMOD2: I2C × 1ch, USB communication
Security	TSIP-Lite
Wireless standards	LoRa/LoLaWAN GNSS (GPS/BeiDou) 802.11b/g/n Wi-Fi (Passive scan)
Antennas RF connectors	2 × chip-based antennas (LoRa (Sub-GHz band) and Wi-Fi (2.4GHz band)) 2 × RF connectors (LoRa (Sub-GHz band) and GNSS (1.5GHz band)
Sensor	Temperature and humidity sensor (HS3001)
Board	60 × 90mm (4-layer PCB)

Table 2-1: Evaluation board specifications

3. Pin Assignments

ID/purpose	Model number	Pin number	Signal name	Description
CN1 LoRa communication	MS-156C3	-	-	-
CN2 GNSS (SMA) communication	HRM-300-134B(40)	-	-	-
CN3 USB power supply	10118192-0001LF	1	Vbus	USB power source (+)
		2	D-	Data transfer (Low)
		3	D+	Data transfer (High)
		4	ID	Not connected
		5	GND	USB power source (-)
		6 to 9	SG	Signal GND (-)
CN4 Emulator E2 J-Link/I-jet power supply	20021121-00020C4LF	1, 6	VCC	Power source (+)
		2	SWDIO	SWD data I/O
		4	SWCLK	SWD clock input
		10	RES#	Reset signal input pin
		11, 13	EML_5V	5V supply from emulator
		3, 5, 9, 12, 15, 17, 19	GND	Power source (-)
		7, 8, 14, 16, 18, 20	-	Not connected
CN5 EH power supply	XW4E-02C1-V1	1	VSC_VCC	Solar panel power source (+)
		2	GND	Solar panel power source (-)
CN6 SPI communication	PPPC062LJBN-RC	1	SS	I/O pin for slave selection
		2	MOSI	I/O pin for output data from master
		3	MISO	I/O pin for output data from slave
		4	DCLK	Data clock signal
		5, 11	GND	Power source (-)
		6, 12	LR1110_VCC	Power source (+)
		7	P103	I/O port 14bit I/O pin
		8	RES#	Reset signal input pin
		9	P112	I/O port 14bit I/O pin
		10	P110	I/O port 14bit I/O pin
CN7 I2C communication	PPPC062LJBN-RC	1	P112	I/O port 14bit I/O pin
		2, 10	RES#	Reset signal input pin
		3	SCLO	Clock I/O pin
		4	SDAO	Data I/O pin
		5, 11	GND	Power source (-)
		6, 12	VCC	Power source (+)
		7	P208	I/O port 8bit I/O pin
		8	TXD2	Data transmission output pin
		9	RXD2	Data reception I/O pin

CN8 Service port		1	VCC	Power source (+)
		2	RF_VCC	LR1110 power source (+)
		3	P103	I/O port 14bit I/O pin
		4, 13, 14	GND	Power source (-)
		5	P110	I/O port 14bit I/O pin
		6	P112	I/O port 14bit I/O pin
		7	P000	I/O port 14bit I/O pin
		8	P001	I/O port 14bit I/O pin
		9	P002	I/O port 14bit I/O pin
		10	P003	I/O port 14bit I/O pin
		11	P004	I/O port 14bit I/O pin
		12	P005	I/O port 14bit I/O pin

4. Connector Types

ID	Designation	Remarks
CN1	Plug	E.g., MS-156-088LP-H1/HRS
CN2	SMA connector	
CN3	Micro USB Type-B	
CN4	Pin header socket 20 pin 1.27 pitch (2 × 10)	
CN5	Screw terminals for direct wire connection	
CN6 CN7	Pin header 12 pin 2.54 pitch (2 × 6)	

5. Electrical Characteristics

5.1 Absolute maximum ratings

CAUTION: Exceeding the absolute maximum ratings may permanently damage the board.

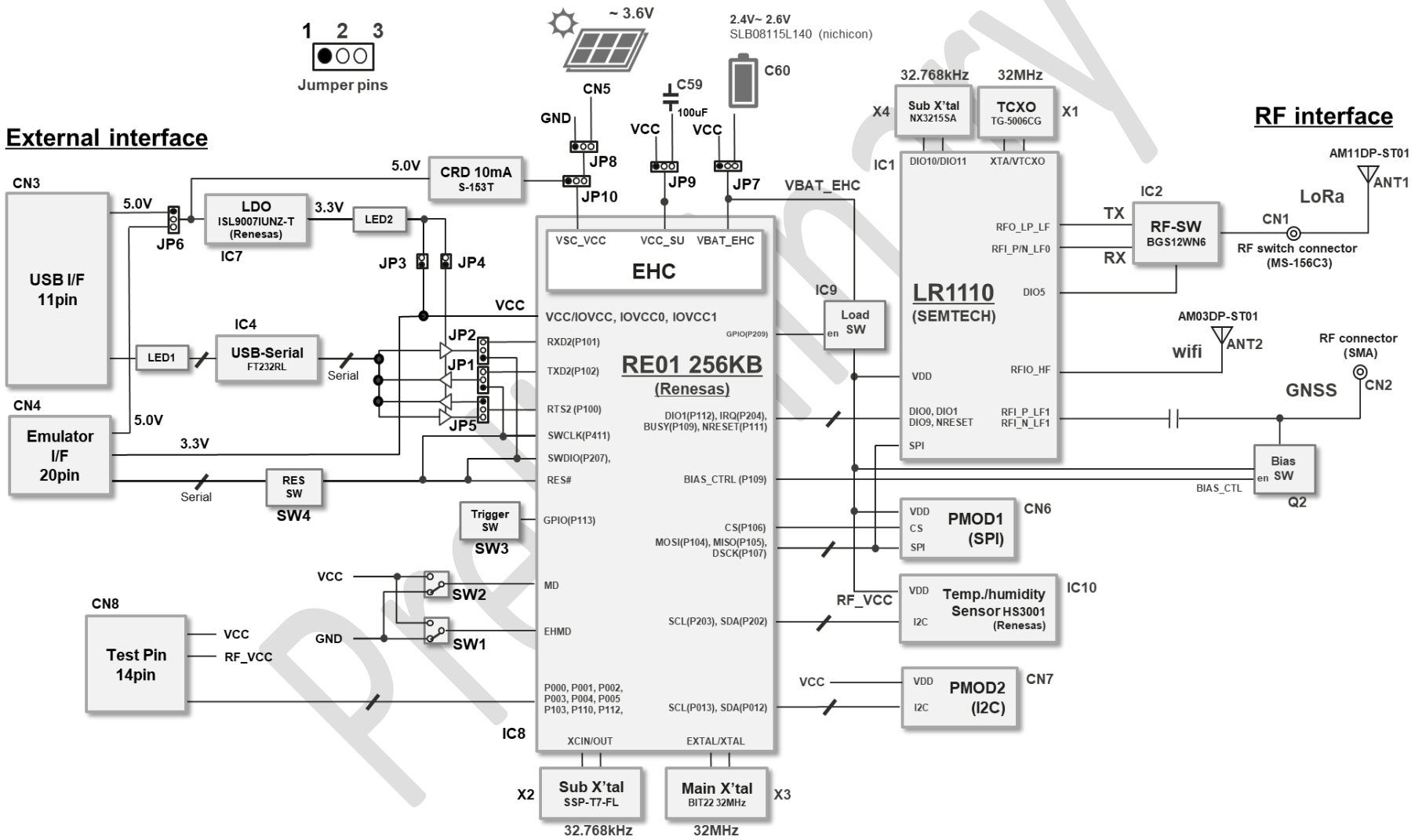
Item	Label	Maximum rating	Unit	Remarks
USB input power supply voltage	USB_VBUS	5.5	V	
External power supply voltage	VCC	3.6	V	
Operating temperature	Topt	-20 to +60	°C	

5.2 Recommended operating conditions

Item	Label	Min	Typ	Max	Unit	Remarks
USB input power supply voltage	USB_VBUS	2.97	5	5.5	V	
External power supply voltage	VCC	1.62	3.3	3.6	V	
Power supply voltage	GND	-	0	-	V	
EHC rechargeable battery input voltage	VBAT_EHC	1.62	-	3.6	V	
EHC input voltage	VSC_VCC	1.62	-	3.6	V	

6. System Block Diagram

The following is a block diagram of the Zero Carbon LoRa® Evaluation Board system. The solar panel connected to CN5 must be purchased separately.



7. Jumper and Switch Settings for Various Use Cases

The RE01 microcontroller can start in three modes: EH (Energy Harvesting) startup mode, normal startup mode, and SCI boot mode. Table 7-1 lists the power source and switch settings for each mode. The jumper settings for various use cases are explained in the subsequent sections.

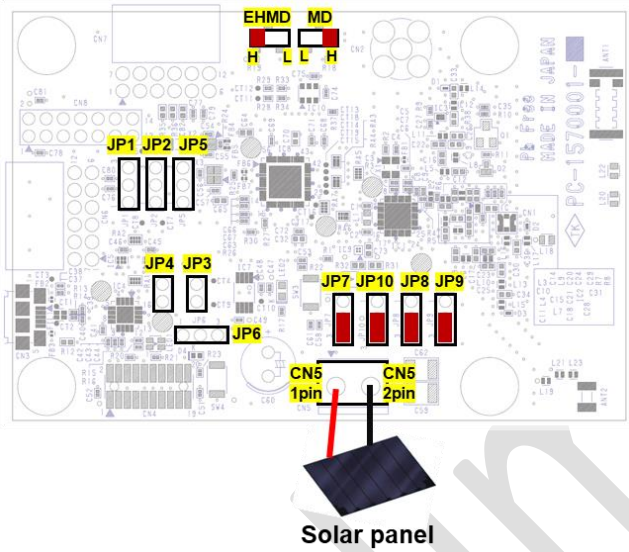
In EH startup mode, the Zero Carbon LoRa® Evaluation Board system uses the internal energy harvesting control circuit (EHC) of the RE01. The EHMD pin setting determines whether the RE01 operates in EH or normal startup mode. In SCI boot mode, MCU boots with a boot program in the MCU which allows the code flash memory to be flashed from an external source via the serial interface (SCIg). To start the RE01 in SCI boot mode, keep the MD pin level low on exiting the reset state. Renesas provides its Renesas Flash Programmer (RFP) free of charge.

Table 7-1: Startup mode, power supply method, and eight use cases

Startup mode	Power source	Description	Switch settings	
		Use case	EHMD (SW1)	MD (SW2)
Energy Harvesting (EH) mode	Energy harvesting devices	The power generated by energy harvesting devices charges the rechargeable battery via the EHC in the RE01, and the rechargeable battery supplies power to the various on-board devices.	**High**	**High**
		When driving applications using energy harvesting devices and a rechargeable battery		
	USB	Instead of energy harvesting devices, the rechargeable battery is charged by USB power using a constant-current diode (10mA), and the rechargeable battery supplies power to the various on-board devices.		
		When the rechargeable battery must be charged quickly to improve evaluation efficiency		
Normal power supply mode	USB	USB power (5.0V) is reduced to 3.3V by the on-board LDO regulator and supplied to the various on-board devices.	**Low**	
		When debugging using a USB power supply and USB serial communication		
	External power supply	The + terminal of the external power supply is connected to JP3 pin 1 and the - terminal to the GND pin (for example JP8 pin 1) and power is supplied to the various on-board devices.		
		When using an external power supply to evaluate current consumption		
	Emulator E2, E2-lite	Power is supplied directly to the on-board devices from the E2 emulator.		
		When using an E2 or E2-lite emulator for software development		
	Emulator J-Link I-jet	The power source (5.0V) of the J-Link or I-jet emulator is reduced to 3.3V by the on-board LDO regulator and supplied to the various on-board devices.		
		When using a J-Link or I-jet emulator for software development		
SCI boot mode	USB		**Don't Care**	**Low**
		When using RFP to flash a program (hex) via USB		
	Emulator E2, E2-lite			
		When using RFP to flash a program (hex) via E2		

7.1 Energy harvesting mode (energy harvesting device)

Figure 7-1 shows the jumper pin settings and basic wiring for energy harvesting mode. The current generated by the energy harvesting device accumulates in the capacitor (100uF) connected to JP9, and activates the EHC (Energy Harvesting Controller) when 2.7V is reached. After the EHC activates, the EHC charges the rechargeable battery connected to JP7 until reaching a predetermined (programmable) voltage, at which point the application runs. In this scenario, the RE01 VCC/IOVCC serves as the power supply **output pin** and supplies voltage to peripheral ICs. The solar panel connected to CN5 preferably has an open circuit voltage of 3.5V or higher to ensure sufficient leeway in its ability to activate the EHC. One example of a suitable solar panel is TDK's indoor/outdoor solar film BCS Series due to its particularly efficient power generation in low-light environments and its film substrate which realizes a light-weight product with support for custom shapes. Another is Panasonic's Amorton Series with its wide variety of panel sizes. For details about the energy harvesting operation of the RE01 microcontroller, see the Application Notes (R01AN4837) published by Renesas.



Reference	Setting
JP1	Open
JP2	Open
JP3	Open
JP4	Don't care
JP5	Open
JP6	Don't care
JP7	2-3
JP8	2-3
JP9	2-3
JP10	2-3
EHMD(SW1)	High
MD(SW2)	High

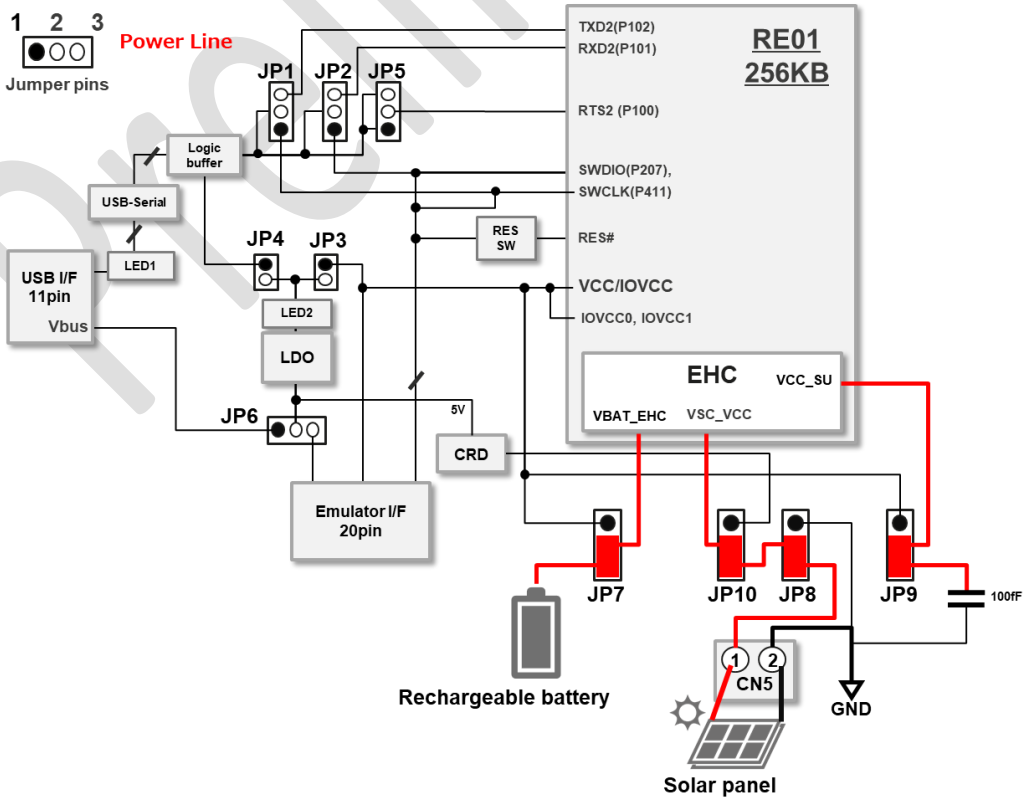
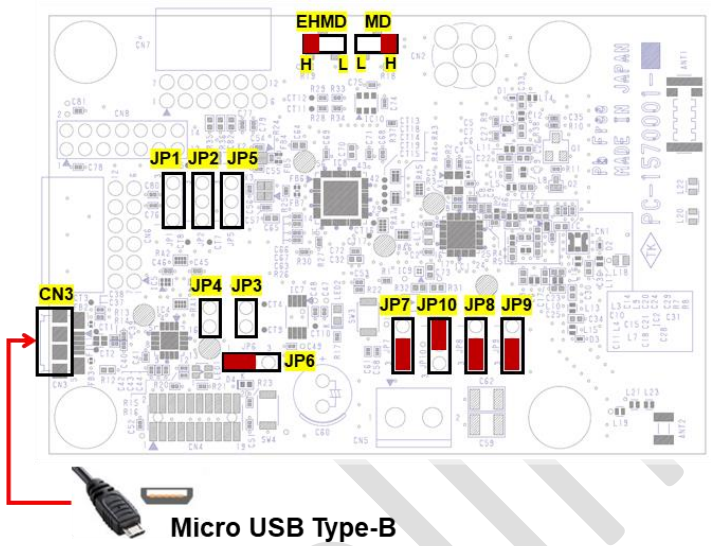


Figure 7-1 Connections for energy harvesting (solar panel)

7.2 Energy harvesting mode (USB fast charging)

Figure 7-2 shows the jumper pin settings and basic wiring for this mode. In this configuration, LED1 and LED2 are lit. The amount of current generated by a small solar panel depends on the lighting in the surrounding environment. You can expect several dozen uA from an indoor panel, and several mA from a panel positioned outdoors. For this reason, the rechargeable battery will take some time to charge. To allow the operator to debug energy harvesting mode more efficiently, you can use a USB power source instead of a solar panel to charge the rechargeable battery quickly via a constant-current diode (10mA). In the case of the on-board 14mAh small lithium-ion rechargeable battery SLB08115L140 (Nichicon), you can fully charge the battery from flat in approximately 1 hour. The charge voltage limit of the rechargeable battery is programmable in the RE01 EHC, and when the limit is reached, any excess charge current is diverted to GND to avoid overcharging. For details, see *14. Energy Harvesting Controller (EHC)* in the RE01 Hardware Manual.

To match the EHC operating voltage, the rechargeable battery preferably has a nominal voltage of 3V or lower. Suitable products include the SLB series (Nichicon) that comes mounted on the board, and the ultrathin (0.45mm) EnerCera series (NGK Insulators) with its high bending resistance.



Reference	Setting
JP1	Open
JP2	Open
JP3	Open
JP4	Open
JP5	Open
JP6	**1-2**
JP7	**2-3**
JP8	Don't care
JP9	**2-3**
JP10	**1-2**
EHMD(SW1)	**High**
MD(SW2)	**High**

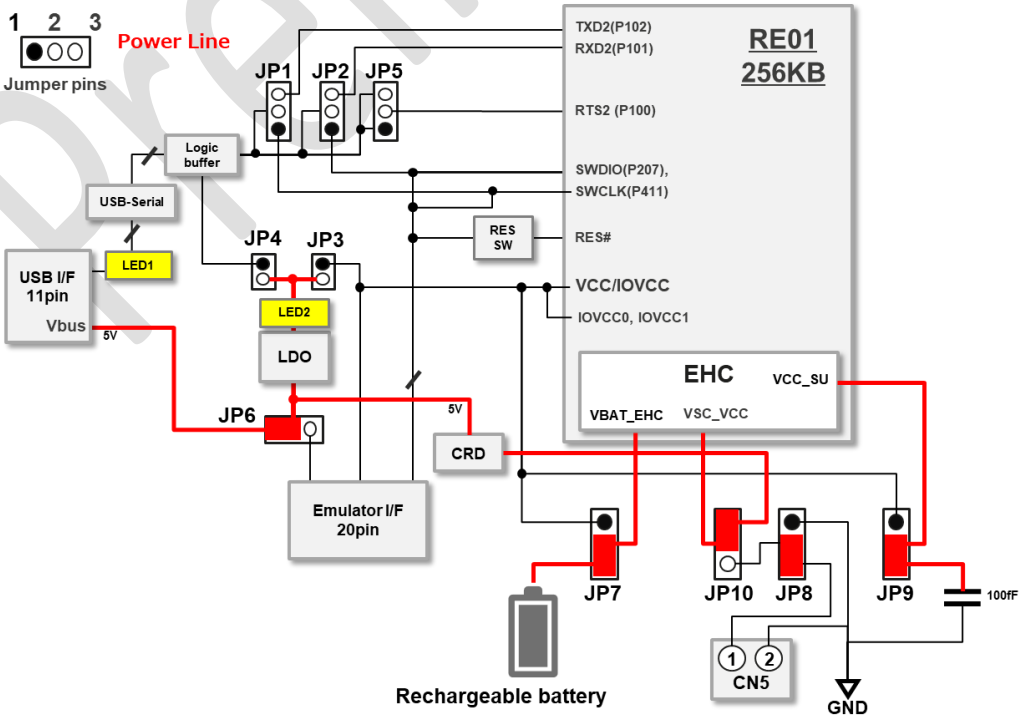


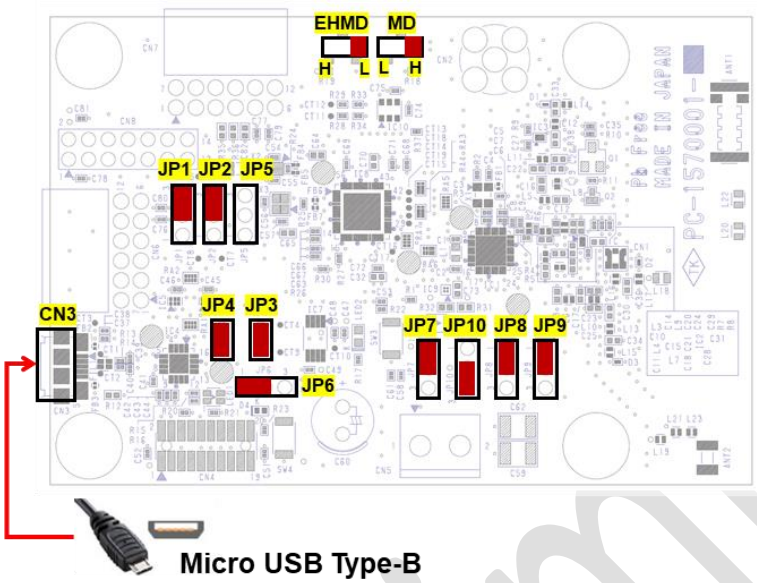
Figure 7-2 Connections for energy harvesting (USB charging)

7.3 USB power supply + Serial communication

Figure 7-3 shows the jumper pin settings and basic wiring for this mode. In this configuration, LED1 and LED2 are lit. The voltage from the USB power supply undergoes a level shift (5.0V → 3.3V) in the LDO regulator (IC7) and is supplied to the VCC line. By setting the EHMD switch (SW1) to Low, you can start the MCU in normal mode.

Because this mode does not use the EHC, the VCC/IOVCC pin of the RE01 functions as the power **input pin**. Regarding the unused EHC pins, connect the VBAT_EHC and VCC_SU pins to VCC and the VSC_VCC pin to GND.

Communication takes place between USB and MCU (TXD2 and RXD2) using USB/Serial conversion, and LED1 blinks during communication.



Reference	Setting
JP1	2-3
JP2	2-3
JP3	Short
JP4	Open
JP5	Open
JP6	**1-2**
JP7	**1-2**
JP8	**1-2**
JP9	**1-2**
JP10	**2-3**
EHMD(SW1)	**Low**
MD(SW2)	**High**

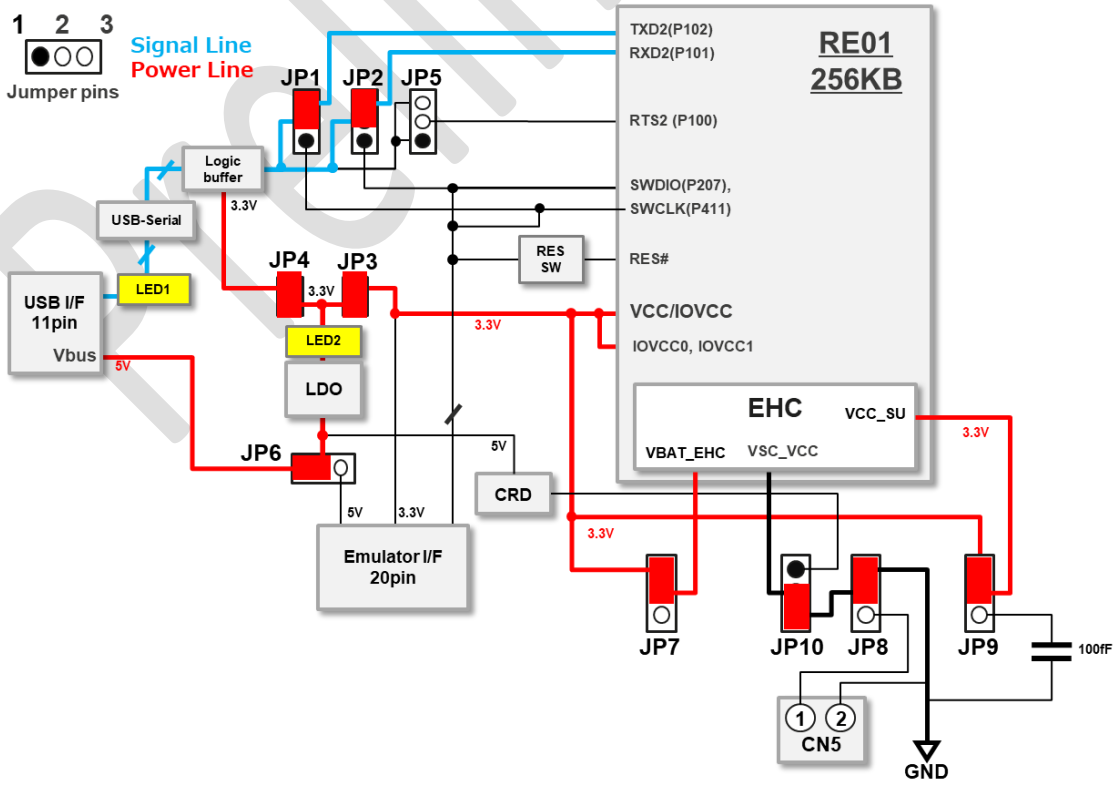
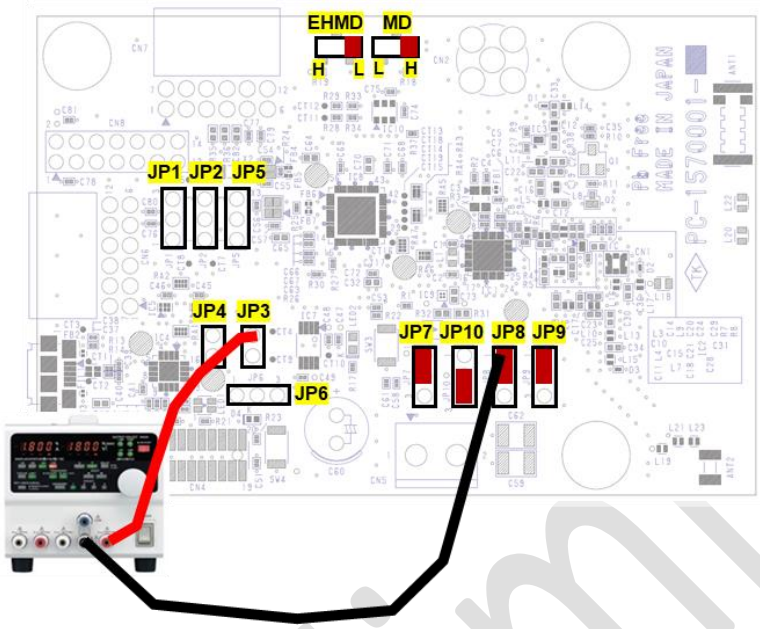


Figure 7-3 Connections for USB power supply + Serial communication

7.4 Debugging and evaluation using an external power source

Figure **7-4** shows the jumper pin settings and basic wiring for this mode. The internal power of the board is supplied directly from a regulated power supply or other source. Connect JP3 pin 1 to the + terminal of the power supply and JP8 pin 1 to the GND of the power supply. Leave the JP3 jumper open so that no voltage is applied to the output pin of the LDO regulator (IC7). Applying voltage to the LDO regulator output pin can damage the LDO regulator.

By using a regulated power supply that can monitor current, you can use this mode to evaluate current consumption.



Reference	Setting
JP1	Open
JP2	Open
JP3	+ terminal of power source to pin 1
JP4	Open
JP5	Open
JP6	Open
JP7	1-2
JP8	1-2, - terminal of power source to pin 1
JP9	**1-2**
JP10	**2-3**
EHMD(SW1)	**Low**
MD(SW2)	**High**

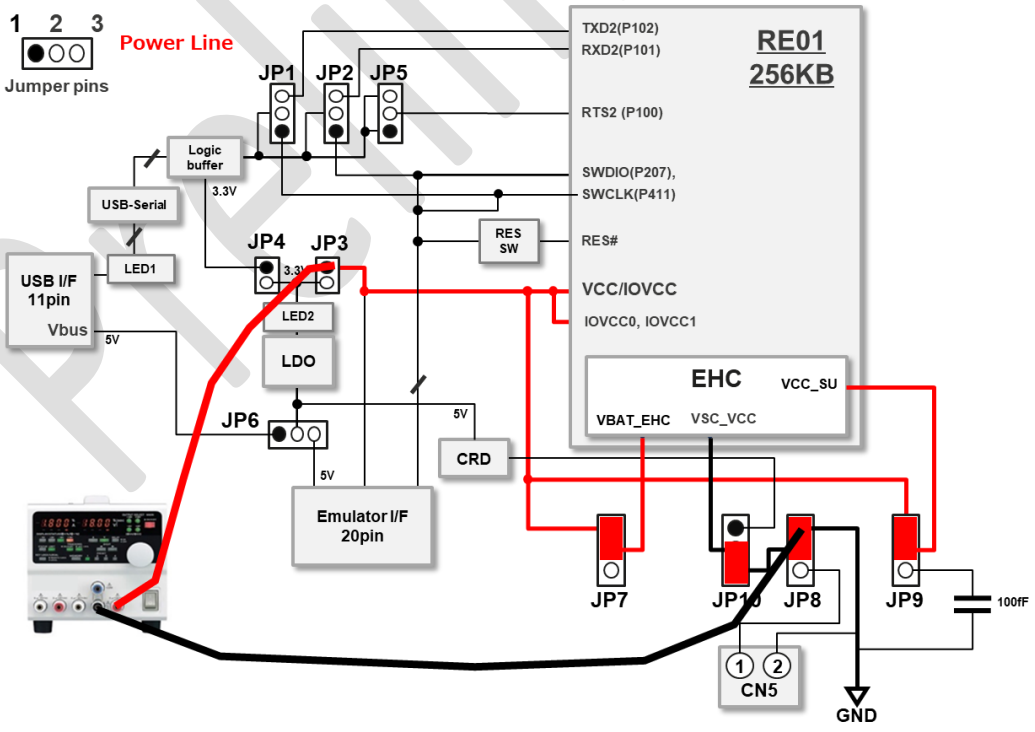


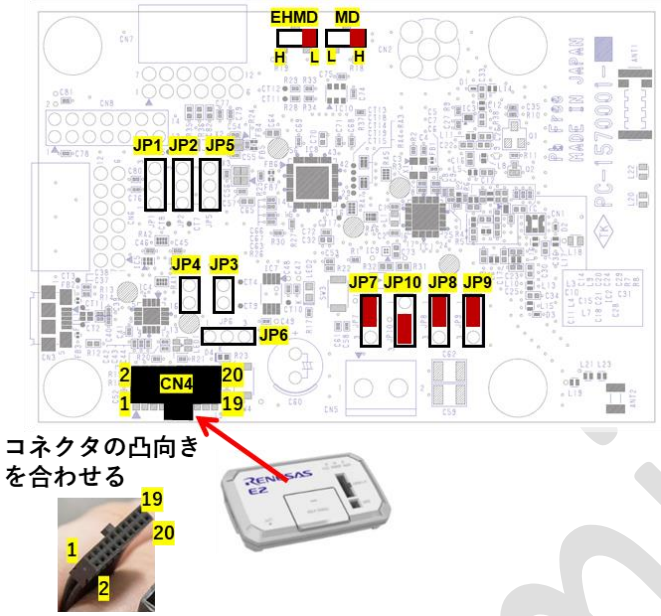
Figure 7-4 Connections for debugging and evaluation using an external power source

7.5 Emulator E2 power supply + SWD debugging

Figure **7-5** shows the jumper pin settings and basic wiring for this mode. The E2 Emulator (E2 Emulator Lite) connected to connector CN4 can directly supply 3.3V of internal power on the board.

SWDIO, SWCLK, and RES# are connected on-board between the emulator and the MCU for Serial Wire Debug (SWD) communication. You can develop software for the RE01 family by downloading the e² studio integrated software development environment, which is available from Renesas free of charge.

References: Getting started with Renesas e²: Installer, How-to video



Reference	Setting
JP1	Open
JP2	Open
JP3	**Close**
JP4	Open
JP5	Open
JP6	**2-3**
JP7	**1-2**
JP8	**1-2**
JP9	**1-2**
JP10	**2-3**
EHMD(SW1)	**Low**
MD(SW2)	**High**

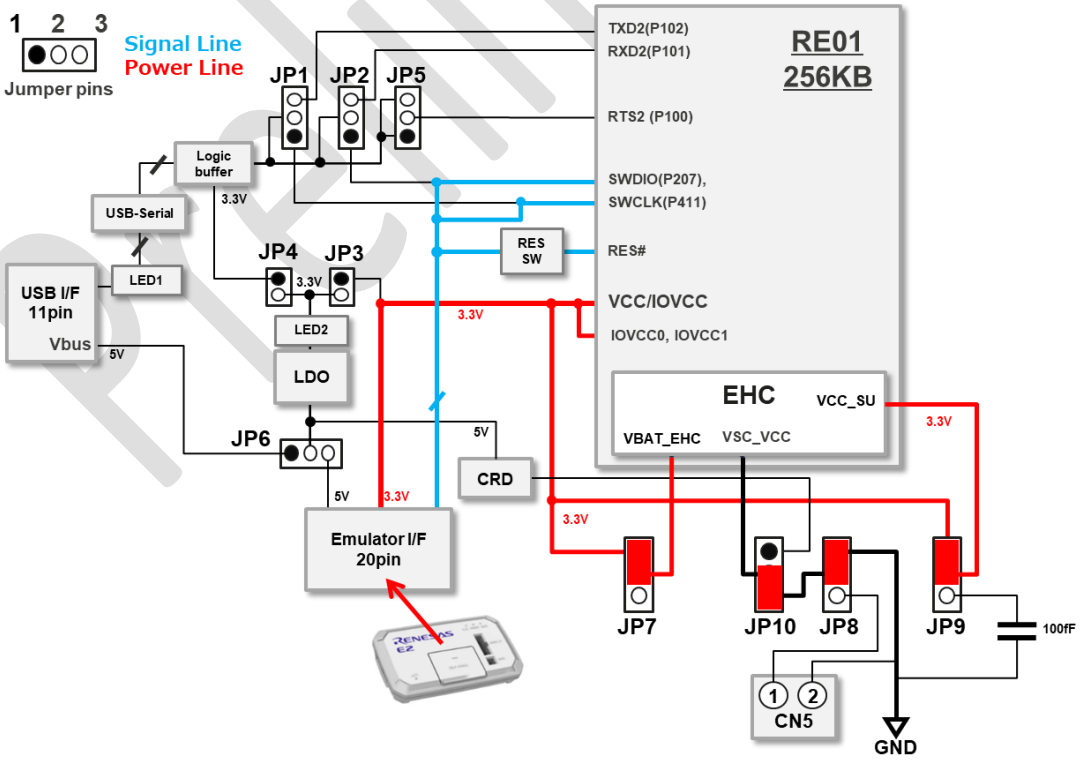


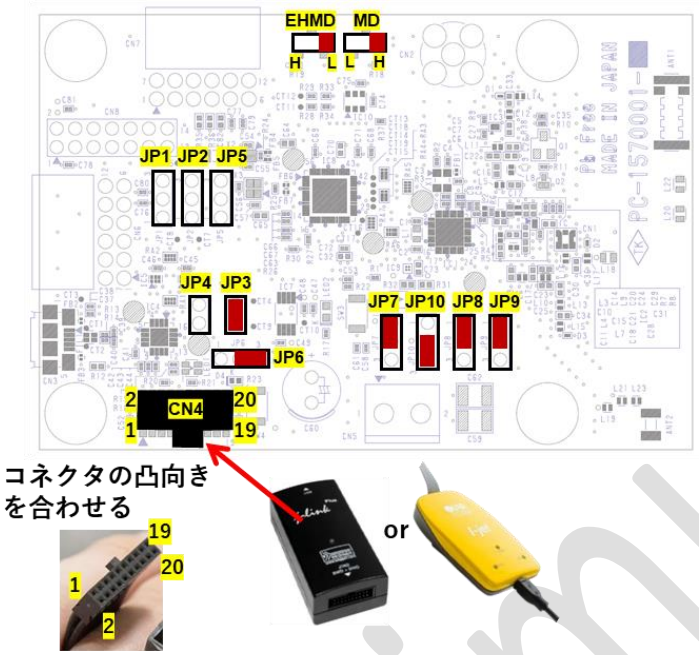
Figure 7-5 Connections for emulator E2 power supply + SWD debugging

7.6 Emulator J-Link/I-jet power supply + SWD debugging

Figure **7-6** shows the jumper pin settings and basic wiring for this mode. In this configuration, LED2 is lit. The internal power of the board is supplied via LDO by a J-Link or I-jet probe connected to connector CN4.

SWDIO, SWCLK, and RES# are connected on-board between the emulator and MCU for SWD communication. When using I-jet, you can develop software for the RE01 family by downloading the IAR EWARM integrated software development environment available from IAR Systems. When using J-Link, you can develop software in Renesas e^2 studio or IAR EWARM.

References: Getting started with IAR EWARM: Online Training



Reference	Setting
JP1	Open
JP2	Open
JP3	**Close**
JP4	Open
JP5	Open
JP6	**2-3**
JP7	**1-2**
JP8	**1-2**
JP9	**1-2**
JP10	**2-3**
EHMD(SW1)	**Low**
MD(SW2)	**High**

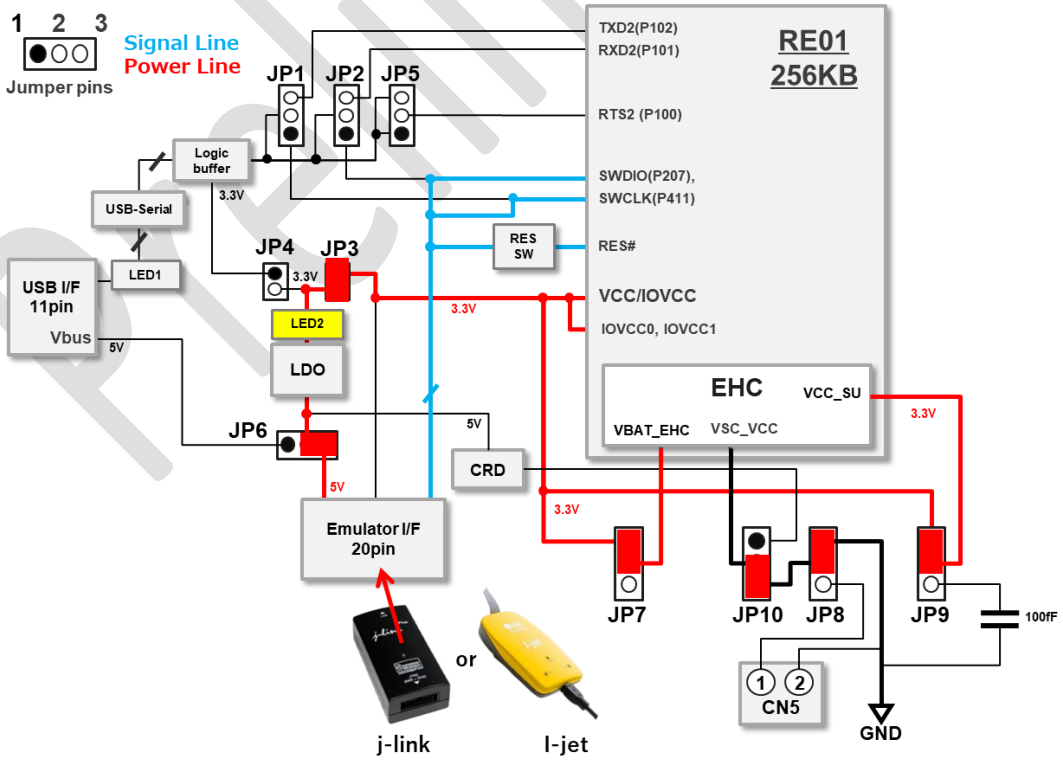


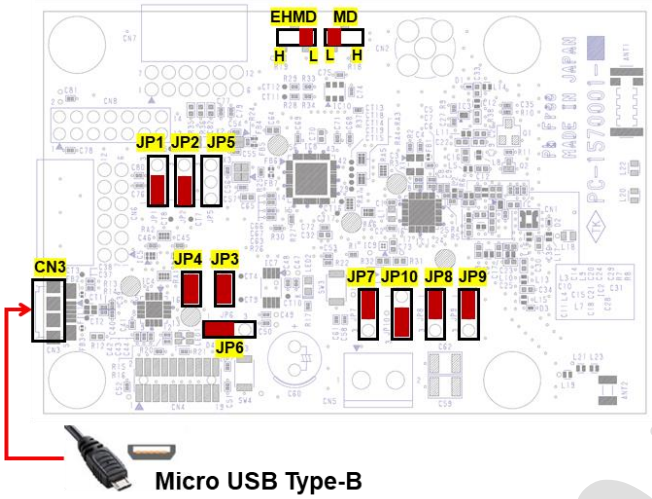
Figure 7-6 Connections for emulator J-Link/I-jet power supply + SWD debugging

7.7 SCI boot mode for USB flashing

Figure **7-7** shows the jumper pin settings and basic wiring for this mode. In this configuration, LED1 and LED2 are lit.

Start the RE01 microcontroller in SCI boot mode by setting the MD (SW2) to Low. You can use Renesas Flash Programmer (RFP) to perform serial flash programming of the RE01 microcontroller flash memory in a graphical interface. This tool is available from Renesas free of charge. The data (hex file) flashed to the flash memory is sent via USB (CN3).

Figure **7-8** shows the settings in RFP. In the **Communication** area, select **COM port** from the **Tool** drop-down menu. In the **Tool Details** dialog box, select the port number of the COM port to which the Zero-Carbon EVB is connected.



Reference	Setting
JP1	1-2
JP2	1-2
JP3	Close
JP4	Close
JP5	Open
JP6	1-2
JP7	1-2
JP8	1-2
JP9	1-2
JP10	2-3
EHMD(SW1)	Low
MD(SW2)	High

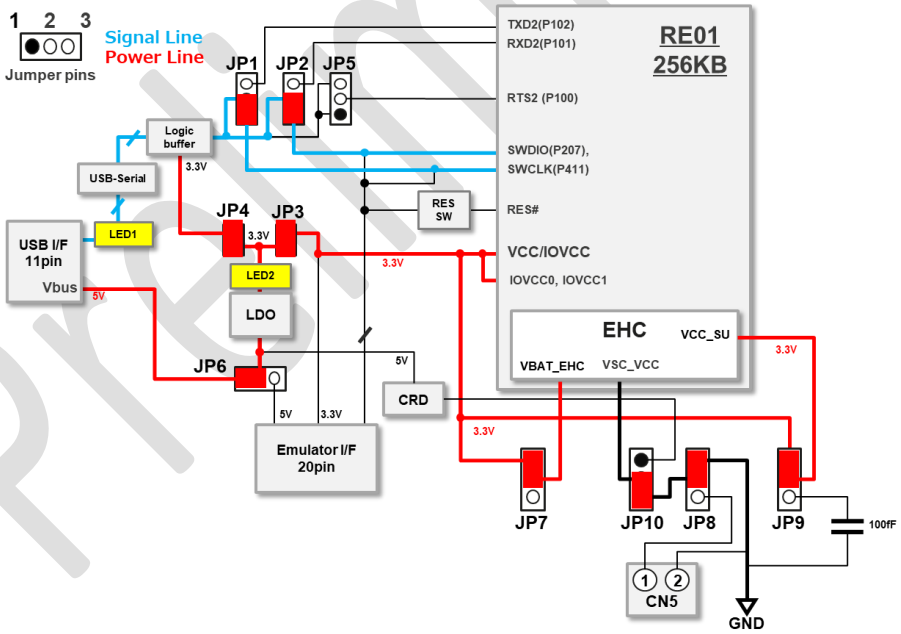


Figure 7-7 Connections for SCI boot mode for USB flashing

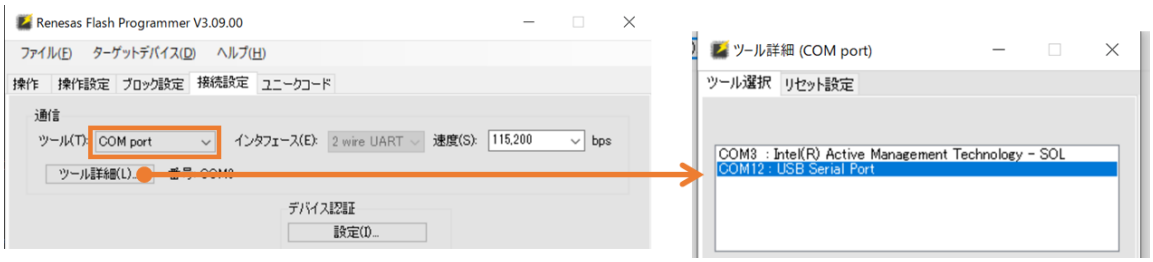
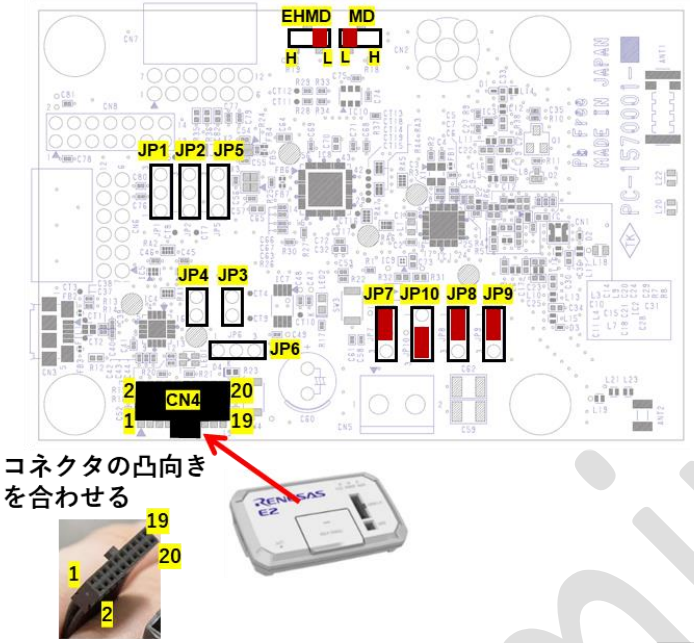


Figure 7-8 RFP settings (communication via USB)

7.8 SCI boot mode for E2 flashing

Figure 7-9 shows the jumper pin settings and basic wiring for this mode. Start the RE01 microcontroller in SCI boot mode by setting the MD (SW2) to Low. You can use Renesas Flash Programmer (RFP) to perform serial flash programming of the RE01 microcontroller flash memory in a graphical interface. This tool is available from Renesas free of charge. The data (hex file) flashed to the flash memory is sent via the E2 emulator (CN4). Data transfer is faster than the transfer via USB in the preceding section. Figure 7-10 shows the RFP settings. In the **Communication** area, select **E2 emulator** from the **Tool** drop-down menu. In the **Tool Details** dialog box, select the **3.3V** option in the **Power Supply** area.



Reference	Setting
JP1	Open
JP2	Open
JP3	Open
JP4	Open
JP5	Open
JP6	Open
JP7	1-2
JP8	1-2
JP9	1-2
JP10	2-3
EHMD(SW1)	Low
MD(SW2)	High

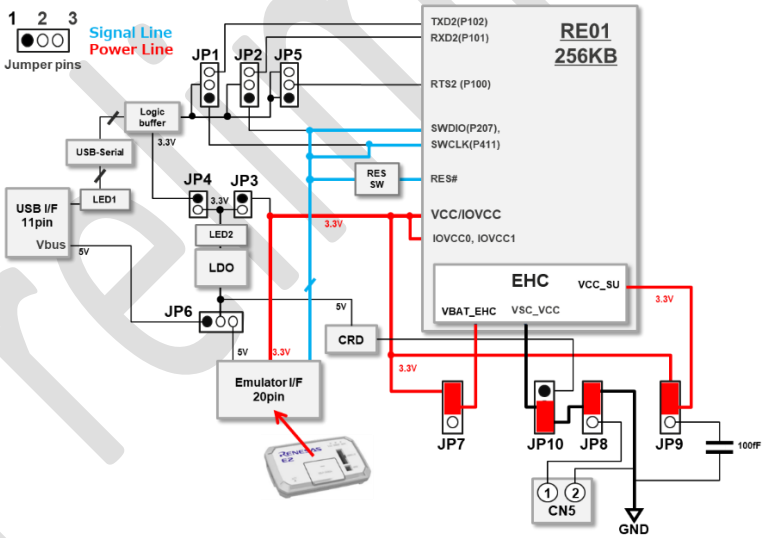


Figure 7-9 Connections for SCI boot mode for E2 flashing

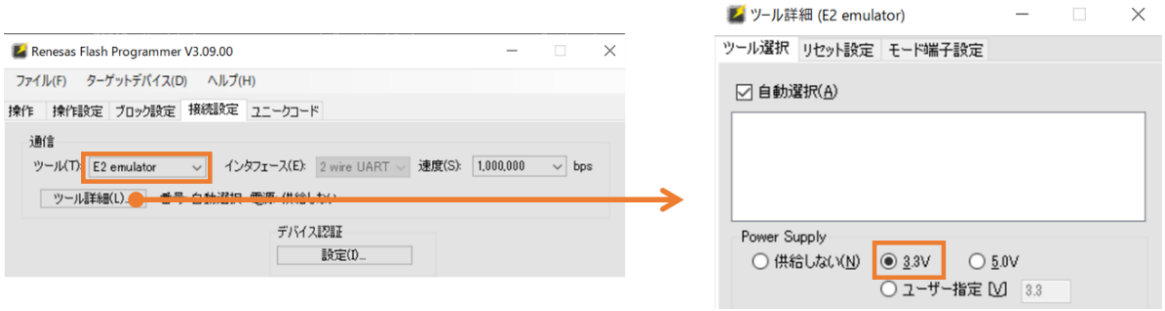
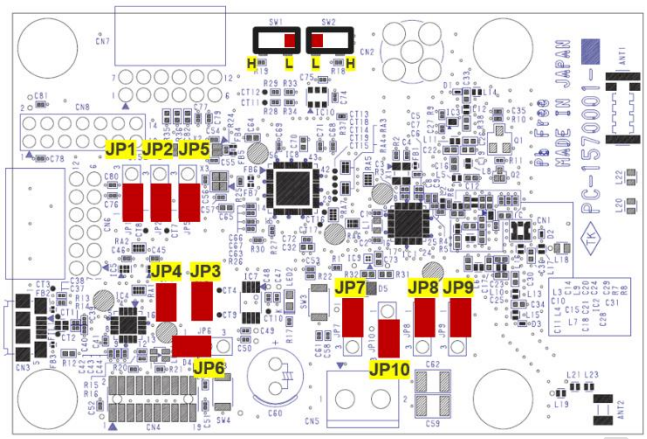


Figure 7-10 RFP settings (communication via E2)

8. Factory Jumper and Switch Settings

8.1 Factory jumper and switch settings

Figure 8-1 shows the jumper and switch settings in effect when the board leaves the factory.



Reference	Setting
JP1	**1-2**
JP2	**1-2**
JP3	**Close**
JP4	**Close**
JP5	Open
JP6	**1-2**
JP7	**1-2**
JP8	**1-2**
JP9	**1-2**
JP10	**2-3**
EHMD(SW1)	Don't care

Figure 8-1 Factory jumper and switch settings

9. Test Specification

The following aspects of the board are tested prior to shipment:

Test item	Nature of test
Input power supply: Insulation check	Confirming that there are no shorts
Internal power supply: Insulation check	Confirming that there are no shorts
Internal power supply: Voltage check	Confirming that when powered by the USB bus power supply, the internal power voltage is within 10% of the 3.3V rating
Switch check	Checking operation and conductivity of SW 1, 2, 3, 4
RE01, LR1110	Testing firmware flashing
RE01, LR1110	Checking the operation of geolocation based on Wi-Fi reception

10. RF Interfaces

Figure **10**-**1** shows a block diagram of the RF interfaces. The Zero Carbon LoRa® Evaluation Board has interfaces for three frequency bands: LoRa (Sub-GHz), GNSS (1.5GHz), and Wi-Fi (2.4GHz).

The RE01 microcontroller controls the power supply lines of the LR1110 (IC1), temperature and humidity sensor (IC10), and PMOD1 (CN6) using the load switch (IC9).

10.1 LoRa (Sub-GHz)

The LoRa interface supports transmission and reception, and the RF-SW (IC2) is used to switch the signal line between transmission and reception. The characteristics of the chip antenna (ANT1) are explained in the following chapter. If you need to use an antenna other than the chip antenna for evaluation purposes, connect the antenna to the RF switch connector (CN1). Because the RF signal line to the chip antenna (ANT1) is disconnected when using the switch connector (CN1), you can perform evaluation using different antenna without the need for soldering work.

10.2 GNSS (1.5GHz)

The GNSS (Global Navigation Satellite System) interface supports GPS and Beidou satellites. You can receive GNSS signals by connecting an antenna to the RF connector (CN2). Use an active antenna that integrates an LNA and SAW filter. Ensure that the active antenna you use can operate at the voltage (approximately 2.4V) of the rechargeable battery (C60). One example of a suitable antenna is the AA.170.301111 (TAOGLAS). You can use BIAS_CTRL to turn the active antenna bias on and off.

For details about the GNSS reception performance of the LR1110, see the SEMTECH Application Note: LR1110 GNSS Antenna Performance Optimization.

10.3 Wi-Fi (2.4GHz)

The Wi-Fi interface supports reception (passive scanning) only. The characteristics of the chip antenna (ANT2) are explained in the following chapter.

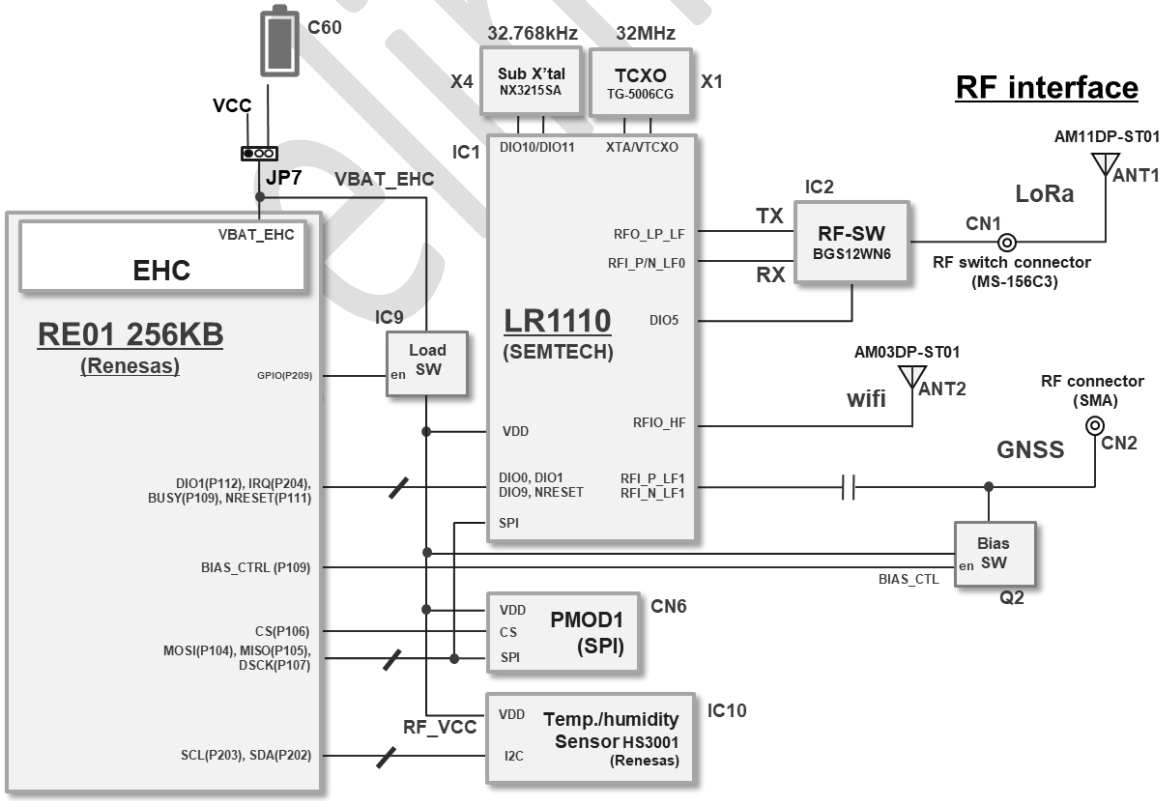
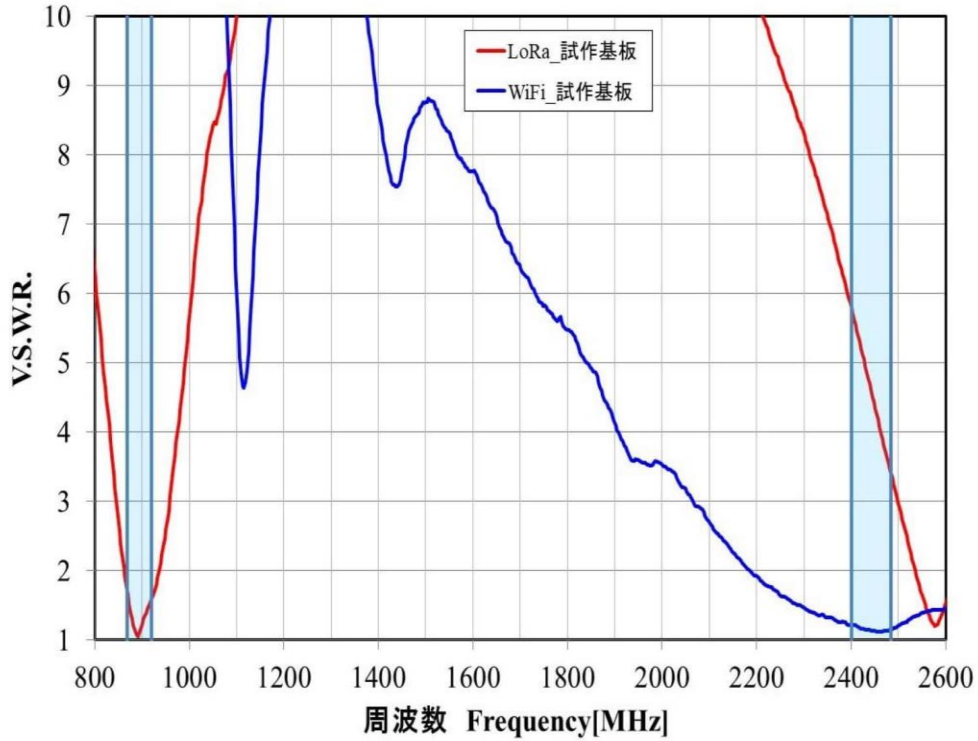


Figure 10-1 Block diagram of RF interface and surrounding components

11. Characteristics of LoRa Chip Antenna and Wi-Fi Chip Antenna

11.1 Results of VSWR measurement

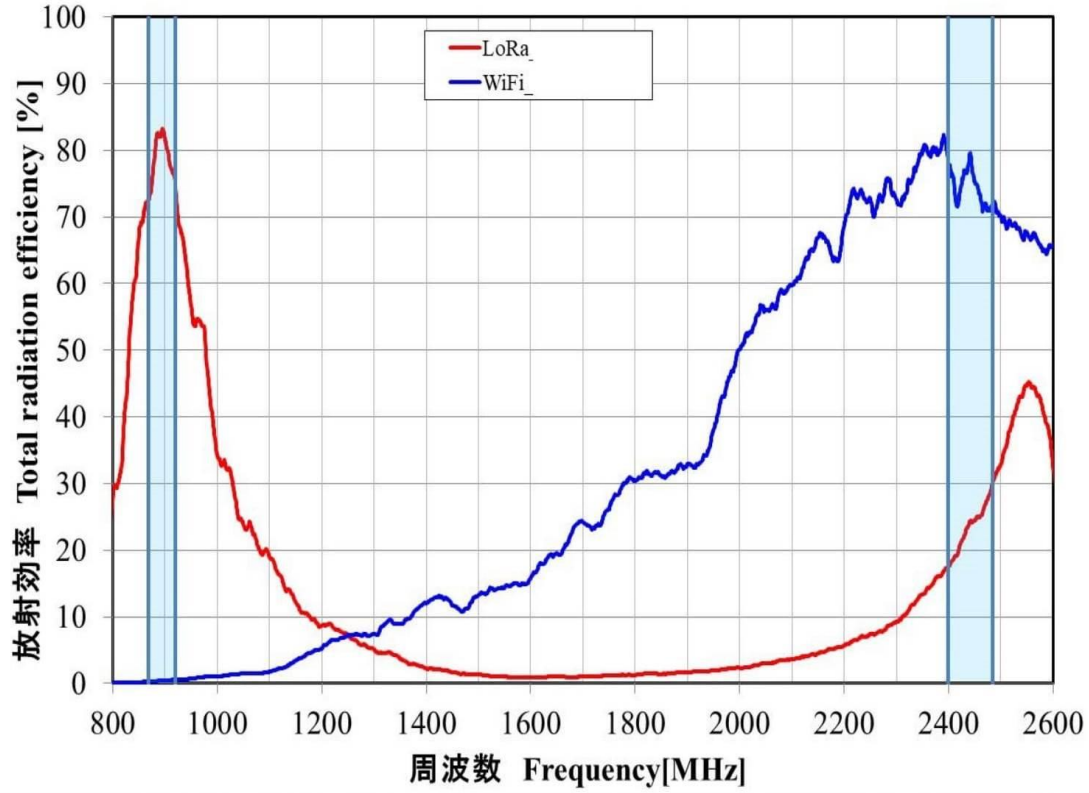
V.S.W.R. 測定結果



アンテナ	LoRa				WiFi			
	VSWR @868MHz	VSWR @894MHz	VSWR @920MHz	BandWidth [MHz] @VSWR≦2	VSWR @2400MHz	VSWR @2442MHz	VSWR @2484MHz	BandWidth [MHz] @VSWR≦2
LoRa/AM11DP-ST01	1.8	1.1	1.6	75	—	—	—	—
WiFi/AM03DP-ST01	—	—	—	—	1.2	1.1	1.2	534

11.2 Results of radiation efficiency measurement

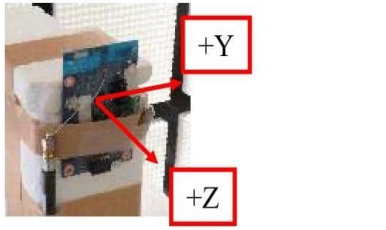
放射効率測定結果

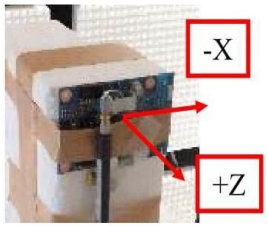


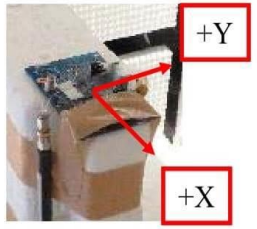
アンテナ	放射効率 [%] @LoRa				放射効率 [%] @WiFi				
	LoRa/AVE	LoRa/MAX	868MHz	920MHz	WiFi/AVE	WiFi/MAX	2400MHz	2442MHz	2484MHz
LoRa/AM11DP-ST01	78.9	83.2	72.5	74.3	—	—	—	—	—
WiFi/AM03DP-ST01	—	—	—	—	74.4	79.5	78.1	79.3	71.6

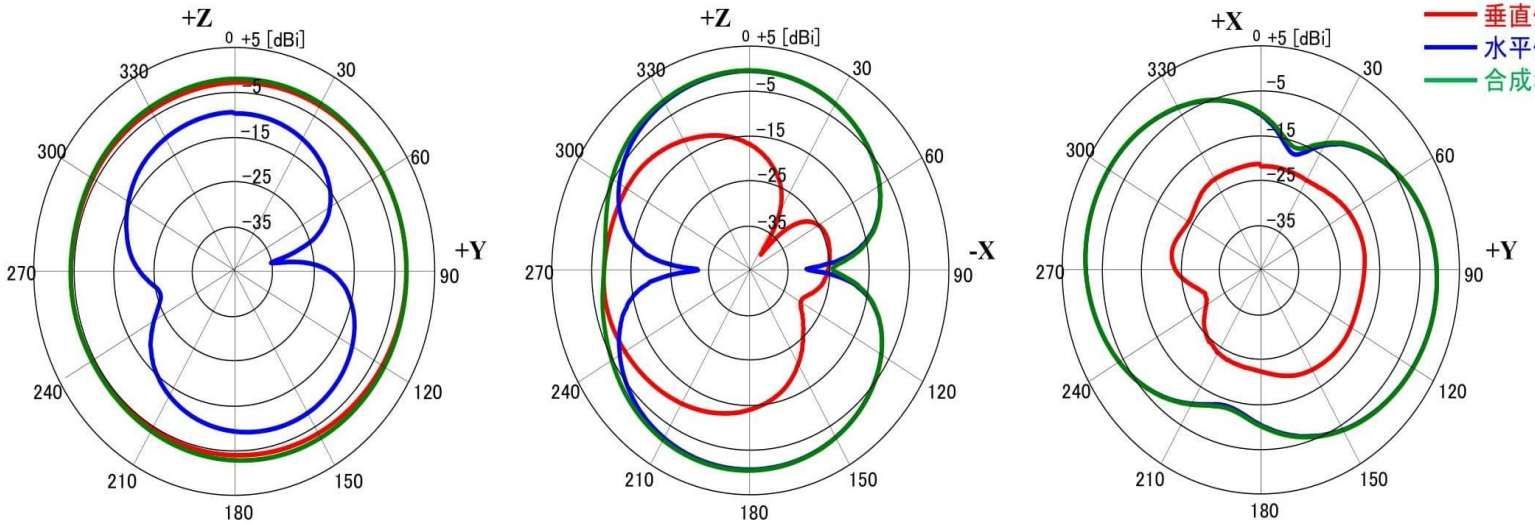
11.3 Radiation patterns/LoRa (measurement frequency: 868MHz)

放射パターン／LoRa　　測定周波数：868MHz





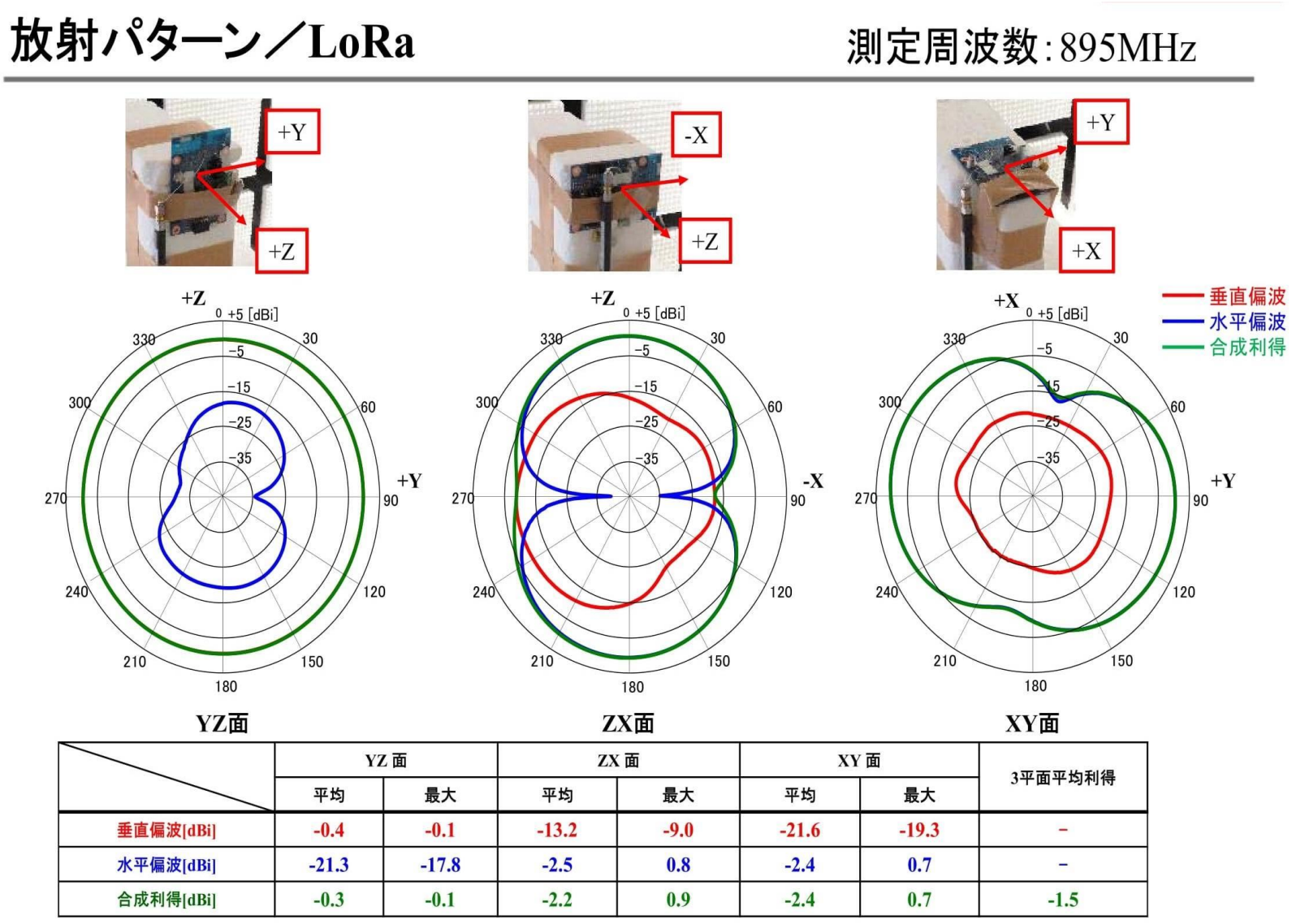




YZ面　　ZX面　　XY面

	YZ 面		ZX 面		XY 面		3平面平均利得
	平均	最大	平均	最大	平均	最大	
垂直偏波[dBi]	-3.2	-2.2	-12.8	-8.1	-21.3	-18.7	-
水平偏波[dBi]	-12.1	-8.5	-3.7	-0.4	-3.6	-0.6	-
合成利得[dBi]	-2.7	-1.8	-3.2	-0.2	-3.5	-0.5	-3.1

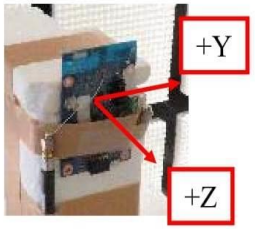
11.4 Radiation patterns/LoRa (measurement frequency: 895MHz)

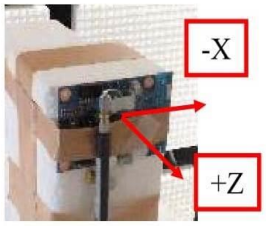


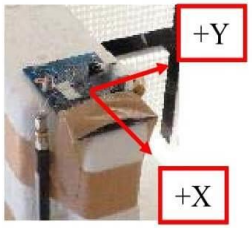
	YZ 面		ZX 面		XY 面		3平面平均利得
	平均	最大	平均	最大	平均	最大	
垂直偏波[dBi]	-0.4	-0.1	-13.2	-9.0	-21.6	-19.3	-
水平偏波[dBi]	-21.3	-17.8	-2.5	0.8	-2.4	0.7	-
合成利得[dBi]	-0.3	-0.1	-2.2	0.9	-2.4	0.7	-1.5

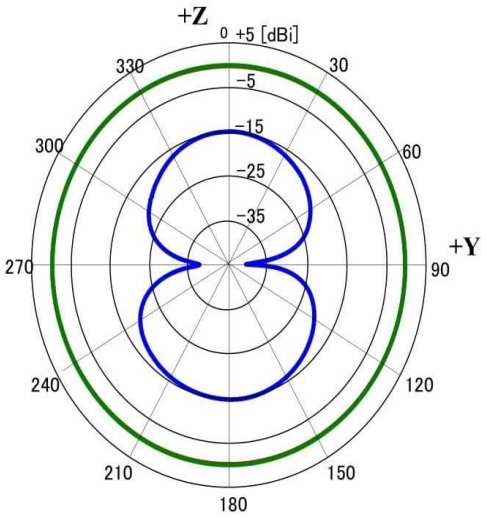
11.5 Radiation patterns/LoRa (measurement frequency: 915MHz)

放射パターン／LoRa　　測定周波数：915MHz

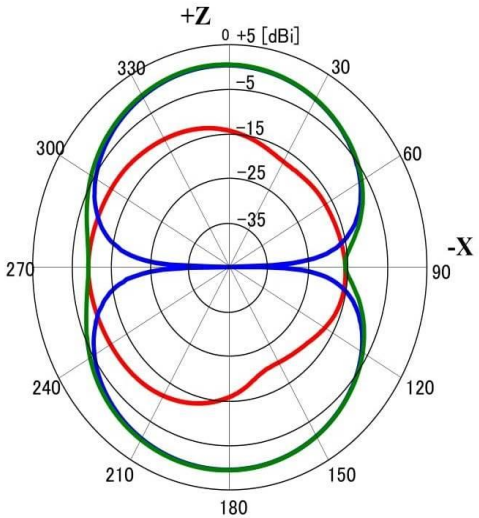




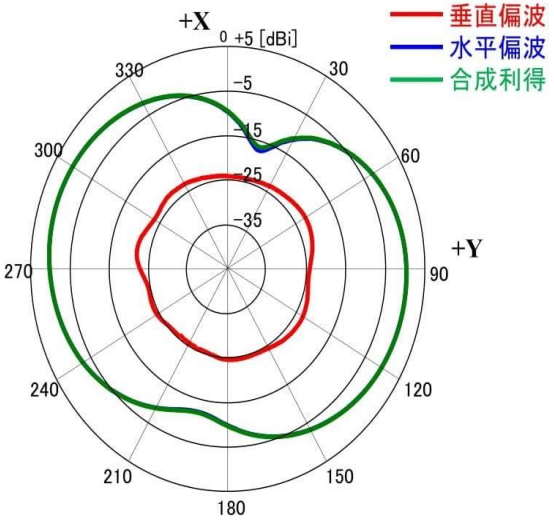




YZ面



ZX面

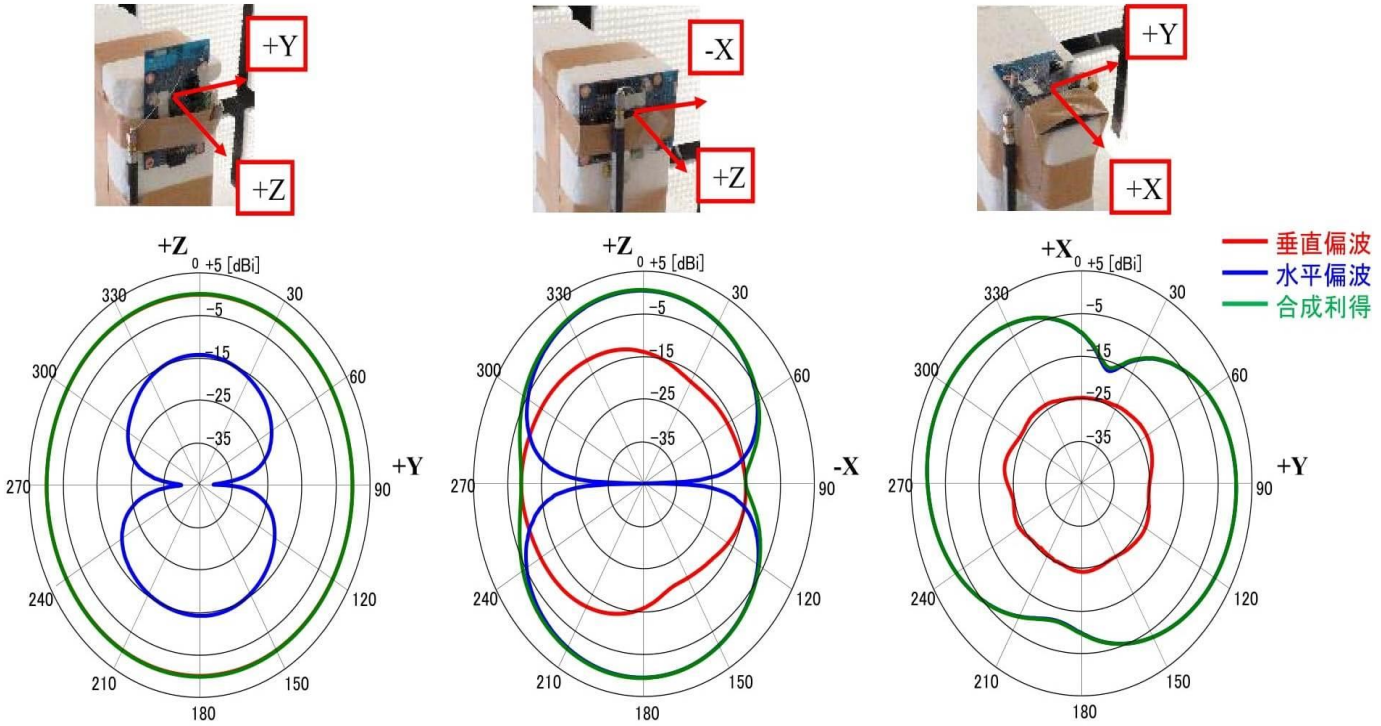


XY面

	YZ 面		ZX 面		XY 面		3平面平均利得
	平均	最大	平均	最大	平均	最大	
垂直偏波[dBi]	-0.2	-0.1	-13.1	-9.4	-23.7	-21.7	-
水平偏波[dBi]	-17.8	-14.7	-2.7	0.6	-2.5	0.7	-
合成利得[dBi]	-0.1	0.0	-2.3	0.8	-2.5	0.7	-1.5

11.6 Radiation patterns/LoRa (measurement frequency: 920MHz)

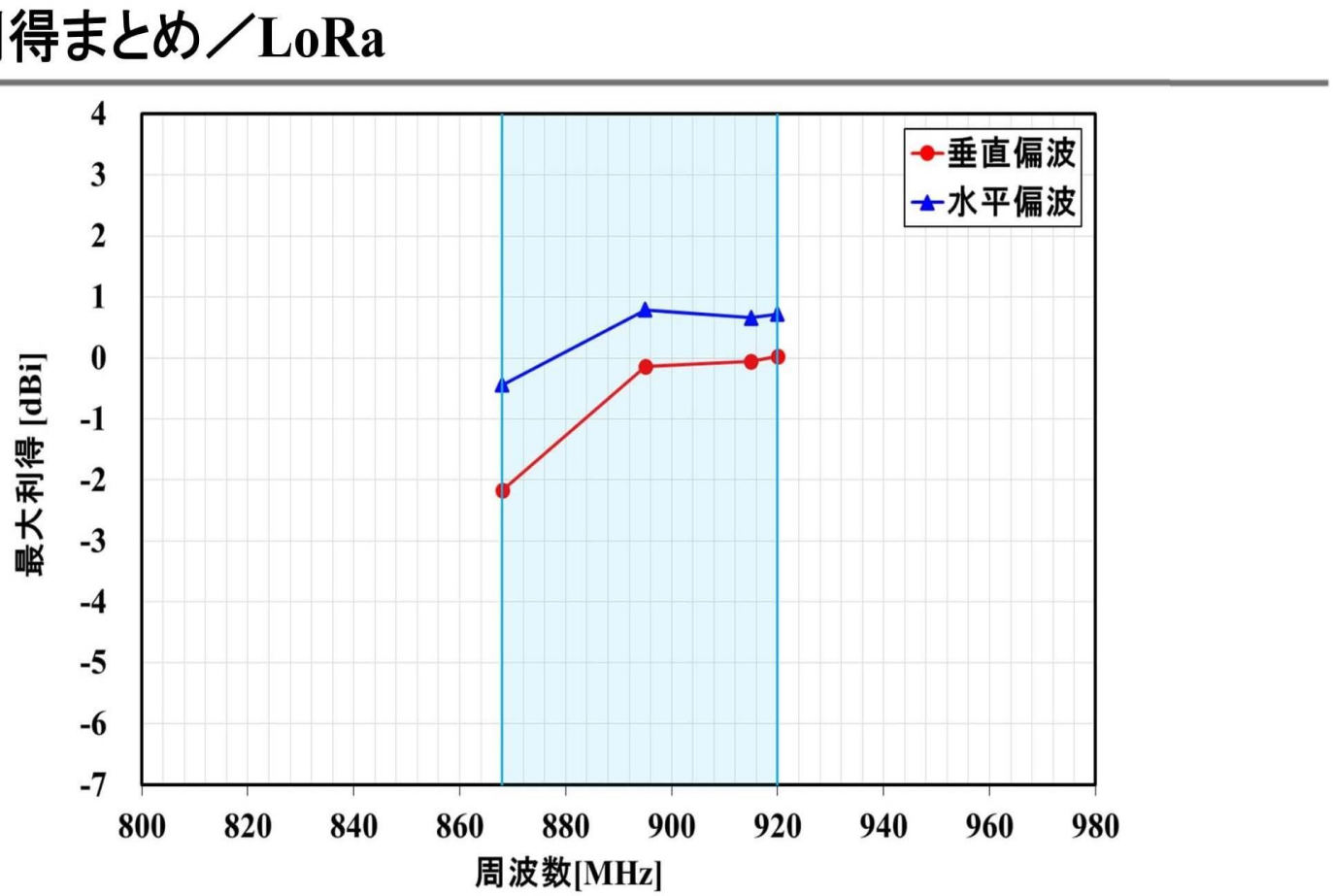
放射パターン／LoRa　　測定周波数：920MHz



YZ面　　ZX面　　XY面

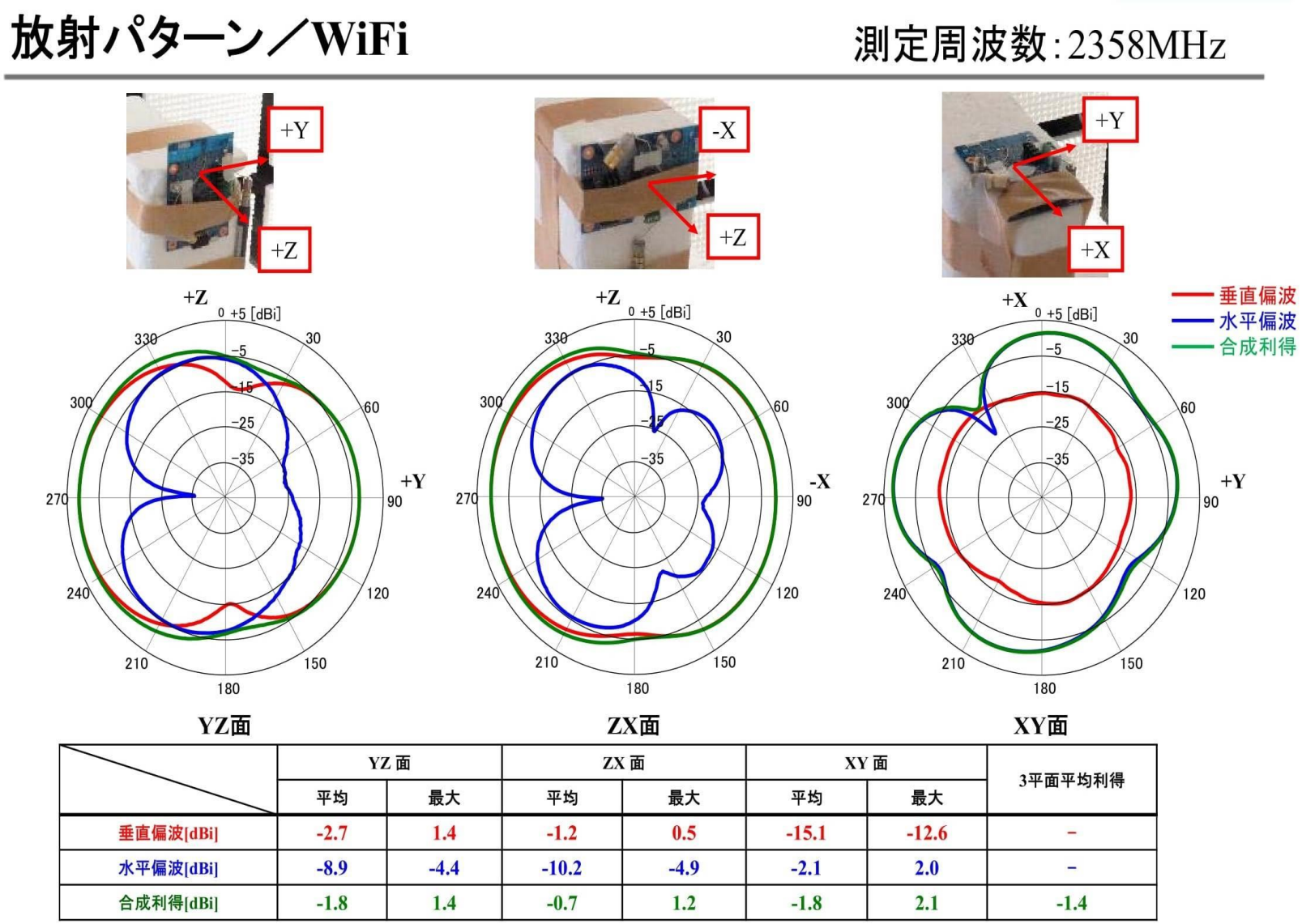
	YZ 面		ZX 面		XY 面		3平面平均利得
	平均	最大	平均	最大	平均	最大	
垂直偏波[dBi]	-0.1	0.0	-12.9	-9.2	-24.1	-22.1	-
水平偏波[dBi]	-17.2	-14.2	-2.6	0.7	-2.5	0.7	-
合成利得[dBi]	0.0	0.2	-2.2	0.8	-2.4	0.7	-1.4

11.7 Summary of maximum gain/Lora (Sub-GHz band)



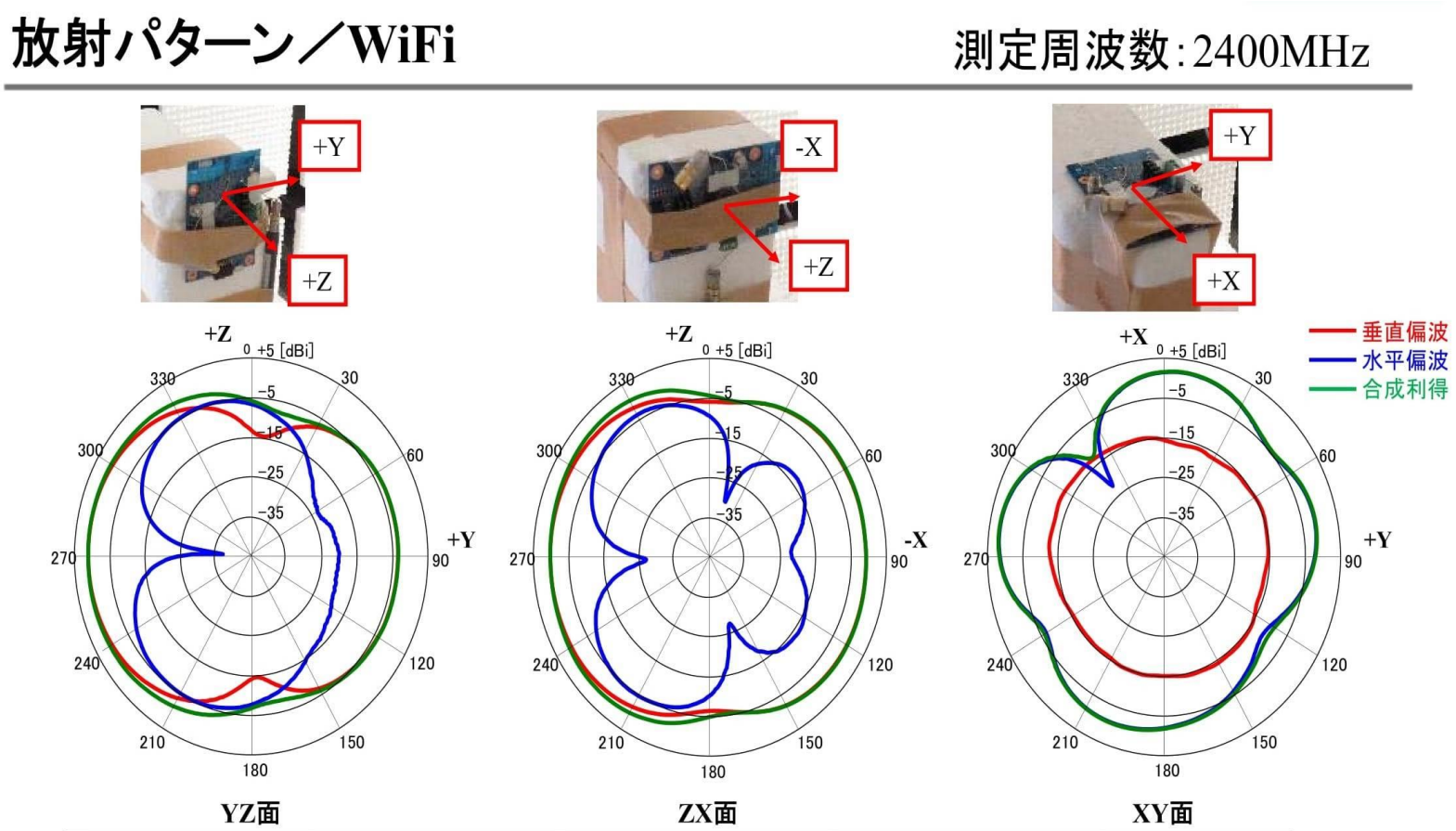
偏波	最大利得[dBi] ＠周波数 [MHz]			
	868	895	915	920
垂直偏波	-2.2	-0.1	-0.1	0.0
水平偏波	-0.4	0.8	0.7	0.7

11.8 Radiation patterns/Wi-Fi (measurement frequency: 2,358MHz)



	YZ 面		ZX 面		XY 面		3平面平均利得
	平均	最大	平均	最大	平均	最大	
垂直偏波[dBi]	-2.7	1.4	-1.2	0.5	-15.1	-12.6	-
水平偏波[dBi]	-8.9	-4.4	-10.2	-4.9	-2.1	2.0	-
合成利得[dBi]	-1.8	1.4	-0.7	1.2	-1.8	2.1	-1.4

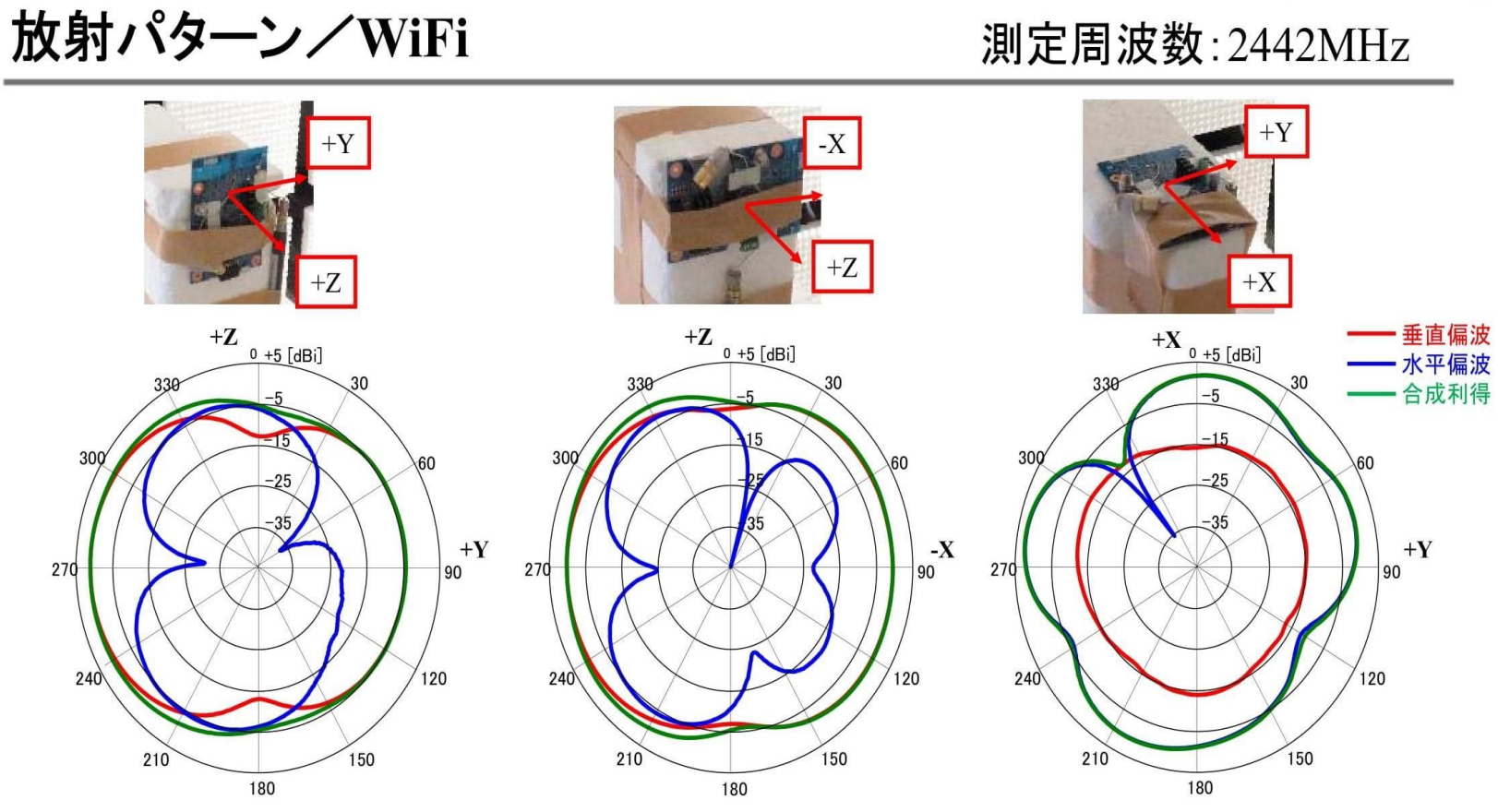
11.9 Radiation patterns/Wi-Fi (measurement frequency: 2,400MHz)



YZ面　　ZX面　　XY面

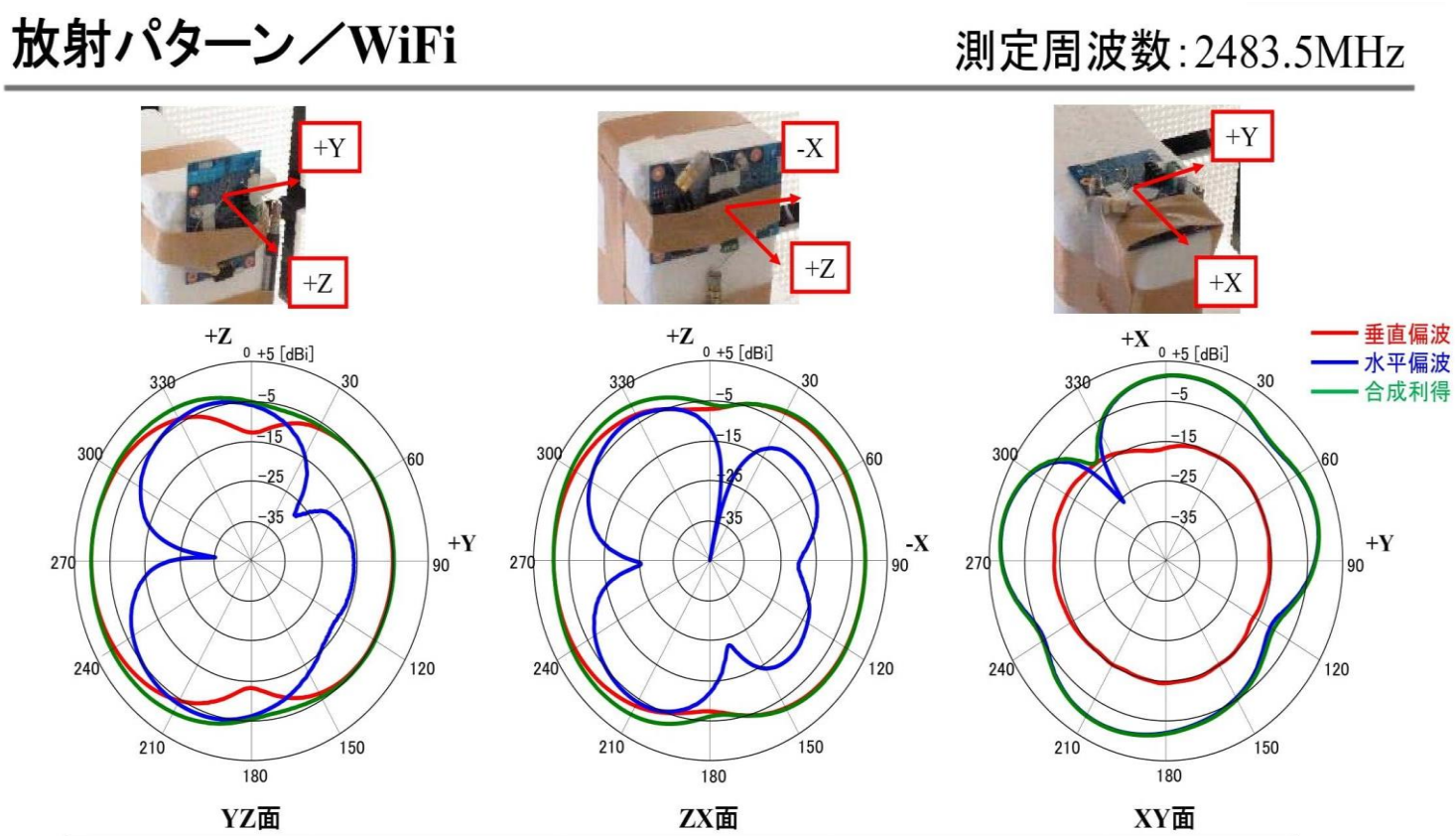
	YZ 面		ZX 面		XY 面		3平面平均利得
	平均	最大	平均	最大	平均	最大	
垂直偏波[dBi]	-2.8	1.3	-1.4	0.1	-14.6	-12.3	-
水平偏波[dBi]	-9.2	-4.6	-9.2	-3.8	-2.0	1.9	-
合成利得[dBi]	-1.9	1.3	-0.7	1.0	-1.8	2.1	-1.4

11.10 Radiation patterns/Wi-Fi (measurement frequency: 2,442MHz)



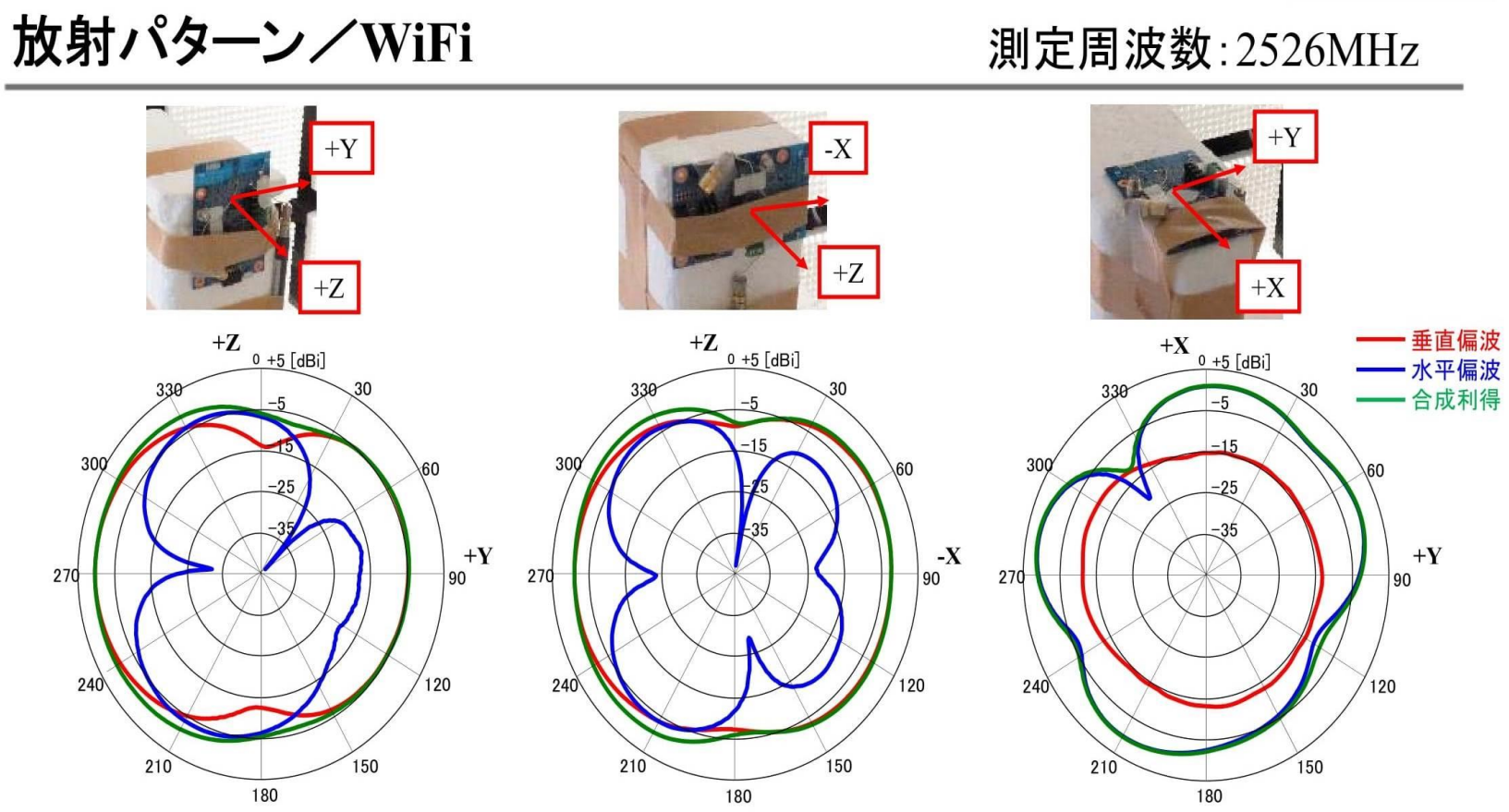
	YZ 面		ZX 面		XY 面		3平面平均利得
	平均	最大	平均	最大	平均	最大	
垂直偏波[dBi]	-3.1	1.3	-1.5	0.0	-14.2	-11.4	-
水平偏波[dBi]	-8.5	-3.9	-8.5	-3.0	-1.5	2.5	-
合成利得[dBi]	-2.0	1.3	-0.7	0.9	-1.2	2.6	-1.3

11.11 Radiation patterns/Wi-Fi (measurement frequency: 2,483.5MHz)



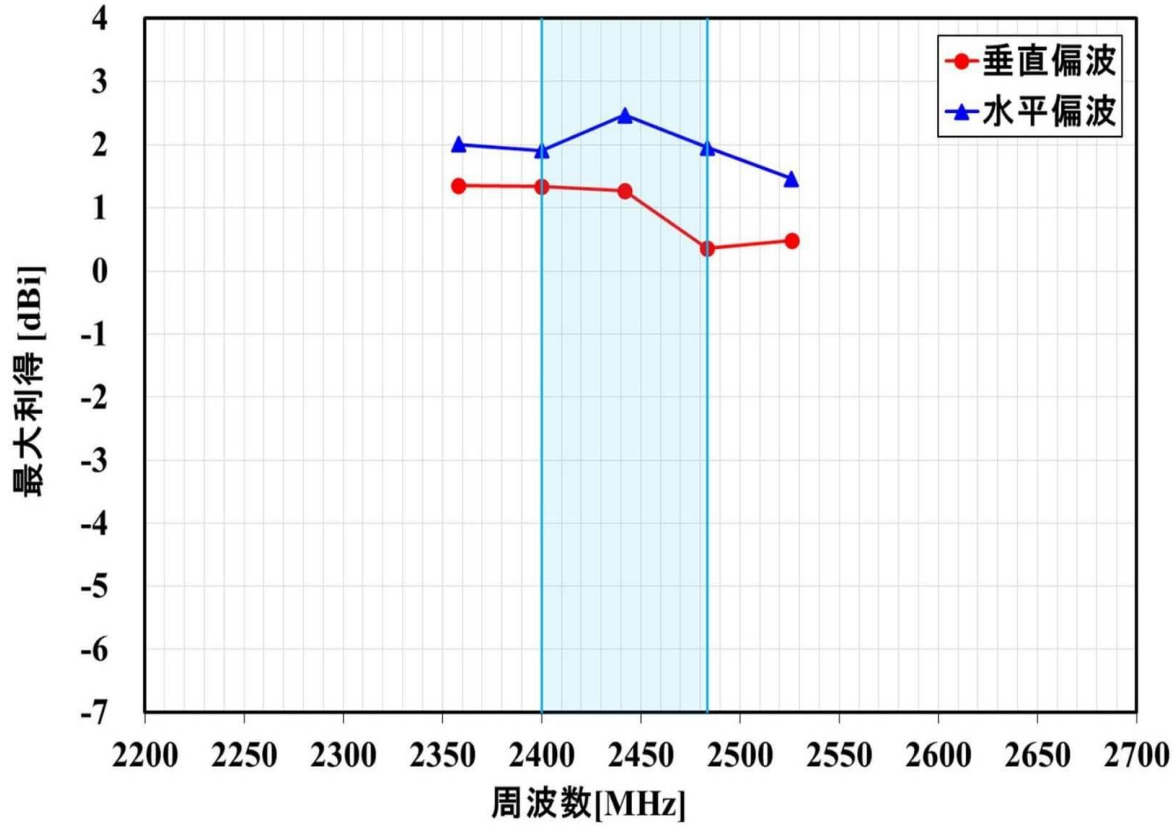
	YZ 面		ZX 面		XY 面		3平面平均利得
	平均	最大	平均	最大	平均	最大	
垂直偏波[dBi]	-3.7	0.4	-2.1	-0.8	-14.7	-12.5	-
水平偏波[dBi]	-8.1	-3.6	-8.7	-3.3	-1.8	2.0	-
合成利得[dBi]	-2.4	0.5	-1.3	0.6	-1.6	2.1	-1.7

11.12 Radiation patterns/Wi-Fi (measurement frequency: 2,526MHz)



	YZ 面		ZX 面		XY 面		3平面平均利得
	平均	最大	平均	最大	平均	最大	
垂直偏波[dBi]	-3.7	0.5	-2.9	-1.3	-13.2	-10.6	-
水平偏波[dBi]	-8.3	-3.6	-8.6	-3.5	-2.0	1.5	-
合成利得[dBi]	-2.4	0.5	-1.9	0.2	-1.7	1.7	-2.0

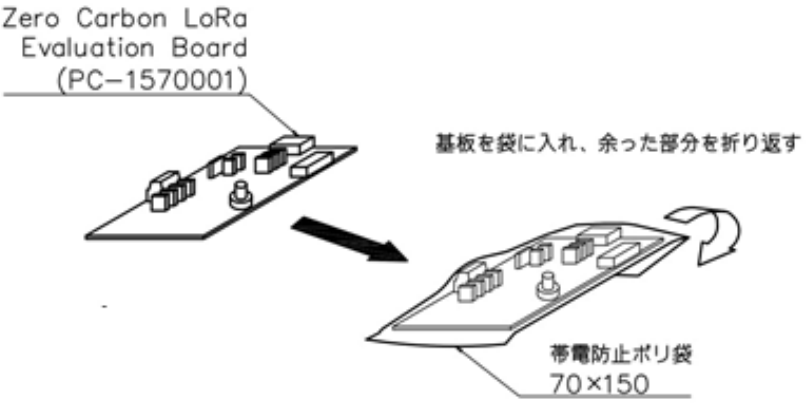
11.13 Summary of maximum gain/Wi-Fi (2.4GHz band)



偏波	最大利得[dBi] @周波数 [MHz]				
	2358	2400	2442	2483.5	2526
垂直偏波	1.4	1.3	1.3	0.4	0.5
水平偏波	2.0	1.9	2.5	2.0	1.5

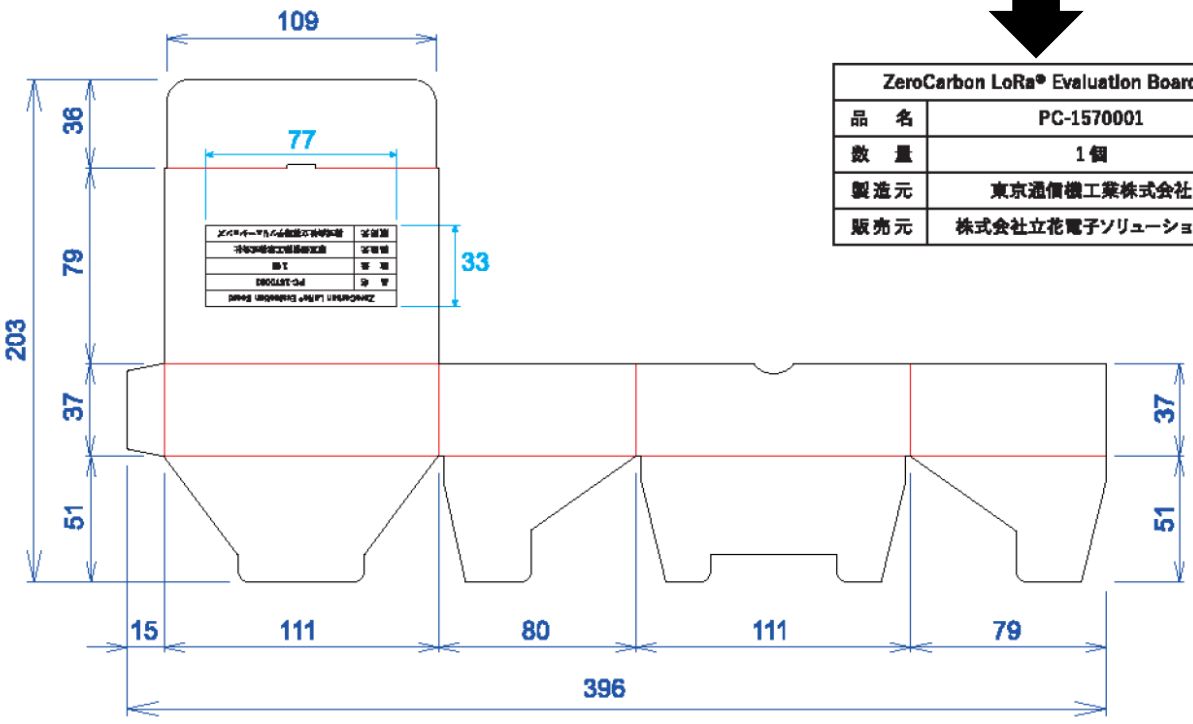
12. Packaging

The following shows the packaging of the Zero Carbon LoRa® Evaluation Board.



Above: Open box. Below: Labeling on top of box

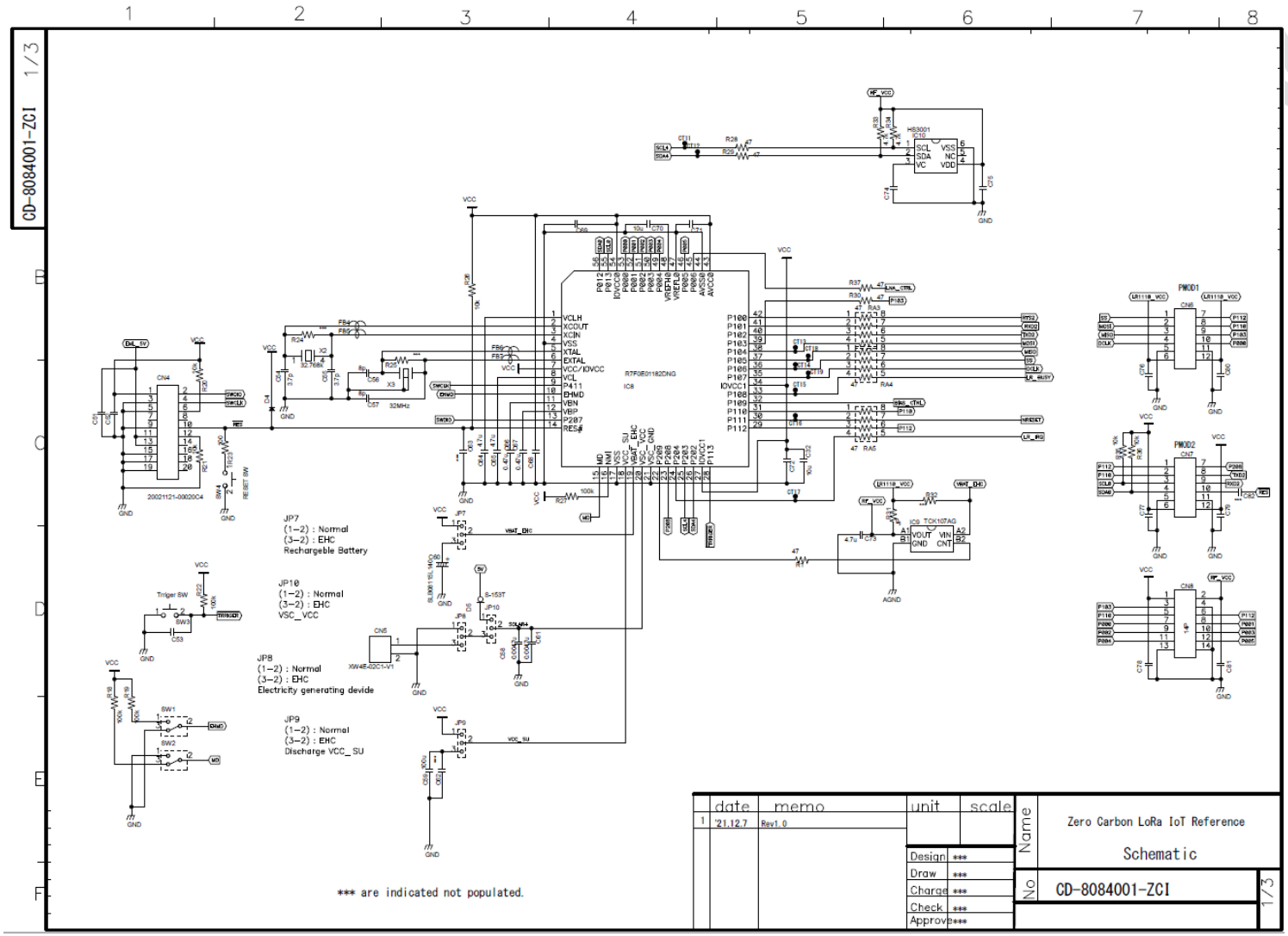
Package dimensions and labeling (units: mm)



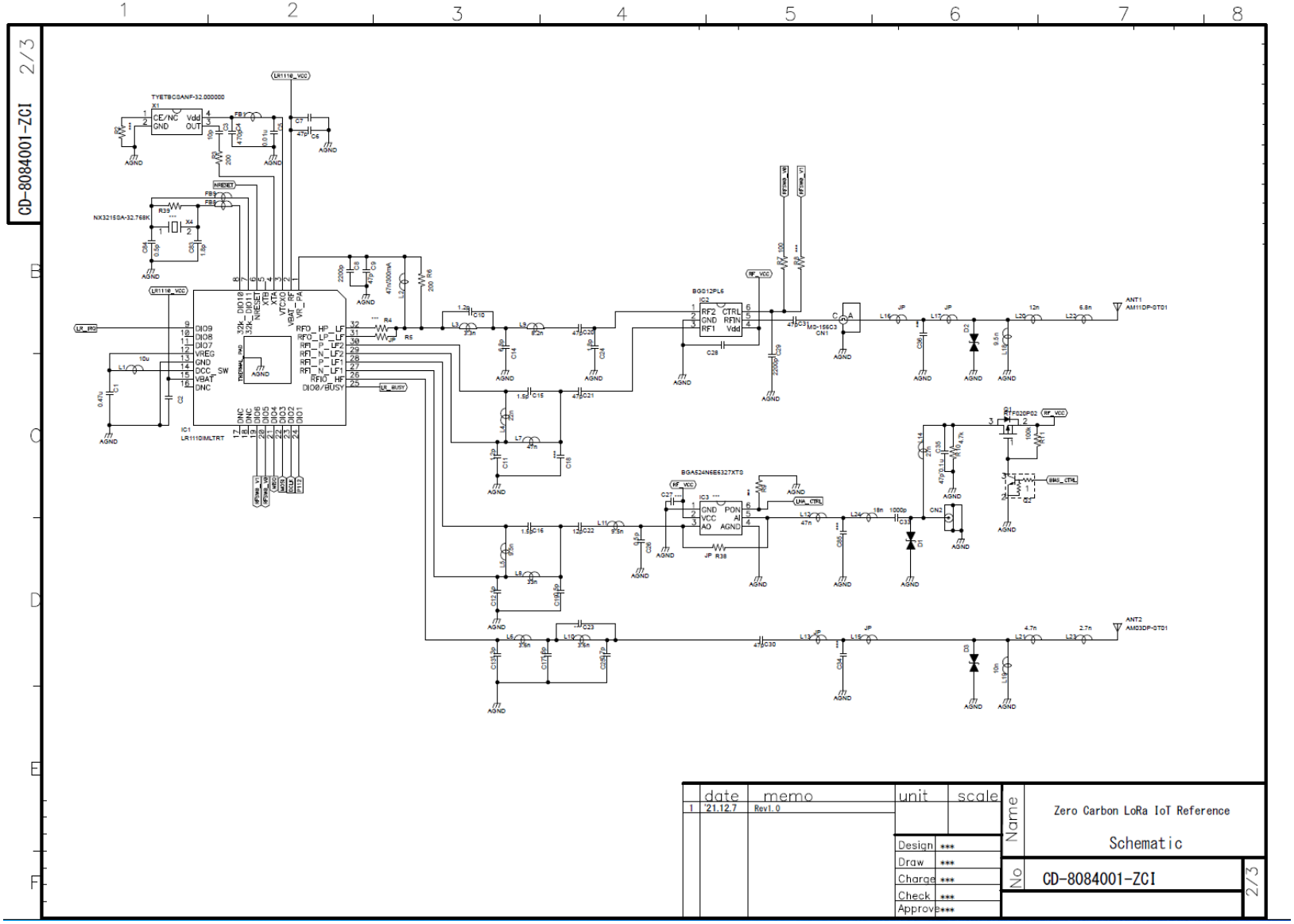
ZeroCarbon LoRa® Evaluation Board	
品　名	PC-1570001
数　量	1個
製造元	東京通信機工業株式会社
販売元	株式会社立花電子ソリューションズ

13. Circuit Diagram

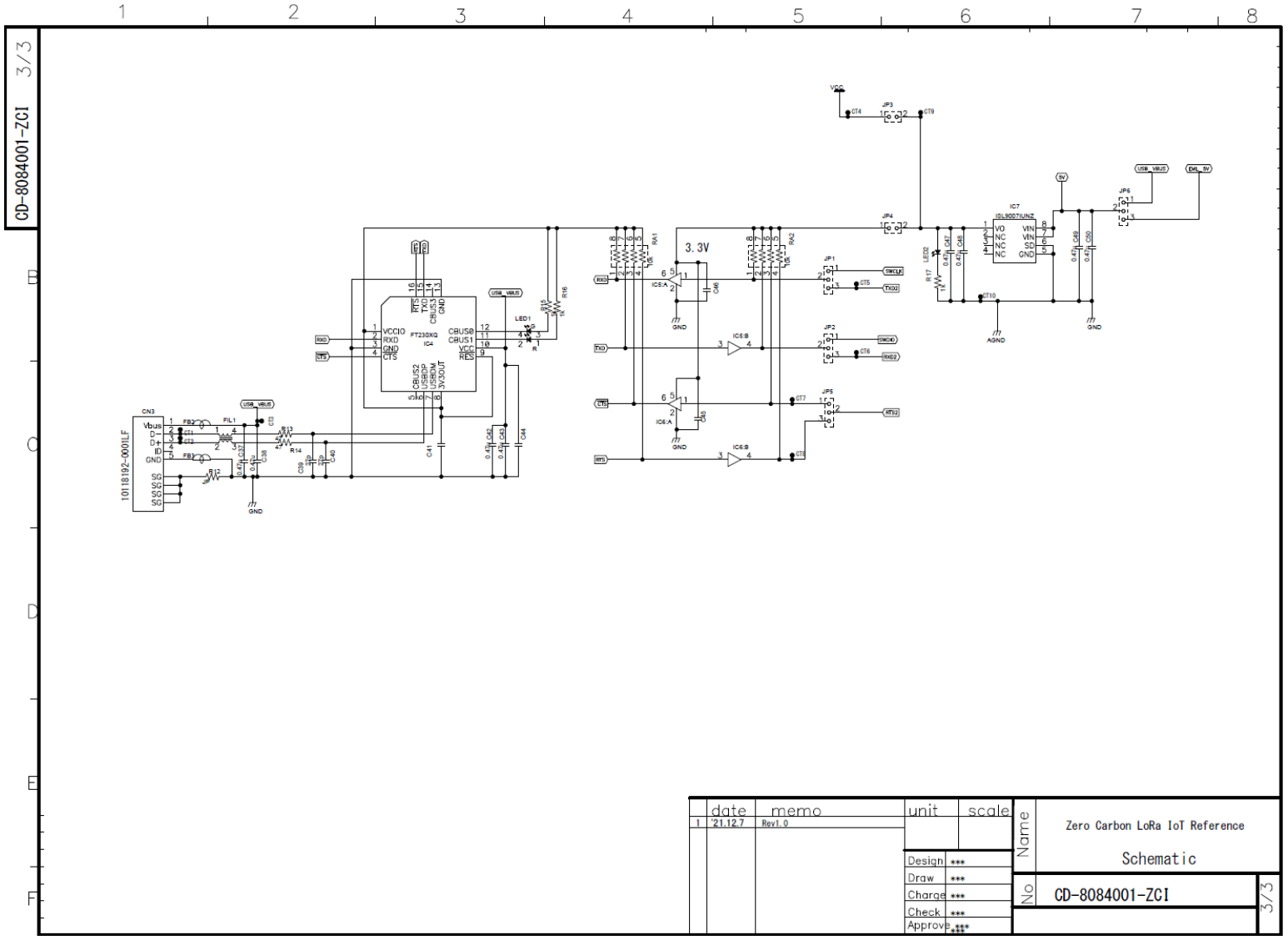
13.1 MCU section



13.2 RF section



13.3 USB section



14. Parts List

Item／Name Zero Carbon LoRa IoT Reference Board　　BM-8084001-ZCI　　Rev.1'st　　1/3

	Item	Name	Manufacture	ID	Fig	Memo
1	Resistor	ERJ-1GN0R00C	Panasonic	R5	3	0201
2	Resistor	ERJ-1GNJ470C	Panasonic	R1,R13,R14,R28,R29,R30,R37	7	0201
3	Resistor	ERJ-1GNJ101C	Panasonic	R7,R23	2	0201
4	Resistor	ERJ-1GNJ201C	Panasonic	R3,R6	2	0201
5	Resistor	ERJ-1GNJ102C	Panasonic	R15,R16,R17	3	0201
6	Resistor	ERJ-1GNJ472C	Panasonic	R10,R33,R34	3	0201
7	Resistor	ERJ-1GNJ103C	Panasonic	R20,R21,R26	3	0201
8	Resistor	ERJ-1GNJ104C	Panasonic	R11,R18,R19,R22,R27	5	0201
9	Resistor	ERJ-2GE0R00X	Panasonic	R12,R31,R38,L12,L13,L15,L16,L17	8	0402
10	Resistor	ERJ-2GEJ103X	Panasonic	R35,R36	2	0402
11	Resistor Araray	EXB-18V470JX	Panasonic	RA3,RA4,RA5	3	0502
12	Resistor Araray	EXB-18V103JX	Panasonic	RA1,RA2	2	0502
13	Ceramic Capasitor	GRM0335C1HR50BA01D	Murata Electronics	C84	1	0201
14	Ceramic Capasitor	GRM0335C1H1R8BA01D	Murata Electronics	C83	1	0201
15	Ceramic Capasitor	GRM0335C1H3R7BA01D	Murata Electronics	C54,C55	2	0201
16	Ceramic Capasitor	GRM0335C1H8R0DA01D	Murata Electronics	C56,C57	2	0201
17	Ceramic Capasitor	GRM0335C1H100JA01D	Murata Electronics	C3	1	0201
18	Ceramic Capasitor	GRM0335C1H270GA01D	Murata Electronics	C39,C40	2	0201
19	Ceramic Capasitor	GRM0335C1H470GA01D	Murata Electronics	C6,C9	2	0201
20	Ceramic Capasitor	GRM033R71H471KA12D	Murata Electronics	C4	1	0201
21	Ceramic Capasitor	GRM033R71C222KA88D	Murata Electronics	C8,C29	2	0201
22	Ceramic Capasitor	GRM033R71E472KE14D	Murata Electronics	C58,C61	2	0201
23	Ceramic Capasitor	GRM033B31C103MA12	Murata Electronics	C5	1	0201
24	Ceramic Capasitor	GRM033B31C104ME84	Murata Electronics	C2,C7,C28,C35,C41,C44-C46,C51-C53,C68,C69,C71,C72,C74-C81	23	0201
25	Ceramic Capasitor	C0603X5R1A474M	TDK	C1,C37,C38,C42,C43,C47,C48,C49,C50,C66,C67	11	0201
26	Ceramic Capasitor	GJM1555C1HR50WB01D	Murata Electronics	C19,C26	2	0402
27	Ceramic Capasitor	GJM1555C1HR70WB01D	Murata Electronics	C25	1	0402
28	Ceramic Capasitor	GJM1555C1H1R0WB01D	Murata Electronics	C12	1	0402
29	Ceramic Capasitor	GJM1555C1H1R2WB01D	Murata Electronics	C10,C11	2	0402
30	Ceramic Capasitor	GJM1555C1H1R3WB01D	Murata Electronics	C13	1	0402
31	Ceramic Capasitor	GJM1555C1H1R5WB01D	Murata Electronics	C15,C16	2	0402
32	Ceramic Capasitor	GJM1555C1H1R6WB01D	Murata Electronics	C17	1	0402
33	Ceramic Capasitor	GJM1555C1H1R8WB01D	Murata Electronics	C24	1	0402
34	Ceramic Capasitor	GJM1555C1H6R8WB01D	Murata Electronics	C14	1	0402
35	Ceramic Capasitor	GJM1555C1H120FB01D	Murata Electronics	C22	1	0402
36	Ceramic Capasitor	GJM1555C1H470JB01D	Murata Electronics	C20,C21,C30,C31	4	0402
37	Ceramic Capasitor	GRM155R71H102KA01J	Murata Electronics	C33	1	0402
38	Ceramic Capasitor	GRM155R61A475MEAAD	Murata Electronics	C64,C65,C73	3	0402
39	Ceramic Capasitor	ZRB15XR61A106ME01D	Murata Electronics	C32,C70	2	0402
40	Ceramic Capasitor	GRM32ER61A107ME20K	Murata Electronics	C59	1	1210
41	Small Lithium Ion Rechargeable	SLB08115L1401PM	Nichicon	C60	1	

Parts List (2/3)

Item／Name Zero Carbon LoRa IoT Reference Board　　BM-8084001-ZCI　　Rev.1'st　　2/3

	Item	Name	Manufacture	ID	Fig	Memo
42	Inducctor	LQW15AN2N7B00D	Murata Electronics	L23	1	0402
43	Inducctor	LQW15AN3N3C80D	Murata Electronics	L3	1	0402
44	Inducctor	LQW15AN3N6C10D	Murata Electronics	L6,L10	2	0402
45	Inducctor	LQW15AN4N7G80D	Murata Electronics	L21	1	0402
46	Inducctor	LQW15AN8N2J00D	Murata Electronics	L9	1	0402
47	Inducctor	LQG15WH9N5J02D	Murata Electronics	L5,L11	2	0402
48	Inducctor	LQW15AN10NJ00D	Murata Electronics	L19	1	0402
49	Inducctor	LQG15HS18NH02D	Murata Electronics	L24	1	0402
50	Inducctor	LQG15HS22NH02D	Murata Electronics	L4	1	0402
51	Inducctor	LQW15AN27NG80D	Murata Electronics	L14	1	0402
52	Inducctor	LQG15HS33NH02D	Murata Electronics	L8	1	0402
53	Inducctor	LQG15HH47NH02D	Murata Electronics	L2,L7,L12	3	0402
54	Inducctor	LQW18AS6N8J00D	Murata Electronics	L22	1	0603
55	Inducctor	LQW18AS9N5J00D	Murata Electronics	L18	1	0603
56	Inducctor	LQW18AS12NJ00D	Murata Electronics	L20	1	0603
57	Inducctor	MLZ1608N100LTD25	TDK	L1	1	0603
58	Ferrite Bead	MMZ0603S100CT000	TDK	FB1,FB2,FB3,FB4,FB5,FB6,FB7,FB8,FB9	9	0201
59	Common Mode Choke	EXC-24CB102U	Panasonic	FIL1	1	
60	Diode	RB520CM-30	Rohm	D4	1	
61	TVS Diode	RClamp1851ZATFT	Semtech	D1,D2,D3	3	
62	CRD	S-153T	Semitec	D5	1	
63	LED	FRYPY1211C-0005-TR	Stanley Electric Co	LED1	1	
64	LED	VFHL1111C-4B23C-TR	Stanley Electric Co	LED2	1	
65	TCXO	TG-5006CG-42L 32.000000MHz	SeikoEpson	X1	1	2520
		TYETBCSANF-32.000000	Taitien			
66	XTAL	SSP-T7-FL	SII	X2	1	
67	XTAL	NX3215SA-32.768K-EXS00A-MU00	NDK	X4	1	3215
68	XTAL	BIT22 32MHz	KYUSHU DENTSU	X3	1	2016
69	MOSFET	RTF020P02	Rohm	Q1	1	
70	Transistor	DTC114EM	Rohm	Q2	1	
71	RFIC	LR1110IMLTRT	Semtech	IC1	1	
72	RFSW	BGS12WN6E6327XTSA1	Infinon	IC2	1	
73	Communication IC	FT230XQ	FTDI	IC4	1	
74	Logic IC	SN74LVC2G07DRYR	TI	IC5,IC6	2	
75	Power IC	ISL9007IUNZ	Renesus	IC7	1	
76	MPU	R7F0E01182DNG	Renesus	IC8	1	
77	Logic IC	TCK107AG,LF	Toshiba	IC9	1	
78	Temparature Sensor IC	HS3001	Renesus	IC10	1	
79	Slide SW	CJS-1200TA1	Nidec Copal	SW1,SW2	2	
80	Push SW	SKRKAEE020	Alps Alpine	SW3,SW4	2	

Parts List (3/3)

Item／Name RE01+LR1110(Referance) BM-8084001-ZCI Rev.1'st 3/3

	Item	Name	Manufacture	ID	Fig	Memo
81	CONN HEADER VERT 2POS	PREC002SAAN-RC	Sullins Connector	JP3,JP4	2	2.54mm
82	CONN HEADER VERT 3POS	PREC003SAAN-RC	Sullins Connector	JP1,JP2,JP5,JP6,JP7,JP8,JP9,JP10	8	2.54mm
83	RF Connector	MS-156C3	Hirose Electric	CN1	1	
84	RF Connector	HRM-300-134B(40)	Hirose Electric	CN2	1	
		RF2-04A-T-00-50-G	Adam Tech			
85	USB Connector	10118192-0001LF	Amphenol ICC	CN3	1	
86	CONN HEADER SMD 20POS	20021121-00020C4LF	Amphenol ICC	CN4	1	for debug
87	Connector	XW4E-02C1-V1	Omuron	CN5	1	
88	PMOD Connector	PPPC062LJBN-RC	Sullins Connector	CN6,CN7	2	
89	RF Antenna	AM11DP-ST01	Mitsubishi Material	ANT1	1	
90	RF Antenna	AM03DP-ST01	Mitsubishi Material	ANT2	1	
91	PCB	PC-1570001	TK	FR4 t=1.6mm 4 Layer	1	
	Total Qty				195	
	DNP			R2,R4,R8,R9,R24,R25,R39(0603),R32(1005),C27,C63(0603),C18,C23,C34,C36,C82,C85(1005),C6	19	
				IC3,CN8(2.54mmpitch TH)		
	※RoHs2 Compliant					

15. 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.
- The PC-1570001 grants no license to any patent rights, copyrights, or other intellectual property rights of Tachibana Electronic Solutions or any third party.
- 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

16. 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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		Pages	Description
1.00	Apr. 28, 2022	-	First publication

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