Environment Sensing Board RIOT-002C

NO.EEV-628-221011

1. Overview

The RIOT-002C is an environment sensing board consisting of two boards: the RIoT2 Main Board ("Main Board") and the RIoT2 EnerCera® Board ("EnerCera® Board") equipped with a coin-type EnerCera® series secondary ceramic chip battery, ET1210C-H, manufactured by NGK Insulators, Ltd. It can send information of a temperature, humidity, and atmospheric pressure sensor, an ambient light sensor, and a 3-axis acceleration sensor mounted on Main Board to a tablet or other devices using Bluetooth Low Energy (BLE) and can be operated with an indoor-use photovoltaic panel (*1).

The secondary battery mounted on EnerCera® Board stores electric power extracted efficiently from a photovoltaic panel by the R1801, a buck DC/DC switching regulator for energy harvesters, mounted on Main Board. The RP605, an ultra-low consumption current buck-boost DC/DC switching regulator, and the RP118, a voltage regulator, efficiently supply electric power to a built-in BLE module in a MCU and various sensors. The RP605 also has a function to monitor the voltage of the secondary battery, which can be checked by sending it to a tablet or other devices as BLE data via an AD converter (ADC) of the BLE module.

In addition, this product has the R2221, a real-time clock IC, and it can set any desired operating day of the week and operating start/end time, such as 8:00 to 19:00, by using a dedicated application.

(*1) A photovoltaic panel not included.

Figure 1. RIOT-002C

2. Board Specifications

2-1. Block Diagram

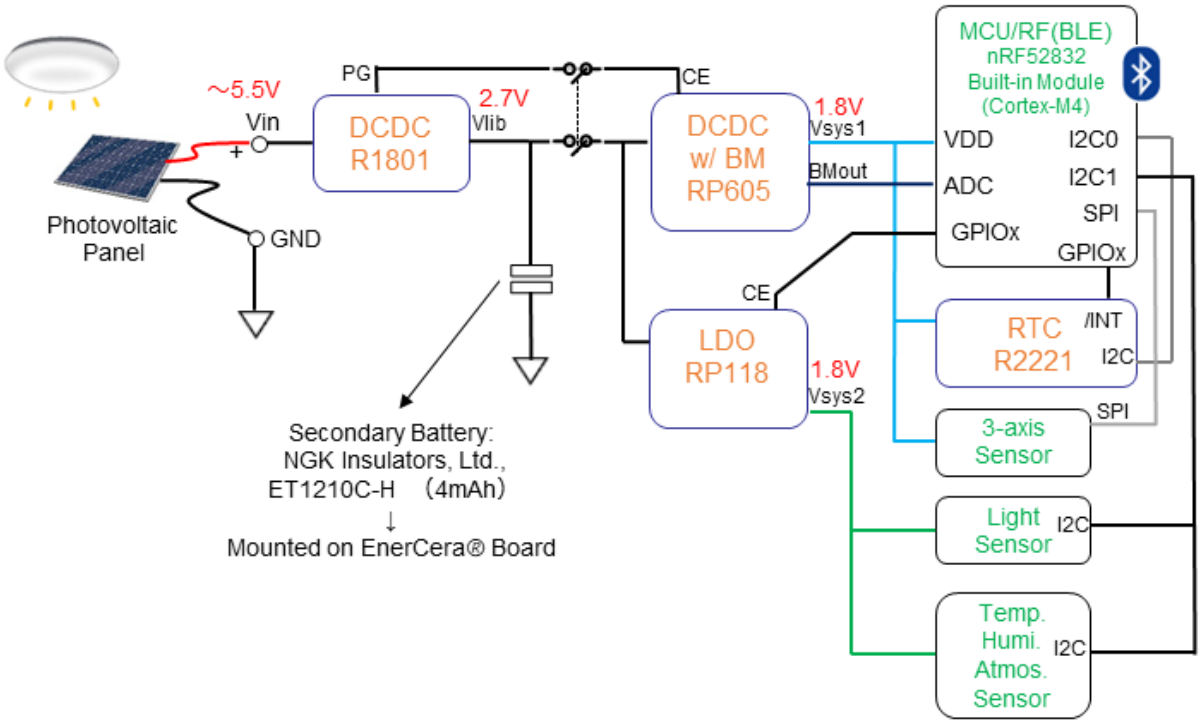


Figure 2. Block Diagram of RIOT-002C

2-2. Electrical Characteristics

Table 1. Main Electrical Characteristics

(RIOT-002C recommended operating ambient temperature: 0 to 50°C)

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
V_{in}	Operation Available Input Voltage		2.30	-	5.50	V
V_{mp}	Minimum Chargeable Input Voltage	(*2)		4.40		V
V_{lib}	Secondary Battery Charging Voltage	(*2)	2.62	2.70	2.78	V
V_{sys}	Sensor System Input Voltage	V_{sys1} and V_{sys2}	1.77	1.80	1.83	V
I_{cc}	Avg. Operating Current	5 Seconds Intermittent Operation		22		uA

(*2) The typical Vmp value of the R1801K004A mounted on the RIOT-002C is 4.5 V and the typical Vset (or Vlib in the table above) value is 2.8 V, which can be adjustable within ±300 mV by attaching pull-up or pull-down resistors to each of the setting terminals (VMP1, 2, 3 and VSET1, 2, 3) of the R1801.

The adjustment range of the RIOT-002C is shown in yellow cells in the table below (orange cells show the settings when this product is shipped).

Please contact us if you wish to change the settings of Vmp and Vset.

Table 2. Setting Range of Vmp and Vset in R1801K004A

Item	Vmp			Vset		
	Min.	Typ.	Max.	Min.	Typ.	Max.
Voltage [V]	4.2	4.5	4.8	2.5	2.8	3.1

Table 3. How to Set VMP1,2,3 and VSET1,2,3 Terminals with Pull-up (H) / Pull-down (L) Resistors

Adjustment voltage	VMP1	VMP2	VMP3	VSET1	VSET2	VSET3
-300[mV]	H	H	L	H	H	L
-200[mV]	L	H	L	L	H	L
-100[mV]	H	L	L	H	L	L
0[mV]	L	L	L	L	L	L
+100[mV]	L	H	H	L	H	H
+200[mV]	H	L	H	H	L	H
+300[mV]	L	L	H	L	L	H
Inhibit	H	H	H	H	H	H

2-3. BLE Transmit/Receive Function

The RIOT-002C can change a device name, measurement intervals, and so on by using our application for Android ("RIoT002 Setting"). After the RIOT-002C is powered on, during approximately 15 seconds from the time the LED blinks once to the time it blinks twice, it is possible to change various settings by connecting to RIoT002 Setting described above. In addition, the changed settings can be saved in a flash memory in the BLE module by using RIoT002 Setting. In the case that you use the settings you saved in the flash memory, there is no need to reconfigure them by RIoT002 Setting at the next power-on.

The parameters that can be set by RIoT002 Setting are listed below.

Table 4. Parameters That Can be Set by RIoT002 Setting

Items	Overview
Device Name	Can be set within 5 alphanumeric characters.
Current Time	Can be set by xml file. (*3)
Operation Date	Can be set by xml file. (*3)
Start Time	Can be set by xml file. (*3)
Finish Time	Can be set by xml file. (*3)
BLE Advertising Data Type	Can be set either <Default> or <Acceleration>.
Measurement Intervals	Can be set in units of seconds.
BLE Advertising Interval	Can be set by xml file. (*3)
BLE Advertising Stop Period	Can be set by xml file. (*3)
Temperature, Humidity, and Atmospheric Pressure Sensor	Can be set either enable or disable. When it is disable, the acquisition values are all 0.
Ambient Light Sensor	Can be set either enable or disable. When it is disable, the acquisition value is 0.
3-axis Accelerometer	Can be set either enable or disable. When it is disable, the acquisition values are "Unknown" or all 0.
Acquisition of Secondary Battery Voltage	Can be set either enable or disable. When it is disable, the acquisition value is 0.

Save Settings in Flash Memory	Can be set either enable or disable. When it is enabled, all parameters except current time are saved in the flash memory in the BLE module.

(*3) Please refer to the "RIoT002 Setting Application Manual" for details.

The RIOT-002C sends BLE advertising data to connect to RIoT002 Setting at 500 millisecond intervals during the 15 seconds described above. The BLE advertising data sent by the RIOT-002C is shown below.

Table 5. BLE Advertising Data Format

Type	Date
Flags	02 01 04
LocalName	06 09 (1) (1) (1) (1) (1)
ManufactureData	08 FF 5B 08 01 FF (2) (2) (3)

(1)

The device name (5-byte-long) is stored.

(2)

The firmware version ("01" and "00" as of September 2022) is stored.

(3)

Whether the setting data in the flash memory exist or not ("00"/"01") is stored.

The RIOT-002C has a temperature, humidity, and atmospheric pressure sensor (BME280), an ambient light sensor (OPT3004), a 3-axis accelerometer (LIS2DW12), and a buck-boost DC/DC switching regulator with a battery monitor function (RP605). After the connection period (15 seconds) to RIoT002 Setting, this product measures and calculates the measured value at the timing of the measurement intervals set above (default: 5 seconds) and sends it as BLE advertising data.

The format of BLE advertising data is selectable in either <Default> or <Acceleration>.

The specifications of <Default> and <Acceleration> formats are shown below.

Table 6. BLE Advertising Data Format <Default>

Type	Data
Flags	02 01 04
LocalName	06 09 (1) (1) (1) (1) (1)
ManufactureData	10 FF 5B 08 01 01 (4) (4) (5) (5) (6) (6) (7) (7) (8) (8) (9)

(4)

Temperature (℃). The value calculated to the first decimal place is multiplied by 10 and stored as a signed 2-byte (hexadecimal) value.

(5)

Humidity (%RH). The value calculated to the first decimal place is multiplied by 10 and the value is stored as an unsigned 2-byte (hexadecimal) value.

(6)

Atmospheric pressure (hPa). The value calculated to the first decimal place is multiplied by 10 and the value is stored as an unsigned 2-byte (hexadecimal) value.

(7)

Illuminance at the surface of the board (lx). The calculated value (integer) is multiplied by 1/4 (round down after the decimal point) and the value is stored as an unsigned 2-byte (hexadecimal) value.

(8)

Battery voltage (V). The value calculated to the third decimal place is multiplied by 1000 and the value is stored as an unsigned 2-byte (hexadecimal) value.

(9)

The orientation of the accelerometer (from 0 to 7) (*4) is stored as an unsigned 1-byte.

For example, the following is BLE advertising data in the case of device name: I2001, temperature: 25.2°C, humidity: 40.8%, atmospheric pressure: 1012.4 hPa, illumination: 680 lx, battery voltage: 2.62V, and board orientation: facing up to the surface.

Table 7. Example of BLE Advertising Data Format <Default>

Type	Data
Flags	02 01 04
LocalName	06 09 49 32 30 30 31
ManufactureData	10 FF 5B 08 01 01 FC 00 98 01 8C 27 AA 00 3C 0A 07

Table 8. BLE Advertising Data Format < Acceleration >

Type	Data
Flags	02 01 04
LocalName	06 09 (1) (1) (1) (1) (1)
ManufactureData	0B FF 5B 08 01 05 (10) (10) (11) (11) (12) (12)

(10)

Acceleration in x direction (m/s2). The value calculated to the third decimal place is multiplied by 1000 and the value is stored as a signed 2-byte value.

(11)

Acceleration in y direction (m/s2). The value calculated to the third decimal place is multiplied by 1000 and the value is stored as a signed 2-byte value.

(12)

Acceleration in z direction (m/s2). The value calculated to the third decimal place is multiplied by 1000 and the value is stored as a signed 2-byte value.

Each of the 2 bytes from (4) to (12) described above is stored in little-endian format.

For example, the BLE advertising data in the case of device name: I2001, accelerations in x-direction: 0.313[m/s2], in y-direction: -0.941[m/s2], and in z-direction: -9.708[m/s2] are shown below.

Table 9. Example of BLE Advertising Data Format <Acceleration>

Type	Data
Flags	02 01 04
LocalName	06 09 49 32 30 30 31
ManufactureData	0B FF 5B 08 01 05 39 01 53 FC 14 DA

The transmitted BLE advertising data of <Default> or <Acceleration> described above can be read by our application (RIoT Monitor) for Android.

(*4) Please refer to the "RIoT Monitor Application Manual" for the correlation between the acquired values (0 to 7) and the actual board orientation.

2-4. Main Parts

Table 10. Main Parts

Product Name	Product Category	Vendor	Purpose	Part No.
R1801K004A	Buck DC/DC Switching Regulator for Energy Harvesters	Nisshinbo Micro Devices, Inc.	Electric Power control of Photovoltaic Panel	U103
RP605K184B	Low Power Consumption Buck-Boost DC/DC Converter with Battery Monitor	Nisshinbo Micro Devices, Inc.	Power Supply to BLE Modules, etc. and Voltage Monitoring of Secondary Battery	U105
RP118K181D	Low Power Consumption Voltage Regulator	Nisshinbo Micro Devices, Inc.	Power Supply to Ambient Light Sensor, etc.	U106
R2221L	Low Power Consumption Real Time Clock	Nisshinbo Micro Devices, Inc.		U109
EYSHCNZWZ	BLE Module	Kaga FEI Co., Ltd.	BLE Module with Built-in MCU	U107
OPT3004DNPR	Ambient Light Sensor	Texas Instruments		U101
BME280	Temperature, Humidity, and Atmospheric Pressure Sensor	Bosch Sensortec		U104
LIS2DW12	3-axis Accelerometer	STMicroelectronics		U108

R1801 Series:
https://www.nisshinbo-microdevices.co.jp/en/products/dc-dc-switching-regulator/spec/?product=r1801

RP605 Series:
https://www.nisshinbo-microdevices.co.jp/en/products/dc-dc-switching-regulator/spec/?product=rp605

RP118 Series:
https://www.nisshinbo-microdevices.co.jp/en/products/ldo-linear-regulator/spec/?product=rp118

R2221 Series:
https://www.nisshinbo-microdevices.co.jp/en/products/real-time-clock/spec/?product=r2221

2-5. Secondary Battery

NGK Insulators, Ltd., ET1210C-H (4 mAh)

Link for reference: https://enercera.ngk-insulators.com/en/

Since EnerCera® Board has a land pattern that allows the EnerCera® series coin-type ET2016C-R or ET2016C-H, and the ultra-thin (pouch-type) ET271404P-H to be mounted, it is possible to replace the ET1210C-H mounted currently with any one of the above three types of secondary batteries (*5).

(*5) Please contact us or NGK Insulators, Ltd. for details on battery arrangements and mounting methods when changing batteries. Please note that we are not responsible for any trouble that may occur during or after battery change.

2-6. Appearance

Table 11. Appearance of the RIOT-002C's Main Board

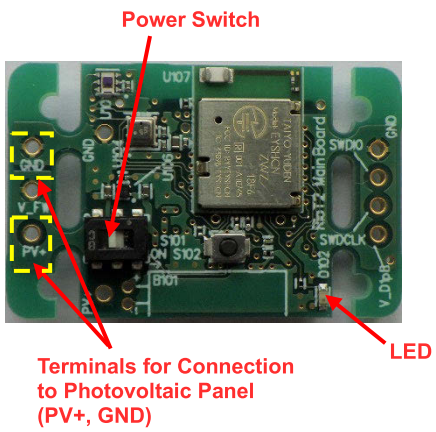
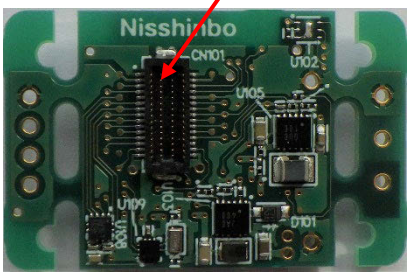
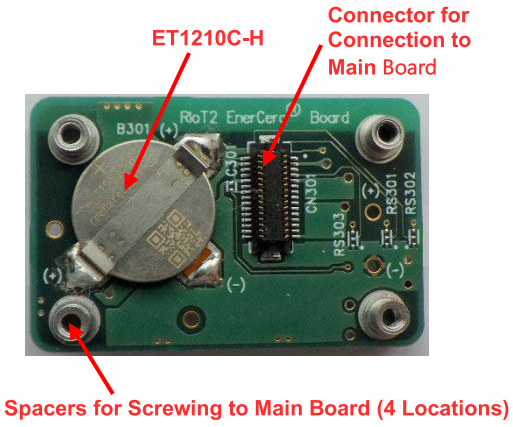
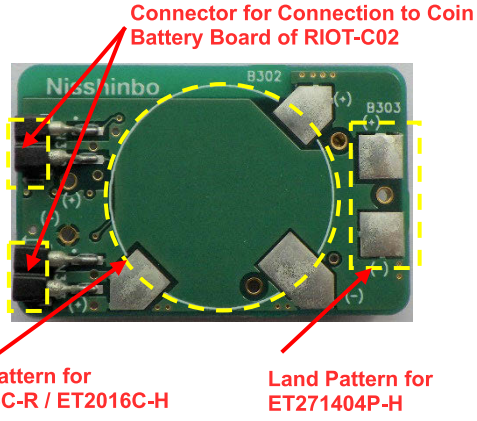
Top View	Bottom View
	

Table 12. Appearance of the RIOT-002C's EnerCera® Board

Top View	Bottom View
	

2-7. Photovoltaic Panel

A photovoltaic panel is not included with the RIOT-002C and should be prepared by the customer. The recommended photovoltaic panel is as follows.

Panasonic Solar Amorton Co., Ltd. Amorphous Silicon Solar Cells, Indoor lighting levels

Product name: AM-18xx (Voltage at open circuit: Voc = 5.0 V)

Reference link: https://panasonic.co.jp/ew/psam/en/products/

Another manufacturers' photovoltaic panels can also be used if the open circuit voltage is in the range of around 5.0V for indoor-use illumination specifications. The wires of the photovoltaic panel are connected to the terminals for photovoltaic panel connection (PV+, GND) on Main Board by soldering or other means.

2-8. How to Use

2-8-1. How to Connect Main Board to EnerCera® Board

After confirming the position of the 30-pin connector, align the outline of Main Board and EnerCera® Board as shown in the figure below, and gently press the area of the 30-pin connector from the top and the bottom to fit it in. If necessary, use M2x4mm screws to fix at 4 locations (*6).

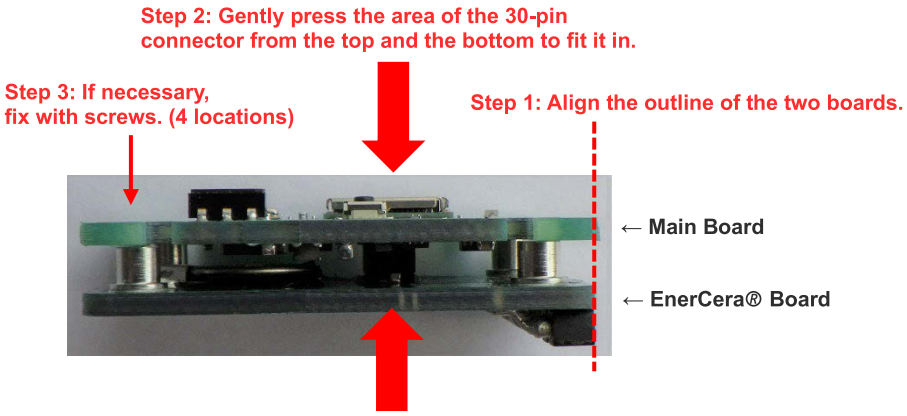


Figure 3. Connection of Main Board to EnerCera® Board (Side View)

(*6) Screws not included.

2-8-2. How to Start

By sliding the power switch on Main Board to the right (ON side of the silk printing on the board), the BLE module and various sensors, etc. are powered, and this product starts operation as an environment sensor.

When the power switch is turned on, the LED blinks once, and approximately 15 seconds later the LED blinks twice to start operation. The change of settings by our application for Android (RIoT002 Setting) described in Chapter 2-3 is made in approximately 15 seconds from the first blink of the LED to the second blink of the LED after the power switch is turned on.

2-8-3. How to Charge

The basic configuration of the RIOT-002C is to extract electric power from an indoor-use photovoltaic panel and charge it to a secondary battery. When charging a secondary battery in a discharged state, the RIOT-002C can be operated only after the voltage of the secondary battery exceeds a certain voltage (2.43 V (typ.)) and the PG signal (*7), which monitors the voltage of the secondary battery, is output. When this product is used for the first time or if the secondary battery is discharged, it is recommended to turn the power switch to the left (off state) and charge the battery from a photovoltaic panel for a sufficient time before using the product.

It takes approximately 11 hours (*8) to become ready for operation after being charged by a photovoltaic panel.

[Conditions]

- Photovoltaic panel: AM-1816 (external size 96.7 mm × 56.7 mm)
- External Environment: White LED (approx. 5000 K) Approx. 800 lx (indoor rather bright environment))

When the PG signal becomes High, the R1801 continues to monitor the secondary battery voltage even when the photovoltaic panel is removed and continues to output High until the lower voltage limit (1.9 V (typ.)) is detected (*9).

The optional board (the RIOT-C02) that can charge a secondary battery from a CR2032 coin battery is also available, and the battery can be charged by connecting to this board.

(Please refer to the specifications of the RIOT-C02 for details on how to charge a battery using the RIOT-C02.)

It takes approximately 2 hours (*8) to become ready for operation after being charged by the coin battery board. Note that the photovoltaic panel should basically remain connected even when charging with the coin battery Board. The PG signal may be cleared (*9) (*10).

Please do not remove EnerCera® Board from Main Board, as the R1801 will detect the secondary battery voltage as discharged and the PG signal will be cleared. In the case of removal, connect a photovoltaic panel and charge the secondary battery additionally depending on the status of the battery voltage (*10).

(*7) It means Power Good signal. The R1801, a DC/DC switching regulator, monitors the output voltage (= secondary battery voltage). Once it becomes High, it remains High until it falls below 1.9V (typ.) (if R1801's input voltage is supplied). This PG signal is used for CE control of the RP605 DC/DC switching regulator at the next stage of the circuit.

(*8) This is not the time to fully charge the secondary battery.

(*9) When the R1801 input voltage falls below 2.0 V due to a removal of the photovoltaic panel or insufficient illumination, a reverse current flows from the output of the R1801 (= secondary battery) to the input of the R1801, and this operation maintains the input voltage of the R1801 at approximately 2.0 V. This operation continues until the rechargeable battery reaches a discharged state. For details, please refer to the "REVERSE CURRENT PROTECTION" of "THEORY OF OPERATION" in the R1801 data sheet.

For reference,

https://www.nisshinbo-microdevices.co.jp/en/pdf/datasheet/r1801-ea.pdf

(*10) Basically, the photovoltaic panel is always connected to PV+ and GND on Main Board. Only when it is used in combination with the coin battery board, connecting the output of coin battery (3V) to PV+ instead of the photovoltaic panel allows the R1801 to be powered and to output PG signals. Refer to the following diagram for board-to-board connections, etc.

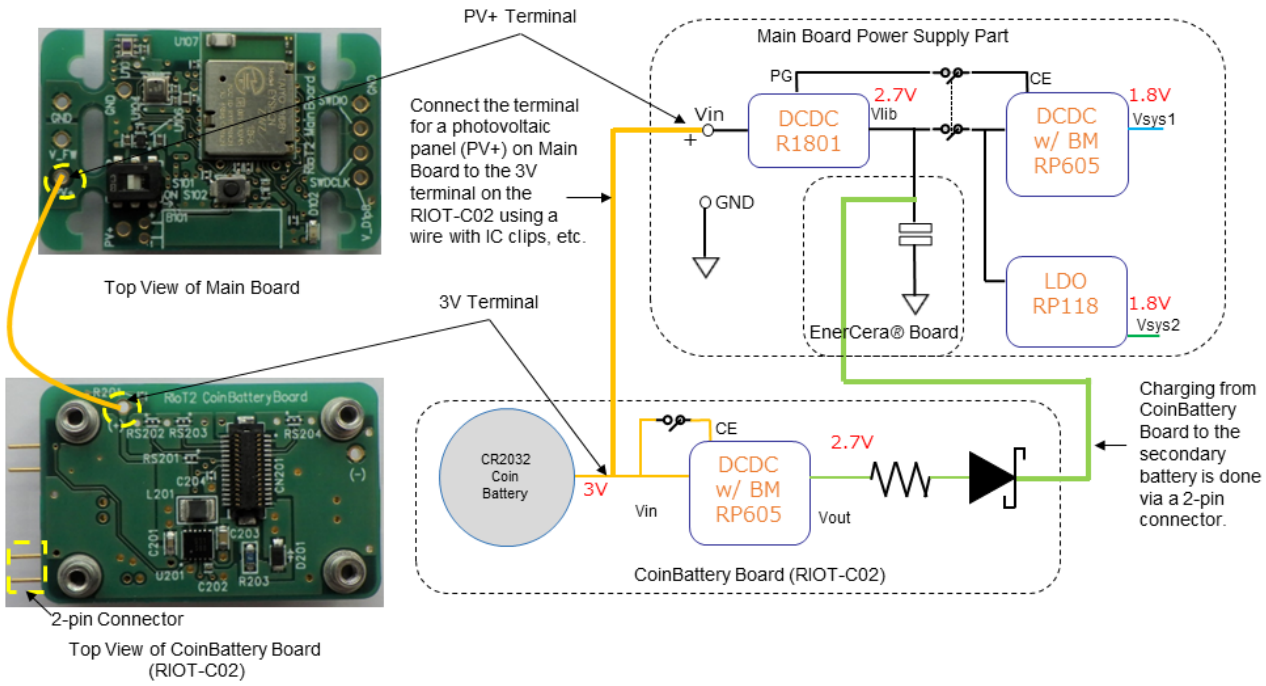


Figure 4. Connection between 3V Terminal of Coin Battery Board and PV+ Terminal of Main Board

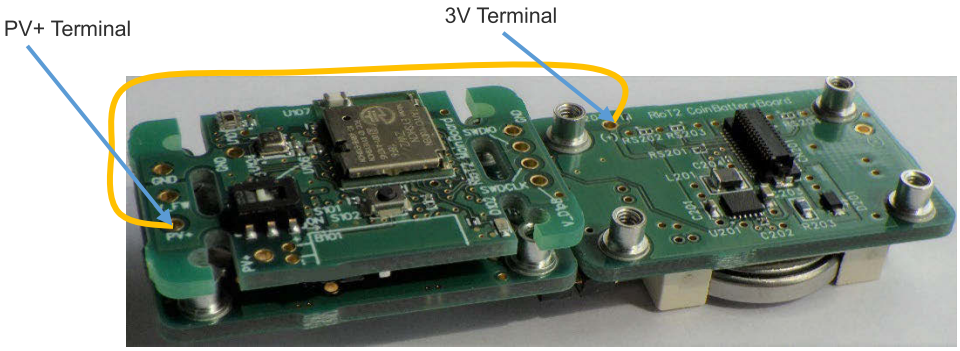


Figure 5. Image of Wiring with Boards Connected

2-9. Operation
2-9-1. Intermittent Operation

The following figure shows a diagram of the intermittent operation of each sensor, the battery monitor function (ADC) in the BLE module, and BLE communication when operated with the firmware that is set at the time of shipment (default).

Figure 6. Diagram of Intermittent Operation with Default Firmware

It is set by the default firmware to operate all sensors and the battery monitor function (ADC) in the BLE module, and to BLE communication of each sensor's output at 5-second intervals. Each sensor, battery monitor function (ADC), and BLE communication enter the operation state once every 5 seconds and enter the sleep state for the rest of the time.

The change of settings, such as measurement intervals, by our application for Android (RIoT002 Setting) described in Chapter 2-3 is made in approximately 15 seconds from the first blink of the LED after the power switch of Main Board is turned on.

The following figure shows a diagram of the intermittent operation when the following settings are made.

- Measurement intervals: 10 seconds
- Ambient light sensor: Enable
- Temp./humidity/atmospheric pressure sensor: Enable
- 3-axis acceleration sensor: Disable
- Secondary battery voltage monitor: Disable

Figure 7. Diagram of Intermittent Operation with Settings Changed

As shown in the figure above, inactive sensors and battery monitors keep sleep mode.

2-9-2. Utilization of Real Time Clock Function

The real time clock function can set operating day of the week and operating time range as described in Chapter 2-3. The intermittent operation timing settings, such as once per second operation, are made by using the timer function of the BLE module, not the real time clock function of the R2221, a real time clock IC. Please refer to the "RIoT002 Setting Application Manual" for setting contents of operating day of the week and time and setting method.

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8. radio wave regulation of the country where this product is used.
9. Our company is not responsible for damage caused by failure to properly follow the recommended operating conditions or product specifications described in this document.
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Please note that our warranty does not cover free samples and products purchased via another channels.
14. This product is a sample board for customers to understand our power management ICs. Safety, reliability, compatibility, etc., which are commonly required by final products for consumers or industries, are not considered in design, nor in sales, nor in manufacturing.
Please note that we do not take any responsibility or liability for any damage or loss using the product for any final products for consumer or industry.
15. Customers shall be strictly prohibited to use the products in equipment or systems that require extreme level of quality and reliability, and of which malfunction or failure may cause loss of human life and/or bodily injury, e.g., equipment used in aerospace industry, nuclear reactor control systems, traffic control systems, automotive and transportation equipment, combustion equipment, safety devices, life support systems.
16. Customer shall not use the products under any of the conditions mentioned bellow. This may cause malfunction or defect.
in water
in high humidity
under oily environment
in corrosive atmosphere
under environment with corrosive gas or inflammable gas
under an extremely high or low temperature environment
under conditions of violent vibration
in the place that generates electrostatic charges and electrifies
in a place that exposed to direct sunlight
in a dusty place
Anti-radiation design is not implemented in the products described in this document.
17. Improper or unintended use or misuse may lead to loss of human life and bodily injury, firing and smoking, failure of the products and connected components, and damage to property or loss of social profits.
18. Sharp edge of components such as short plug may unavoidably appear. Customer shall handle the products with the utmost care and attention to avoid injury from the sharp edge.
19. To avoid electrostatic discharge failure, Customer shall not touch the metal portion of the connector with bare hands or fingers.
Also, Customer shall remove static electricity of the human body before handling the products through touching something made of metal such as door handles. Customer
20. shall turn off immediately when firing, smoking or abnormal heating occur during operation.
21. When connecting the products to other products, Customer shall not give excessive stress on the products. Customer shall not warpage boards nor push forcefully the mounted components.
22. Customer shall not apply the supply voltage to the product if the surface of the board is wet or the product touches any metals.
23. The X-ray exposure can influence functions and characteristics of the products.
24. Do not turn on this product at the place where using wireless devices is prohibited, such as in airplanes, hospitals, near an implantable cardiac pacemaker or medical electrical equipment, etc.
The radio wave generated from this product may interfere with those devices' operation.
25. This product may be affected by radio waves emitted from devices or equipment such as wireless LAN, BLE devices, digital cordless phones, microwave ovens, etc.
26. This product must not be incorporated nor used in a metallic cabinet. Also, do not use cabinets whose coating materials contain metal composition.
27. Our company warrants the products with exceptions as indicated below, to the original purchaser to be free of defects for a period of three months from the date of arrival. Within the warranty period, we will replace a defective product with a substitute. We assumes no liability for indirect, special or incidental damage or loss including loss of profits and consequential damage regardless of possibility of anticipation.

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