User's Manual

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CPX4 AC-PLC Evaluation Kit M02D2
RTK0EE0009D02001BJ

User's Manual

RENESAS
PLC Modem LSI R9A06G061

Renesas Electronics
www.renesas.com

Rev.1.00 July 01, 2021

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(Rev.5.0-1 October 2020)

Corporate Headquarters

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General Precautions in the Handling of Micro processing Unit and Microcontroller Unit Products

The following usage notes are applicable to all Micro processing unit and Microcontroller unit products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

1. Precaution against Electrostatic Discharge (ESD)
   A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.
2. Processing at power-on
   The state of the product is undefined at the time when power is supplied. The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the time when power is supplied. In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the time when power is supplied until the reset process is completed. In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the time when power is supplied until the power reaches the level at which resetting is specified.
3. Input of signal during power-off state
   Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.
4. Handling of unused pins
   Handle unused pins in accordance with the directions given under handling of unused pins in the manual. The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of the LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible.
5. Clock signals
   After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is stabilized. When the clock signal is generated with an external resonator or from an external oscillator during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Additionally, when switching to a clock signal produced with an external resonator or by an external oscillator while program execution is in progress, wait until the target clock signal is stable.
6. Voltage application waveform at input pin
   Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (Max.) and V_{IH} (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (Max.) and V_{IH} (Min.).
7. Prohibition of access to reserved addresses
   Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.
8. Differences between products
   Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a micro processing unit or microcontroller unit products in the same group but having a different part number might differ in terms of internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

Important

Before using this product, be sure to read this document carefully.

This Product:

"This product" in this document collectively refers to the following product manufactured by Renesas Electronics Corporation. "This product" herein encompasses neither the customer's user system nor the host machine.

(a) CPX4 AC-PLC Evaluation kit equipped with PLC modem LSI R9A06G061（RTK0EE0009D02001BJ）

Purpose of use of this product:

This product is a solution kit which adopts Renesas Electronics Corporation PLC modem LSI R9A06G061. Be sure to use this product correctly according to said purpose of use. Please avoid using this product other than for its intended purpose of use.

For those who use this product:

This product can only be used by those who have carefully read the document and know how to use it.
Use of this product requires basic knowledge of electric circuits, logical circuits, and MCUs.
When using this product:

(1) This product is a development-support unit for use in your program development and evaluation stages. When a program you have finished developing is to be incorporated in a mass-produced product, the judgment as to whether it can be put to practical use is entirely your own responsibility, and should be based on evaluation of the device on which it is installed and other experiments.
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(8) The all operation of the USB device connected to this product is not guaranteed.
(9) All of the application note and sample program provided about this product are reference data, and they do not guarantee the operation. Please use as technical reference data for software development.

When disposing of this product:

Penalties may be applicable for incorrect disposal of this waste, in accordance with your national legislation.

Usage restrictions:

This product has been developed as evaluation system for PLC modem LSI R9A06G061.
Therefore, do not use it as an embedded device in other equipment. Also, do not use it to develop systems or equipment for use in the following fields.

(1) Transportation and vehicular
(2) Medical (equipment that has an involvement in human life)
(3) Aerospace
(4) Nuclear power control
(5) Undersea repeaters

If you are considering the use of this product for one of the above purposes, please be sure to consult your local distributor.

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This product is provided "as is" and no repair, analysis, etc. are supported.

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In this document, several icons are used to insure proper handling of this product and also to prevent injuries to you or other persons, or damage to your properties.
This chapter describes the precautions which should be taken in order to use this product safely and properly.
Be sure to read this chapter before using this product.

⚠	This symbol represents a warning about safety. It is used to arouse caution about a potential danger that will possibly inflict an injury on persons. To avoid a possible injury or death, please be sure to observe the safety message that follows this symbol.
⚠ WARNING	**WARNING** indicates a potentially dangerous situation that will cause death or heavy wound unless it is avoided.
⚠ CAUTION	**CAUTION** indicates a potentially dangerous situation that will cause a slight injury or a medium-degree injury unless it is avoided. In addition to the three above, the following are also used as appropriate.
In addition to the three above, the following are also used as appropriate.	
△ means PROHBITION	
Example: 	CAUTION AGAINST AN ELECTRIC SHOCK
⃠	
Example: 	DISASSEMBLY PROHIBITED
● means A FORCIBLE ACTION	
Example: 	UNPLUG THE POWER CABLE FROM THE RECEPTACLE

⚠ WARNING

Warnings for AC Power Supply：

- Do not touch the plug of the AC power cable when your hands are wet. This may cause electric shock.
- If other equipment is connected to the same branch circuit, care should be taken not to overload.

- If you smell a strange odor, hear an unusual sound, or see smoke coming from this product, then disconnect power immediately by unplugging both the AC/DC Adapter and the AC power cables for PLC signal from the outlet.
  Do not use this as it is because of the danger of electric shock and/or fire. In this case, contact your local distributor.

Warnings to Be Taken for This Product:

- Do not disassemble or modify this product. Personal injury due to electric shock may occur if this product is disassembled and modified. Disassembling and modifying the product will void your warranty.
- Make sure nothing falls into the cooling fan on the top panel, especially liquids, metal objects, or anything combustible.

- CAUTION: High Voltage (Risk of Electric Shock)
- This is the evaluation kit for powerline communications. All work in powerline communications must be done with extreme care. Caution must be exercised when using power supplies or power related equipment.
- There is high voltage (100V-230 V AC) power on this board. Do not touch the high voltage area during live operation for debugging, probing, or any other.
- The capacitors on this board can be energized even after disconnecting this board from the main power supply. Be careful to not touch any parts on this board immediately after you disconnect the main power supply.
- Do not touch the high voltage area during live operation for debugging, probing, or any other purpose.
- Renesas Electronics bears no responsibility for any consequences that may result from the improper or hazardous use of this board.

⚠ WARNING

Warning for Installation：

- Do not set this product in water or areas of high humidity. Make sure that the product does not get wet. Spilling water or some other liquid into the product may cause unrepairable damage.

Warning for Use Environment：

- This equipment is to be used in an environment with a maximum ambient temperature of 40°C. Care should be taken that this temperature is not exceeded.
- Do not touch this product immediately after a lightning strike.

⚠ CAUTION

Cautions for AC Power Supply：

- Use a power cord and AC adapter that are appropriate for that country's safety standards.
- Use of an inappropriate power cord or AC adapter may cause generation of heat, fire, or electric shock.

Cautions to Be Taken for Handling This Product：

- Use caution when handling the product. Be careful not to apply a mechanical shock.
- Do not touch the connector pins of this product and the target MCU connector pins directly. Static electricity may damage the internal circuits.
- When attaching and removing the cable, hold the plug of the cable and do not touch the cable. Do not pull this product by the communications interface cable or the flexible cable. And, excessive flexing or force may break conductors.

Caution to Be Taken for System Malfunctions：

- If this product malfunctions because of interference like external noise, do the following to remedy the trouble.
  (1) Exit this product debugger, and shut OFF this product and the user system.
  (2) After a lapse of 10 seconds, turn ON the power of this product and the user system again.

Caution to Be Taken for Disposal：

- Penalties may be applicable for incorrect disposal of this waste, in accordance with your national legislation.

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Regulatory Compliance Notices

European Union regulatory notices

This product complies with the following EU Directives. (These directives are only valid in the European Union.)

CE Certifications:

Directive 2014/35/EU(LVD), 2014/30/EU(EMC) :

EN 50065-4-2:2002 +A1:2003 +A2:2005

EN 50065-1:2001 +A1:2010, EN 50065-2-3:2003 +A1:2005, EN 50065-7:2001

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  Name: Renesas Electronics Corporation
  Address: 5-20-1, Josuihon-cho, Kodaira-shi, Tokyo 187-8588, Japan
- Manufacturer
  Name: Renesas Electronics Corporation
  Address: 5-20-1, Josuihon-cho, Kodaira-shi, Tokyo 187-8588, Japan
- Person responsible for placing on the market
  Name: Renesas Electronics Europe GmbH
  Address: Arcadiastrasse 10, 40472 Dusseldorf, Germany
- Trademark and Type name
  Trademark: Renesas
  Product name: CPX4 AC-PLC BOARD
  Model name: RTK0EE0009D04001BJ **

Environmental Compliance and Certifications:

Waste Electrical and Electronic Equipment (WEEE) Directive 2012/19/EU

UK Government guidance regulatory notices

This product is in conformity with the following relevant UK Statutory Instrument(s) (and their amendments):

UKCA Certifications:

2016 No. 1101 Electrical Equipment (Safety) Regulations 2016

2016 No. 1091 Electromagnetic Compatibility Regulations 2016

EN 50065-4-2:2002 +A1:2003 +A2:2005

EN 50065-1:2001 +A1:2010, EN 50065-2-3:2003 +A1:2005, EN 50065-7:2001

Information for traceability

- Authorized representative
  Name: Renesas Electronics Corporation
  Address: 5-20-1, Josuihon-cho, Kodaira-shi, Tokyo 187-8588, Japan
- Manufacturer
  Name: Renesas Electronics Corporation
  Address: 5-20-1, Josuihon-cho, Kodaira-shi, Tokyo 187-8588, Japan
- Person responsible for placing on the market
  Name: Renesas Electronics Europe GmbH
  Address: Dukes Meadow Millboard Road Bourne End Buckinghamshire , SL8 5FH
- Trademark and Type name
  Trademark: Renesas
  Product name: CPX4 AC-PLC BOARD
  Model name: RTK0EE0009D04001BJ **

United States regulatory notices on electromagnetic compatibility

FCC Certifications (United States Only):

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

** Note)
About representation of the model name
A model name of the kit including accessories is "RTK0EE0009D02001BJ". (It is displayed on a box.)
A model name of the PLC board is "RTK0EE0009D04001BJ". (It is displayed on the board.)

How to Use This Manual

1. Purpose and Target Readers

This manual is designed to provide the user with an understanding of the hardware functions and electrical characteristics of the evaluation board. It is intended for users designing applications and systems based on the board.

Particular attention should be paid to the precautionary notes when using the manual. These notes occur within the body of the text, at the end of each section, and in the Usage Notes section.

The revision history summarizes the locations of revisions and additions. It does not list all revisions. Refer to the text of the manual for details.

2. List of Abbreviations and Acronyms

Abbreviation	Full Form
AFE	Analog Front End
FCC	Federal Communications Commission
GND	Ground Potential
MAC	Media Access Control Layer
MCU	Micro Controller Unit
OCD	On Chip Debugger
OFDM	Orthogonal Frequency Division Multiplexing
PLC	Power Line Communication
PHY	Physical Layer
SAP	Service Access Point
S/W	Software
FW	firmware
UART	Universal Asynchronous Receiver/Transmitter
USB	Universal Serial Bus
Pmod™	Digilent Pmod™ Compatible connector. Pmod™ is registered to Digilent Inc. Digilent-Pmod_Interface_Specification
PWM	Pulse Width Modulation
SPI	Serial Peripheral Interface

Table of Contents

1. Product Overview

This product is an evaluation kit for AC power line communication (hereinafter referred to as AC-PLC) for developing software and evaluating systems compatible with PLC modem LSI R9A06G061 (hereinafter referred to as "CPX4") made by Renesas Electronics.

This chapter describes the configuration and usage of this product.

1.1 Board configuration

This product has a total board configuration that includes the analog front end and control MCU required for AC-PLC. This product is shown in Figure 1-1.

This product is composed of the following four types of boards. The board main unit consists of the following 1), 2), 3) and 4).

1) AC-PLC Board: PLC-modem LSI (CPX4: R9A06G061) and AFE-device (ISL15102)
2) RX651 MCU Board: Control MCU board (RX651: R5F5651EHDFP)
3) Filter Board: There are three types of filters that remove noise outside the corresponding pass band, and are compatible with 35k-90kHz, 150k-500kHz, and 35k-500kHz.
4) PMOD conversion board: Pmod ™ connector female-male conversion board

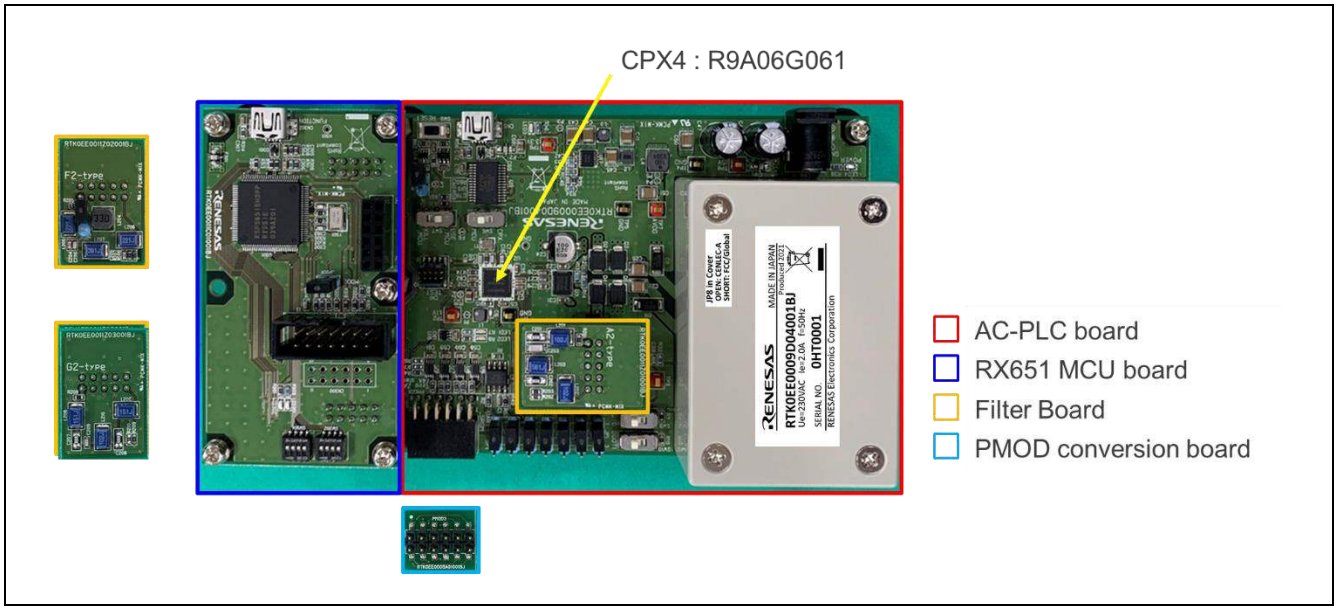

Figure 1-1 CPX4 AC-PLC Evaluation Kit Board Configuration

The model name of the kit including the accessories is "RTK0EE0009D02001BJ" (display on the outer box). The individual model names for each board are shown in Table 1-1.

Table 1-1 CPX4 AC-PLC Evaluation Kit supplied boards model names

AC-PLC Board model name	RTK0EE0009D04001BJ
RX651 MCU Board model name	RTK0EE0011C01001BJ
Filter Board model name	A2-type : RTK0EE0011Z01001BJ F2-type : RTK0EE0011Z02001BJ G2-type : RTK0EE0011Z03001BJ
PMOD conversion board model name	RTK0EE0009A01001BJ

Table 1-2 List of specifications

Product name		CPX4 AC-PLC Evaluation Kit M02D2 RTK0EE0009D02001BJ	
Product Model Number		RTK0EE0009D02001BJ	
PLC modem device		CPX4 (R9A06G061)	
Control MCU		RX651 (R5F5651EHDFP)	
AFE Devices		ISL15102 (Intersil) : Power Amp (hereinafter, PA) + RX Step ATT : discrete	
PLC section specifications		Applicable Frequency	35kHz – 500kHz
		Applicable power line voltage	AC100-230V
Applicable standards		CENELEC-A (35.9375kHz - 90.625kHz), CENELEC-B (98.4375kHz - 121.875kHz), G3-FCC (154.6875kHz - 487.5kHz)	
Legal compliance*1		CE and UKCA Certifications (EN500650-1, 2-3, 4-2, 7) FCC Certifications (FCC part15 subpart B 15.107, 109)	
Power supply		External power supply via AC adapter (rated 15V/1.2A)	
Interface	AC-PLC Board	PLC Signal Port (AC inlet)	PLC connector (CN3): AC power cable connection for PLC signal
		External power supply port	Power connector (CN4): AC jack AC-adapter for supplying power: Connect DC15V or DC12V (Note:AC adapter is not included)
		PMOD	Connector for Digilent Pmod™ interface (PMOD1): Type 2A(SPI) / Type 4A(UART) supported
		USB	USB connector (CN5): for serial communication with CPX4, Mini-B USB cabling for PC communication
	RX651 MCU Board	MCU(RX651) On-chip debugging	OCD connector (CN305): MCU(RX651) E1 emulator connection for debugging
		GPIO(MCU)	GPIO connectors (CN301): For MCU signal monitoring
		USB	USB connector (CN302): For USB function and USB boot mode
Filter board		RX band pass filter Applicable Frequency	A2-type(35k-90kHz), F2-type(150k-500kHz), G2-type(35k-500kHz)
Product description		・AC-PLC Board·····1 unit ・RX651 MCU Board·····1 unit ・Filter board (A2/F2/G2-type)·····3 unit ・PMOD conversion board·····1 unit ・USB cable·····1 pcs ・Precautions for Use (English)·····1 pcs ・Precautions for Use (Japanese) ·····1 pcs ・SJ/T 11364 table of hazardous substance (China RoHS)·····1 pcs	
External Dimensions		AC-PLC board : 130×80×45 mm	

Note *1 : This product has not obtained ARIB certification in Japan, it is not possible to perform communication tests using commercial power supplies in Japan. When conducting a communication test using a commercial power source, it is necessary to submit an application for high-frequency use equipment and obtain permission from the Ministry of Internal Affairs and Communications.

1.2 Circuit function block diagram

The circuit function block diagram of this product is shown in Figure 1-2, Figure 1-3, Figure 1-4, Figure 1-5.

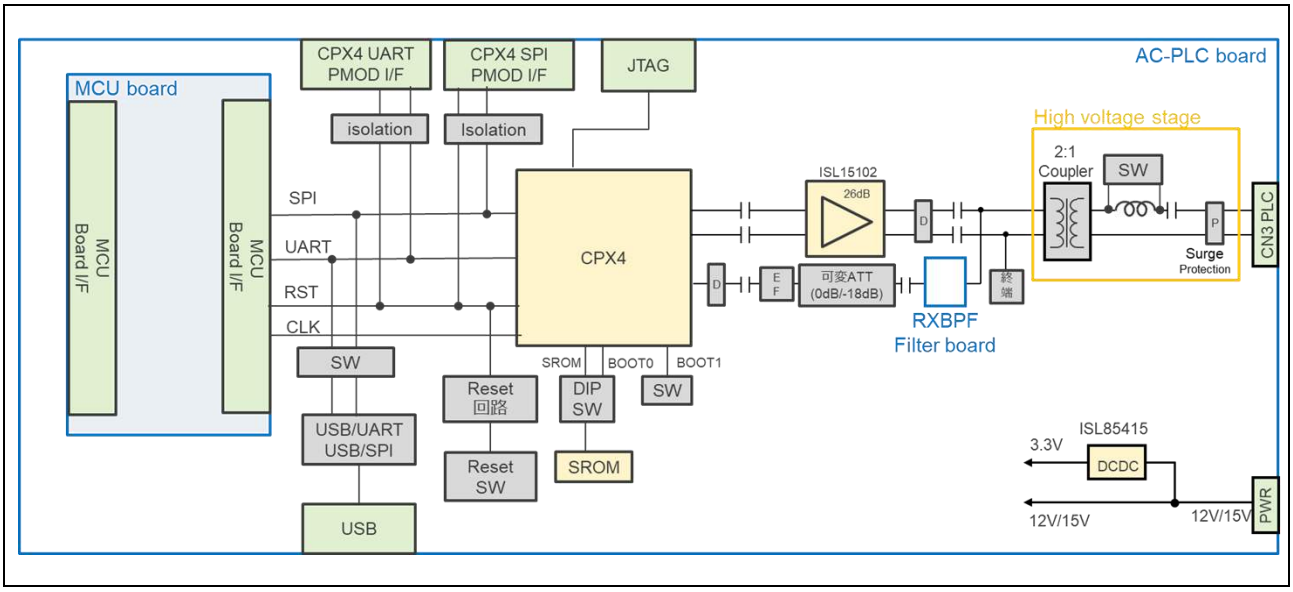

Figure 1-2 AC-PLC Board Block Diagram

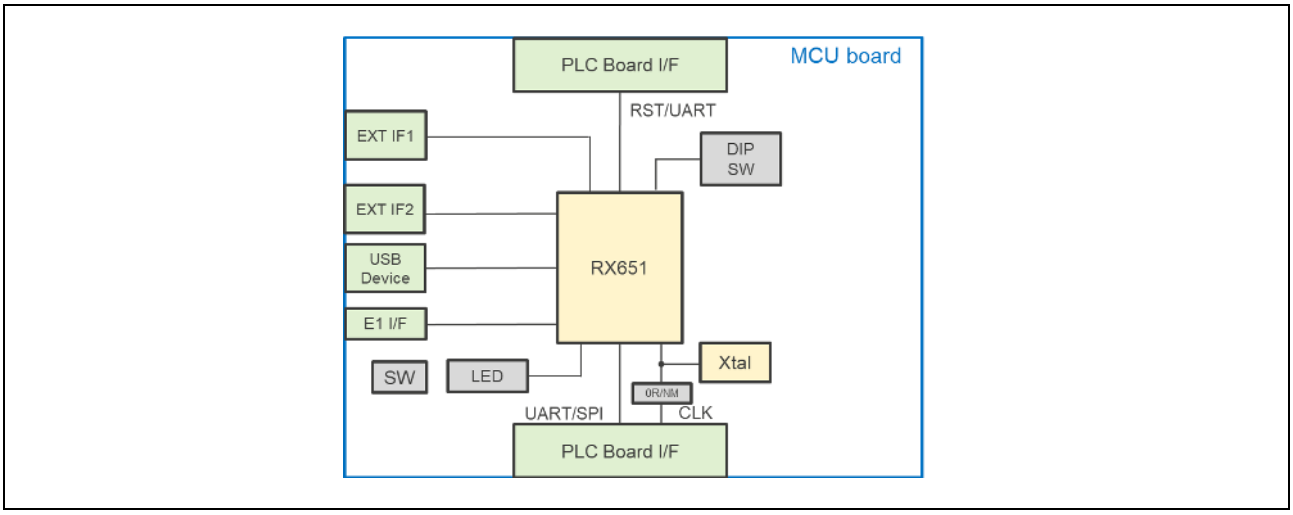

Figure 1-3 RX651 MCU Board Block Diagram

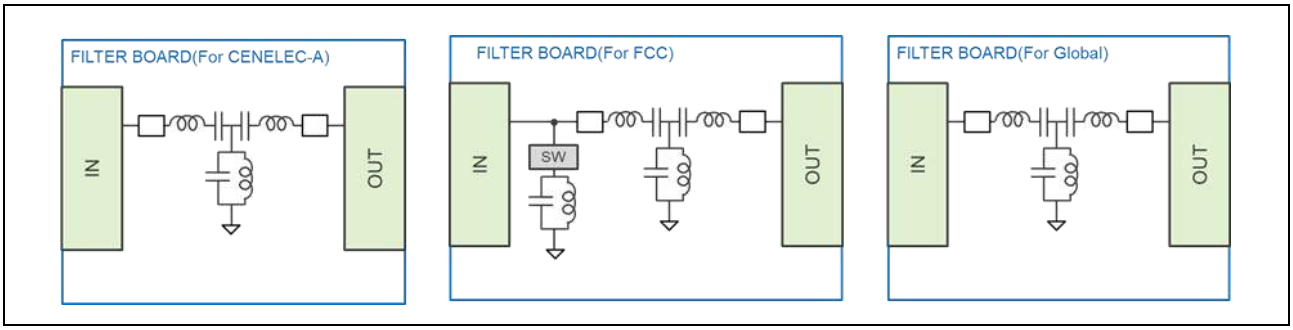

Figure 1-4 Filter Board Block Diagram

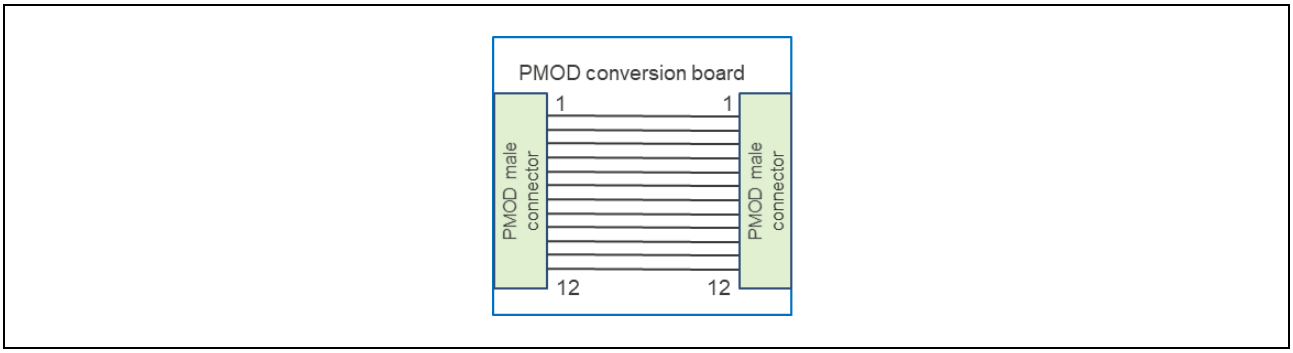

Figure 1-5 PMOD Conversion Board Block Diagram

1.3 Description of each part of CPX4 AC-PLC evaluation kit

Figure 1-6 shows a description of each part of the CPX4 AC-PLC evaluation kit. For a detailed explanation of the connectors, SWs and JPs of each board, refer to Chapter 3, Interface specifications and SW/JP switching.

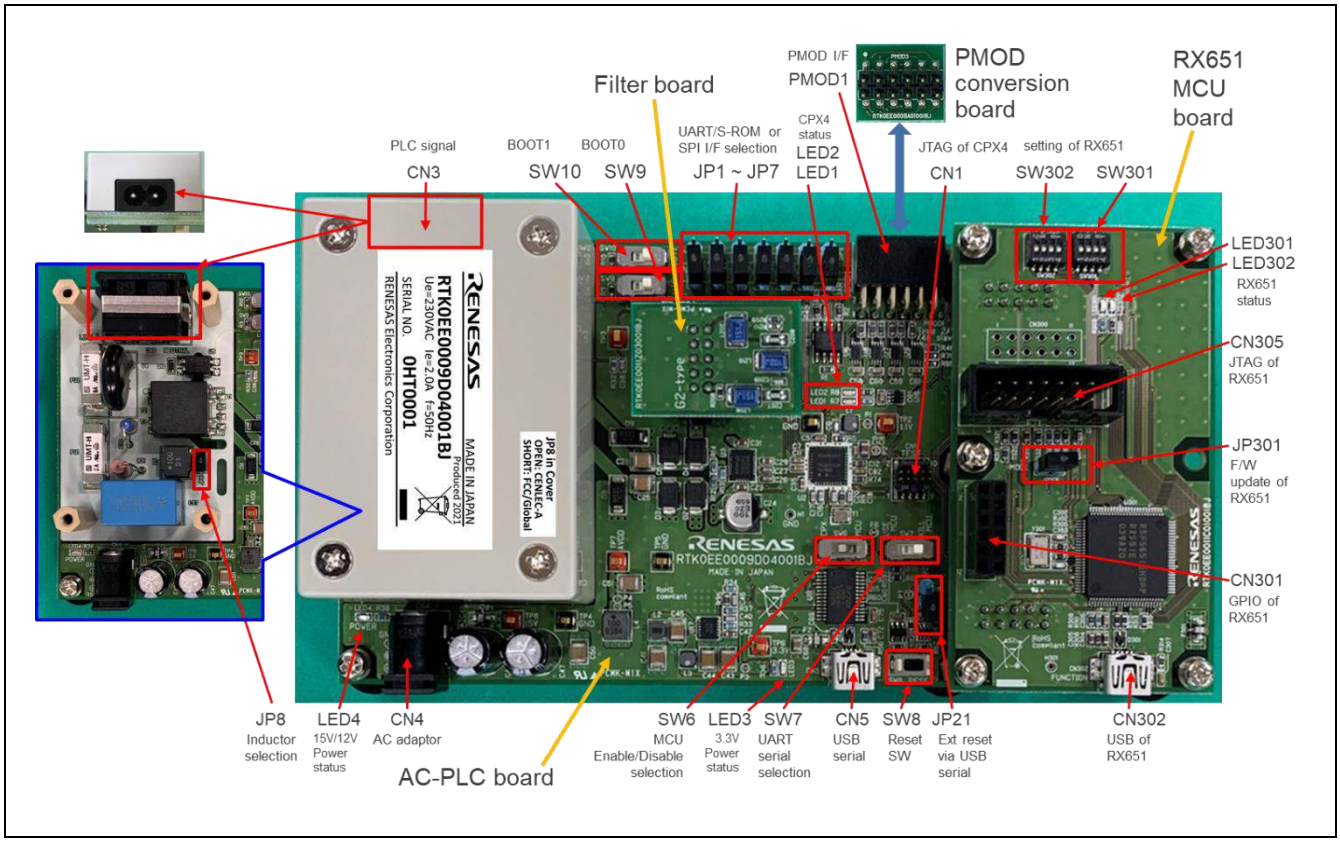

Figure 1-6 Description of each part of the CPX4 AC-PLC evaluation kit

1.4 Board Dimensions

Each board in CPX4 AC-PLC evaluation kit is a four-layer construction (FR4). The dimensions of the boards are shown in Figure 1-7.

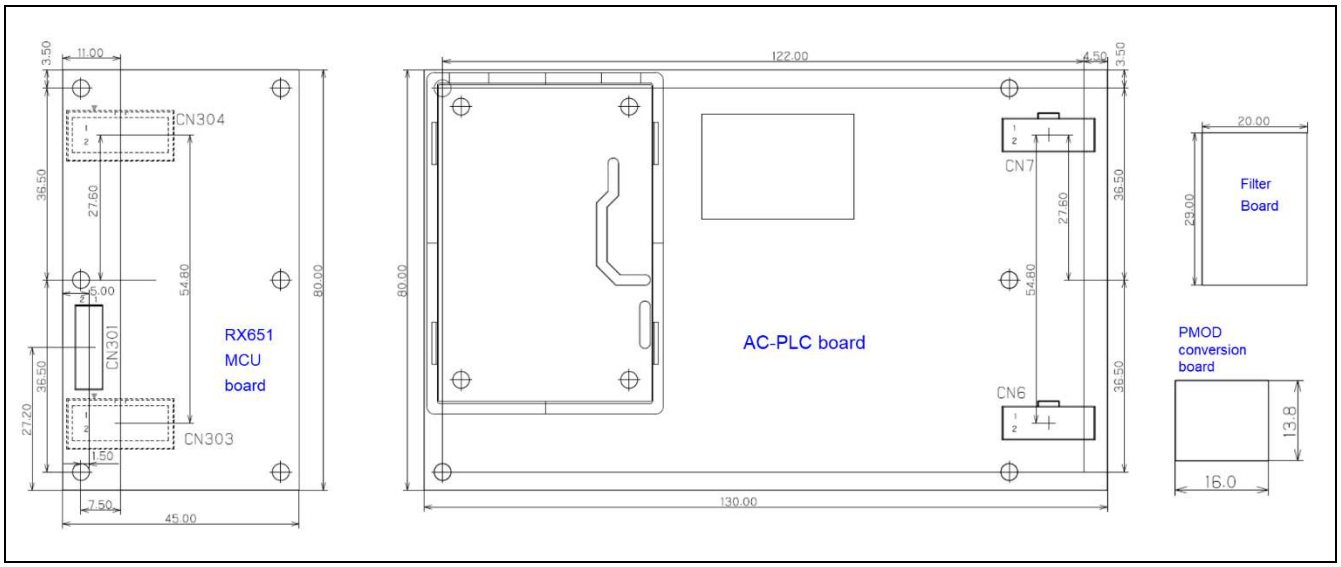

Figure 1-7 Dimensions of CPX4 AC-PLC Evaluation Kit

1.5 To begin evaluating AC-PLC communications

This section describes the required hardware and software to start evaluating AC-PLC communication using this evaluation kit. Obtain the latest version of the PHY-evaluation tool (CPX4 SimpleMAC GUI) and various manuals from the download site that that Renesas informed when the user registered as the PLC user. Information such as circuit diagrams and the latest version of the bill of materials can also be obtained if necessary. For the download site, refer to the "Precautions for Use" included with this evaluation kit.

1.5.1 Items required for AC-PLC communication Evaluation

The items required for evaluating AC-PLC communication in a basic configuration with two evaluation kits are shown below. When adding evaluation kits, please prepare additional items together. Refer to Chapter 2 for the connection method.

Table 1-3 Hardware that requires preparation

Product name	Number of units required	Remarks
AC-PLC board (supplied with this kit)	2 unit	
Filter board (supplied with this kit)	2 unit	Select one type of Filter board for RX-BPF from A2 / F2 / G2-type according to the band used and the corresponding standard.
AC power cable	2 pcs	Required cables that corresponds to the AC voltage used
PC (PC with USB port)	2 unit	When evaluating communication performance, it is recommended that each AC-PLC board be connected to a separate PC.
USB cable (included in this kit)	2 pcs	
AC adapter (15 or 12V / 1.2A or higher recommended)	2 unit	
RX651 MCU board (included with this kit)	2 unit	Required when using an application that uses the RX651.
On-chip debugger	1 unit	Required when using an application that uses the RX651.

Table 1-4 Software that requires preparation

Product name	Remarks
CPX4 SimpleMAC GUI (PHY evaluation tool)	AC-PLC communication is evaluated using CPX4 SimpleMAC GUI from a PC connected to AC-PLC board. CPX4 SimpleMAC GUI can be downloaded from our website. For details on how to start and operate CPX4 SimpleMAC GUI, refer to the manuals on the downloaded website.
Driver for virtual serial port	The driver for the virtual serial port must be installed for the PC to be connected to AC-PLC board. For details, refer to chapter 3.1.12
Renesas Flash Programmer	Required when using an application that uses the RX651. Please download from the URL below. Renesas Flash Programmer (Programming GUI) | Renesas

2. HOW TO USE

This chapter describes how to use AC-PLC board and Filter board. For descriptions of the connectors, SWs and JPs parts of each board, refer to Chapter 3 Interface specifications and SW/JP switching.

2.1 Selecting the Filter board

For this product, the Filter board for RX-BPF must be replaced according to the applicable standards. The Filter board has the following specifications.

- A2-type Filter Board: CENELEC-A band (30k-90kHz)
- F2-type Filter board: FCC band (150k-500kHz)
- G2-type Filter board: Global band (35k-500kHz)

Band	Order	Insertion loss at center frequency[dB]	f_{-3dB} frequency[kHz]		f_{-6dB} frequency[kHz]	
			Low range	High range	Low range	High range
A2	4	-4.4	37.6	87.5	32.0	99.9

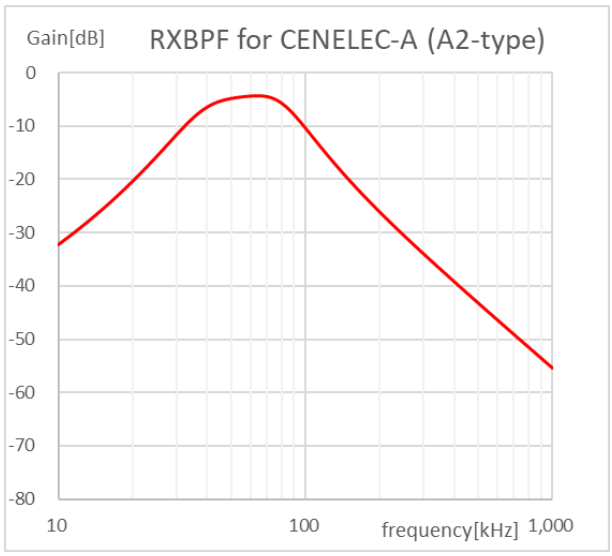

Figure 2-1 A2-type Filter board for CENELEC-A band

Band	Order	Insertion loss at center frequency[dB]	f_{-3dB} frequency[kHz]		f_{-6dB} frequency[kHz]	
			Low range	High range	Low range	High range
F2	4	-3.3	113.1	499.8	93.2	588.9

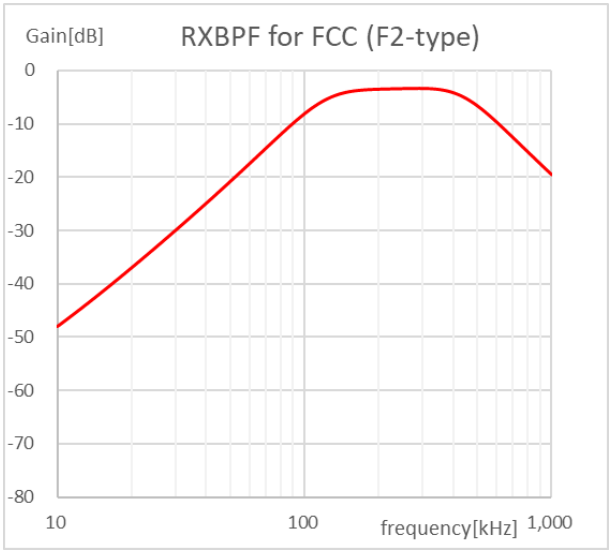

Figure 2-2 F2-type Filter board for FCC band

Band	Order	Insertion loss at center frequency[dB]	f_{-3dB} frequency[kHz]		f_{-6dB} frequency[kHz]	
			Low range	High range	Low range	High range
G2	6	-3.1	44.7	428.1	35.1	541.9

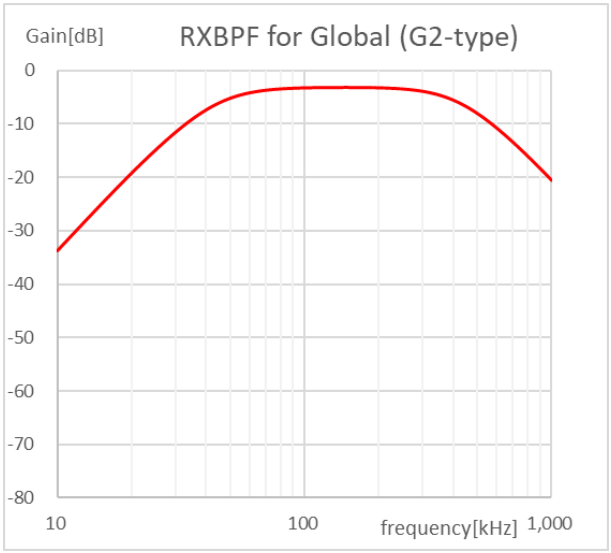

Figure 2-3 G2-type Filter board for Global band

TX-LPF is built into the PLC modem LSI. The characteristics of TX-LPF are described below.

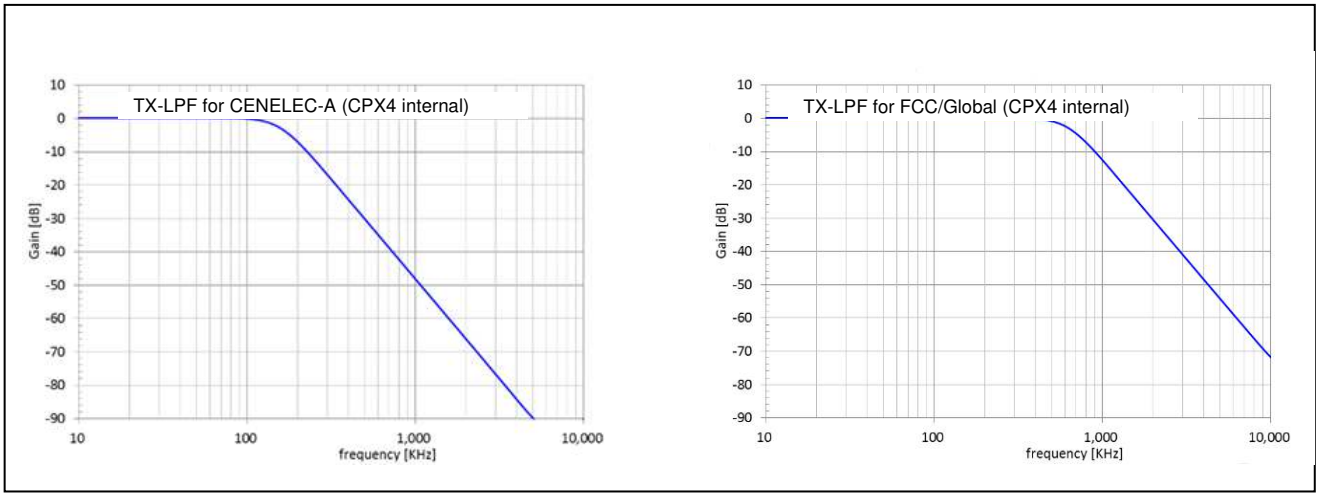

Figure 2-4 TX-PLF (CPX4 internal)

2.2 Example of setting each band

After selecting the Filter board, change JP8 according to **Table 2-1**.
For a detailed explanation of the connectors, SWs and JPs of each board, refer to Chapter 3 Interface specifications and SW/JP switching.
An example of Filter board, SWs and JPs settings for each band when the UART boot setting and RX651 MCU are not used is shown below.

Table 2-1 Example of filter board, SW and JP settings for each band

(UART boot setting and RX651 MCU unused setting)

JP、SW	CENELEC-A	CENELEC-B	FCC	Global
Filter board (RX-BPF)	A2-type (35-90kHz)	G2-type (35-500kHz)	F2-type (150-500kHz)	G2-type (35-500kHz)
TX-LPF(CPX4 internal)*2	fc=150kHz	fc=150kHz	fc=600kHz	fc=600kHz
JP1～JP7	1-2 side	1-2 side	1-2 side	1-2 side
JP8	OPEN	SHORT	SHORT	SHORT
JP21	OPEN	OPEN	OPEN	OPEN
JP301	OPEN	OPEN	OPEN	OPEN
SW6	MCU KILL	MCU KILL	MCU KILL	MCU KILL
SW7	CPX	CPX	CPX	CPX
SW8	Reset SW	Reset SW	Reset SW	Reset SW
SW9	H	H	H	H
SW10	H	H	H	H
SW301,SW302	All OFF	All OFF	All OFF	All OFF

Note *2 : TX-LPF is set when Band is set on CPX4 SimpleMAC GUI

2.3 Method for evaluating AC-PLC communications using CPX4 SimpleMAC GUI

The evaluation environment of AC-PLC communication using CPX4 SimpleMAC GUI is shown in Figure 2-5. For more information about board set and how to launch CPX4 SimpleMAC GUI, see the manual and the Quick Start Guide of CPX4 SimpleMAC GUI.

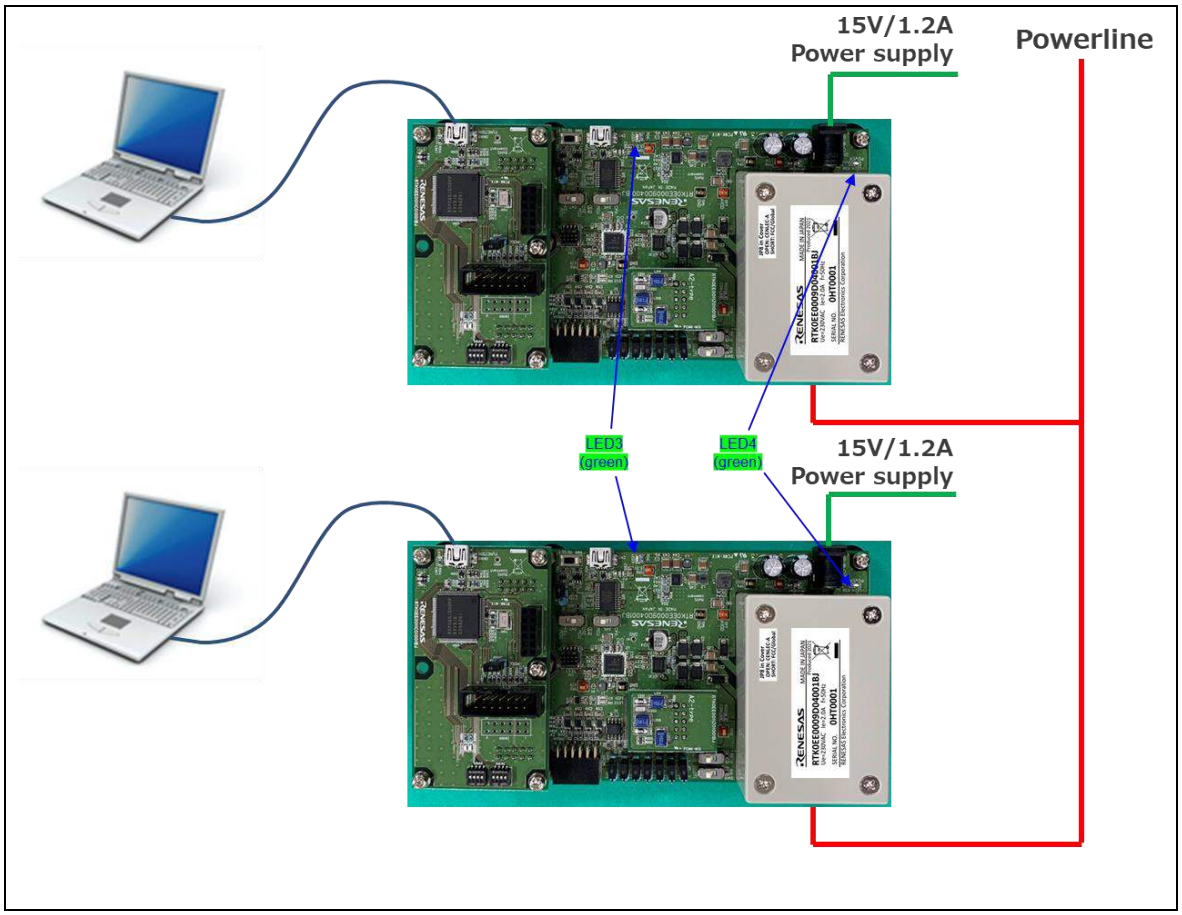

Figure 2-5 Evaluation environment for AC-PLC communication using CPX4 SimpleMAC GUI

Follow the procedure below to set the evaluation environment.

1) Set the Filter board, SWs and JPs that suit the user's usage environment, such as the band to be evaluated, the BOOT method, and whether or not the MCU is used.
2) Connect the USB cable to the USB port of the PC and the USB port (CN5) of the AC-PLC board.
3) Connect the AC adapter to the power connector (CN4) on the AC-PLC board.
4) Confirm that LED3 (green) and LED4 (green) of the AC-PLC board are lit.
5) Connect the AC cable for PLC connection to the PLC connector (CN3) of the AC-PLC board.
6) Launch CPX4 SimpleMAC GUI on the PC. (Refer to the CPX4 SimpleMAC GUI User's Manual for the following settings.)

3. Interface specifications and SW/JP switching

This chapter describes the interface specifications and SW and JP switching of this product.

3.1 AC-PLC Board

This section explains the interface specifications and SWs/JPs settings of AC-PLC board.

3.1.1 Explanation of Connectors, SWs and JPs of AC-PLC Boards

Figure 3-1 shows the arrangement of the connectors, SWs, and JPs, and Table 3-1 shows the usage.

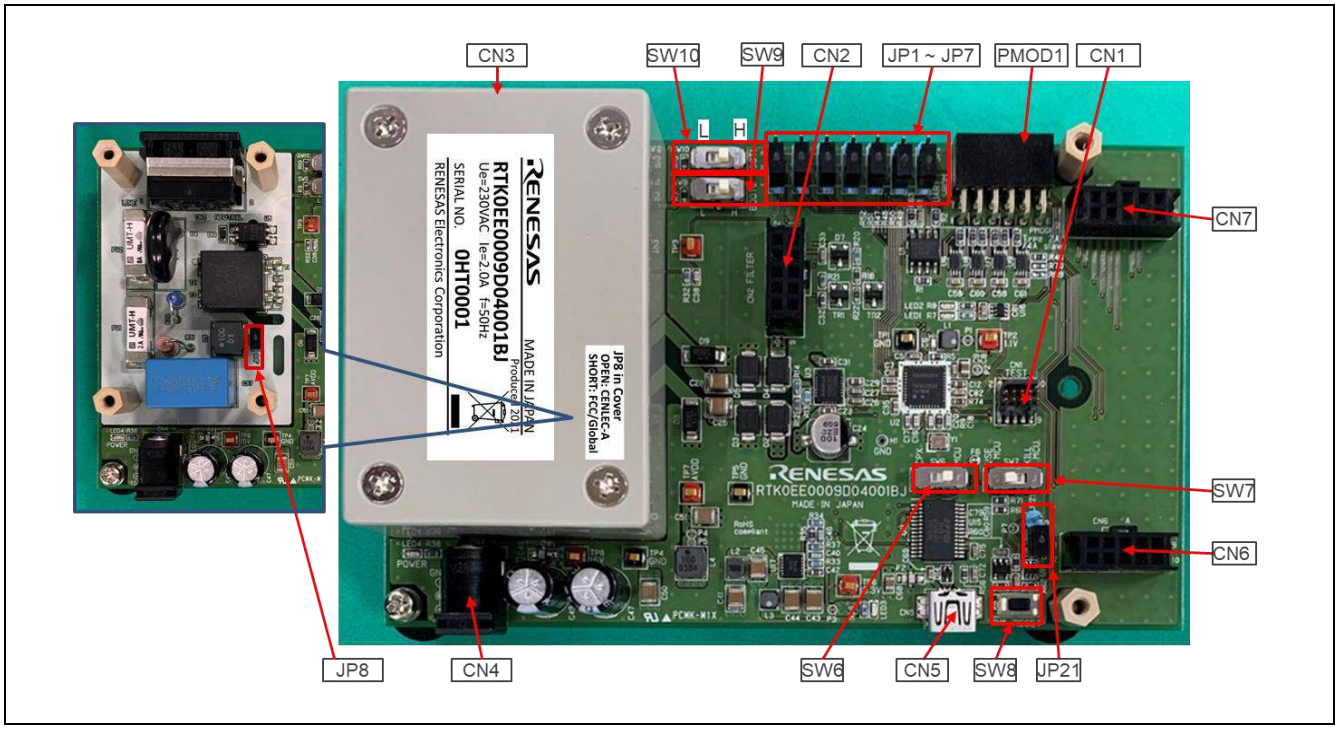

Figure 3-1 Connectors, JPs, and SWs of AC-PLC board

Table 3-1 Usages of connectors, JPs, and SWs for AC-PLC board

Connector, JP, SW name	Use
SW9, SW10	SWs for boot setting switching
SW6	SW for UART-USB switching
SW7	SW for MCU Enable/Disable switching
SW8	Reset SW
JP1, JP2, JP3, JP4, JP5, JP6, JP7	JPs for connection switching between UART_SROM interface and SPI interface
JP21	JP for switching external reset function via USB
CN1	Connector for JTAG of CPX4
CN3	Connectors for AC-PLC communication
CN4	Connector for power supply
CN5	USB connector for serial communication
CN6, CN7	Connector for RX651MCU board connector

3.1.2 LED (LED1, LED2, LED3, LED4)

AC-PLC board contains several LEDs that indicate the state.

- LED for PLC modem LSI signal: LED indicating the state of PLC modem LSI (2 locations)
  - LED1: When sending packets *3
  - LED2: When packets are received *3

  Note *3: Depends on Boot F/W port-setting
- Power-side LED: LED indicating power supply status (2 locations)
  - LED3: Lights when power is supplied to the 3.3V power supply.
  - LED4: Lights when power is supplied to the 15V/12V power supply.

3.1.3 JP1, JP2, JP3, JP4, JP5, JP6, JP7 for connection switching between UART_SROM interface and SPI interface

JP1 to P7 are the connection switching between UART_SROM interface and SPI interface. The factory default is UART_SROM interface. Table 3-2 shows the switching setting of JPs.

Table 3-2 UART_SROM/SPI interface switching setting.

Interface	Jumper setting
UART_SROM (factory default)	JP1to JP7 are short-circuited to 1-2.
SPI	JP1to JP7 are short-circuited to 2-3

3.1.4 JP for Inductor switching (JP8)

JP8 is a jumper for switching the inductor to the transmission power. JP8 is used when the inductor in the transmission power line is open, and is unused when the inductor is short-circuited. Note that JP8 is inside the enclosure that protects the primary circuitry. The cover is labeled with a JP8 inside the cover.

When using a CENELEC-A band, using an inductor for the transmit output improves the transmit output (several dB) in a low-load-impedance state. This inductor also has an adjusting function to satisfy the impedance standards of EN50065-7. On the other hand, in FCC band, using an inductor for the transmit output can cause band degradation,

which can reduce the transmit output by more than 10dB under low-load-impedance conditions. See Configuring Table 3-3.

Table 3-3 JP(JP8) setting for inductor switching3

Inductor setting	JP8 Setting	Setting conditions
Use	Open	Set when CENELEC-A band
Not used	Short	Set when FCC or Global (35 kHz-500 kHz) band

3.1.5 JP (JP21) for switching external reset function via USB

JP21 is JP for switching the external reset function via USB. When using the RTS signal via USB as an external reset, set JP21 to short-circuit.

3.1.6 Serial communication selector switch (SW6)

SW6 is used to select the MCU (RX651) or CPX4 for the serial port to be connected to the USB connector (CN5). For more information, see section 3.1.12.

3.1.7 Switch for selecting enable/disable of MCU (RX651) (SW7)

The selection switch (SW7) enables/disables the control from the MCU (RX651) to CPX4. The setting of SW7 is shown in Table 3-4. When using CPX4 SimpleMAC GUI, disable the MCU (factory default).

Table 3-4 MCU(RX651) enable/disable setting (SW7)

MCUtatus	SW7 Setting	Function
MCU disabled (factory default)	KILL MCU	MCU (RX651) disabled CPX4 is controlled from PCs using CN5 USBs Resetting CPX4 is controlled by SW8.
MCU enabled	USE MCU	MCU (RX651) are enabled CPX4 is controlled from MCU (RX651) Resetting of CPX4 is controlled by the MCU (RX651).

3.1.8 Reset switch (SW8)

The reset switch (SW8) is a push switch for system reset. Press this button (SW8) to initialize CPX4 and MCU (RX651).

3.1.9 BOOT setting switch (SW9, SW10)

SW9 and SW10 are set to the selection switch of the BOOT method (UART/SROM/SPI). UART is a BOOT method using UART communication, the SPI is a BOOT method using SPI communication, and SROM is a BOOT method from SROM installed in the evaluation kit. The factory default is UART Boot. Table 3-5 shows the switching pattern of SWs.

Table 3-5 CPX4 Boot Settings

Boot method	Setting
UART (factory default)	Set SW9 (BOOT0) to H and SW10 (BOOT1) to H.
SROM	Set SW9 (BOOT0) to L and SW10 (BOOT1) to H.
SPI	Set SW9 (BOOT0) to H and SW10 (BOOT1) to L.

3.1.10 PLC-connector (CN3)

CN3 is a connector (AC inlet) for connecting to an AC line for communication. The AC-PLC board communicates via the PLC connector (CN3). Not used for power supply.

When connecting to an AC line, use an AC cable that complies with the laws, standards, and ratings of the usage environment.

3.1.11 Power connector (CN4)

The power connector (CN4) is used when supplying power from the outside, and the AC adapter is connected.

It is recommended that the compatible AC adapter has an outer diameter of φ5.5 mm, an inner diameter of φ2.1 mm, a center plus, and an output voltage of 15V or 12V and 1.2A or more.

The AC adapter is not included with this product. Please prepare an AC adapter that complies with the laws and regulations of the environment you use.

3.1.12 USB connector (CN5)

The USB connector (CN5) is used for serial communication with the MCU (RX651) or CPX4 serial port via the FTDI virtual serial port. CN5 connects this product to a PC via a USB cable. Switch the connection destination with SW6 . The SW6 settings are shown in Table 3-6.

When using the CPX4 SimpleMAC GUI, select the CPX4 serial port.

Please download the proper USB-to-Serial device driver from the following FTDI website.

http://www.ftdichip.com/Drivers/VCP.htm

Table 3-6 SW6 setting for serial communication switching

USB Serial Sets	Setting	connection destination
Communication with the serial port of CPX4 (factory setting)	CPX	CPX4
Communication with the serial port of RX651	MCU	MCU(RX651)

3.1.13 MCU board-connection connector (CN6, CN7)

Table 3-7 and Table 3-8 show the connection with the RX651 MCU board.

Table 3-7 CN6 connectors

Terminal number	Terminal name	Function
1	CPX_RESB	Connected to the P0 terminal of CPX4
2	GND	Connected to GND
3	RXD_MCU	Connected to UART-RX terminal of the MCU
4	GND	Connected to GND
5	TXD_MCU	Connected to UART-TX terminal of the MCU
6	GND	Connected to GND
7	$\overline{\text{RESOUT}}$	Reset signal to the MCU
8	GND	Connected to GND
9	3.3V	3.3V power supply to MCU board
10	3.3V	3.3V power supply to MCU board

Table 3-8 CN7 connectors

Terminal number	Terminal name	Function
1	UART_RXD	Connected to UART-RX/SPI SI terminal of CPX4
2	UART_TXD	Connected to UART-TX/SPI SO terminal of CPX4
3	S_SPI_SC	Connected to SPI CLK terminal of CPX4
4	SPI_SS	Connected to SPI SS terminal of CPX4
5	SPI_REQ	Connected to SPI REQ terminal of CPX4
6	S_CKOUT	Connected to CPX4 clock-out pin.
7	GND	Connected to GND
8	BOOT0	Connected to the BOOT0 terminal of CPX4
9	BOOT1	Connected to the BOOT1 terminal of CPX4
10	3.3V	3.3V power supply to MCU board

3.2 RX651 MCU Board

This section explains the interface specifications and SWs/JPs setting of RX651 MCU board.

3.2.1 Explanation of Connectors, SWs and JPs of RX651 MCU Boards

Figure 3-2 shows the arrangement of the connectors, SWs and JPs, and Table 3-9 shows the usage.

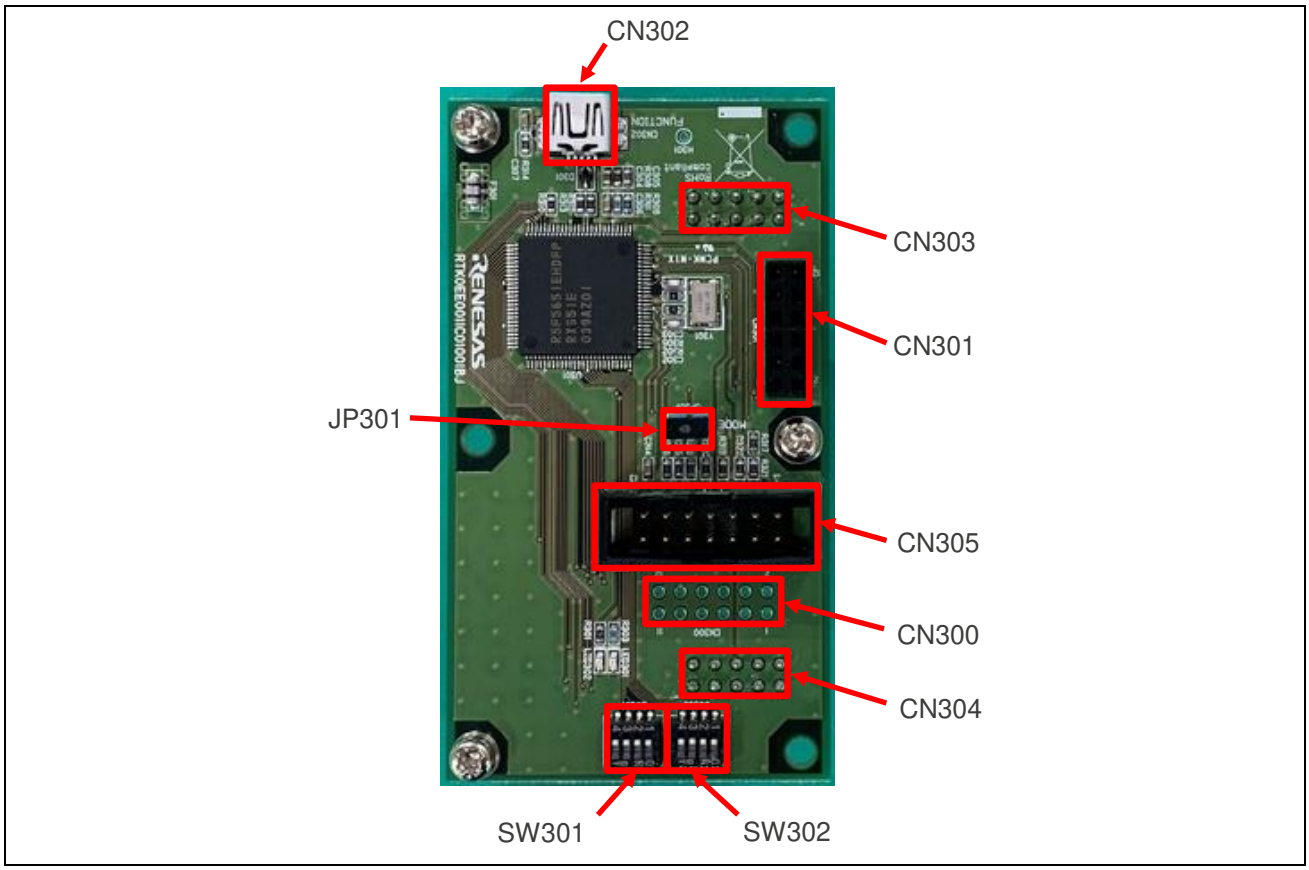

Figure 3-2 Connectors , SWs and JP of RX651 MCU board

Table 3-9 Usages of connectors, SWs and JP for RX651 MCU board

Connector, SW name	Use
SW301, SW302	General-purpose DIP SW for MCU
CN300, CN301	Connector for external expansion
CN302	USB connector
CN303, CN304	Connector for AC-PLC board connector
CN305	Connector for on-chip debugger
JP301	JP for On-chip debugger enable setting

3.2.2 LED (LED301, LED302)

LED301, LED302 are LEDs that can be used when developing applications for MCU (RX651).

3.2.3 MCU(RX651) General-purpose DIP-switch (SW301, SW302)

These are the DIP SWs (SW301, SW302) with the terminal connections of the MCU (RX651) shown in Table 3-19. SW301 and SW302 are SWs that can be used when developing applications for MCU (RX651). When the switch is on, the signal level of the MCU (RX651) is LOW, and when the switch is off, the signal level is HIGH.

(Since there is no pull-up resistor on the MCU board, enable the on-chip pull-up function of RX651.)

3.2.4 JP for program write setting (JP301)

For JP301, the setting varies depending on the program writing method. For details, see chapters 3.2.6 and 3.2.7.

3.2.5 AC-PLC board-connection connector (CN303/CN304)

Table 3-10 and Table 3-11 show the connection with the AC-PLC board.

Table 3-10 CN303 connectors

Terminal number	Terminal name	Function
1	CPX_RESB	Connected to RX651 - P54
2	GND	Connected to GND
3	RXD_MCU	Connected to RX651 - P21/RXD0
4	GND	Connected to GND
5	TXD_MCU	Connected to RX651 - P20/TXD0
6	GND	Connected to GND
7	$\overline{\text{RESOUT}}$	Connected to RX651 - RES#
8	GND	Connected to GND
9	3.3V	3.3V power supply to MCU board
10	3.3V	3.3V power supply to MCU board

Table 3-11 CN304 connectors

Terminal number	Terminal name	Function
1	UART_RXD	Connected to RX651 - UB/PC7/TXD10
2	UART_TXD	Connected to RX651 - PC6/RXD10
3	S_SPI_SC	Connected to RX651 - PC5/SCK10
4	SPI_SS_C	Connected to RX651 - PC4/SS10
5	SPI_REQ	Connected to RX651 - PC1/IRQ12
6	S_CKOUT	Connected to RX651 - EXTAL/P36
7	GND	Connected to GND
8	BOOT0	Connected to RX651 - PC2/RXD5
9	BOOT1	Connected to RX651 - PC3/TXD5
10	3.3V	3.3V power supply to MCU board

3.2.6 OCD-connector (CN305)

The OCD connector (CN305) is a connector for connecting an emulator. When connecting to a development tool via an emulator, set the target power supply to operate with "user power supply", and supply line power or external power to the AC-PLC board.

Figure 3-3 shows the connection configuration with the emulator. Table 3-12 shows the terminal information of the OCD connector (CN305).

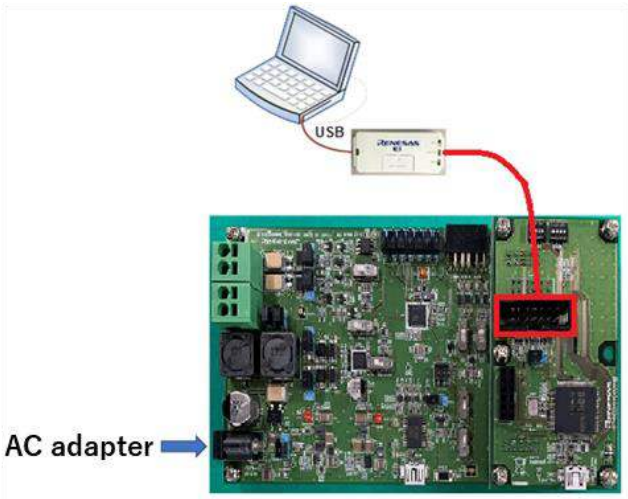

Figure 3-3 Connection configuration with the emulator

Table 3-12 OCD connectors (CN305)

Terminal number	Terminal name	Function
1	TCK	RX651-TCK
2	GND	GND
3	TRST#	RX651-TRST#
4	EMLE	RX651-EMLE
5	TDO	RX651-TDO
6	NC	Open (not connected)
7	MD	RX651-MD
8	VDD	3.3V
9	TMS	RX651-TMS
10	UB	RX651-PC7
11	TDI	RX651-TDI
12	GND	GND
13	RES#	RX651-RES#
14	GND	GND

When writing/erasing programs to the MCU(RX651) via the emulator using the development tool, make the settings shown in Table 3-13. (See the documentation for your emulator for more information.)

Table 3-13 Setting of Firmware update mode

Switch/JP	Setting	Function
JP301	Open	On-chip emulator enable setting
SW7	USE MCU	MCU(RX651) operation mode

3.2.7 USB connector (CN302)

The USB connector (CN302) can be used as a USB function. (Refer to the RX651 user manual for details.)
Table 3-14 shows the USB connector connection.

Table 3-14 CN302 connectors

Terminal number	Terminal name	Function
1	VBUS	Connected to RX651-P16/USB0_BUS
2	D-	Connected to RX651-USB0_DM
3	D+	Connected to RX651-USB0_DP
4	ID	NC
5	GND	Connected to GND

When using the flash programming tool to write/erase programs from CN302 to the MCU in UART boot mode, make the settings shown in Table 3-15. (For details, refer to the manual of the emulator to be used.)

Table 3-15 Settings of USB boot mode

Switch/JP	Setting	Function
JP301	Short circuit	Set the MD pin to low.
SW7	USE MCU	MCU(RX651) Operation mode

3.2.8 Connectors for expansion terminals (CN300/CN301)

Table 3-16 and Table 3-17 show the expansion terminals connected to CN300 / CN301.

Table 3-16 CN300 connectors

Terminal number	Terminal name	Function
1	PC0_MCU	Connected to RX651-PC0
2	PB4_MCU	Connected to RX651-PB4
3	PB3_MCU	Connected to RX651-PB3
4	SPI_SMOSI_MCU	Connected to RX651-PB7
5	PB2_MCU	Connected to RX651-PB2
6	SPI_SMISO_MCU	Connected to RX651-PB6
7	PB1_MCU	Connected to RX651-PB1
8	SPI_SCK_MCU	Connected to RX651-PB5
9	GND_RX	Connected to GND
10	GND_RX	Connected to GND
11	3.3VX	3.3V power supply for external power supply
12	3.3VX	3.3V power supply for external power supply

Table 3-17 CN301 connectors

Terminal number	Terminal name	Function
1	GND_RX	Connected to GND
2	PD7_MCU	Connected to RX651-PD7
3	PD6_MCU	Connected to RX651-PD6
4	PD5_MCU	Connected to RX651-PD5
5	PD4_MCU	Connected to RX651-PD4
6	PD3_MCU	Connected to RX651-PD3
7	GND_RX	Connected to GND
8	PD2_MCU	Connected to RX651-PD2
9	PE7_MCU	Connected to RX651-PE7
10	PE6_MCU	Connected to RX651-PE6
11	PD0_MCU	Connected to RX651-PD0
12	3.3VX	3.3V power supply for external power supply

3.2.9 Control MCU(RX651)

RX651 MCU board is equipped with RX651 as MCU for control. Table 3-18 and Table 3-19 show the connection information of the control MCU terminals.

For unused terminals of the MCU connected to CPX4, set them to the input port. Also, set other unused terminals to the input ports and enable the built-in pull-up function.

Table 3-18 RX651 MCU terminal connection 1/2

Terminal number	Terminal name MCU(RX651) side		Connection destination	Remark (Recommended setting when not in use)
1	AVCC1	-	3.3V	-
2	EMLE	-	CN305-4	-
3	AVSS1	-	GND	-
4	PJ3	I	-	If it is not used, set it to the input port and enable the on-chip pull-up.
5	VCL	-	Stabilization capacity (0.22uF)	-
6	VBATT	-	3.3V	-
7	MD/FINED		C305-7 / JP301-1	-
8	XCIN		Pull-down resistor	-
9	XCOUT		-	-
10	RES#		CN305-13 and CN303-7	-
11	XTAL/P37		24 MHz crystal	-
12	VSS	-	GND	-
13	EXTAL/P36	-	24 MHz crystal	-
14	VCC	-	3.3V	-
15	P35/NMI	I	Pull-down resistor	Input port when not used
16	TRST#/P34	I	CN305-3	Input port when not used
17	P33	I	-	Built-in pull-up when not in use
18	P32	I	-	Built-in pull-up when not in use
19	TMS/P31	I	CN305-9	Input port when not used
20	TDI/P30	I	CN305-11	Input port when not used
21	TCK/P27	I	CN305-1	Input port when not used
22	TDO/P26	I	CN305-5	Input port when not used
23	P25	I	-	Built-in pull-up when not in use
24	P24	O	LED302	Built-in pull-up when not in use
25	P23	O	LED301	Built-in pull-up when not in use
26	P22	I	-	Built-in pull-up when not in use
27	P21/RXD0	I	CN303-3	Built-in pull-up when not in use
28	P20/TXD0	O	CN303-5	Built-in pull-up when not in use
29	P17/SDA2	I/O	-	Input port when not used
30	P16/SCL2	O	CN302-1	Built-in pull-up when not in use
31	P15	I	-	Built-in pull-up when not in use
32	P14	O	-	Built-in pull-up when not in use
33	P13/SDA0	I/O	-	Input port when not used
34	P12/SCL0	O	-	Input port when not used
35	VCC_USB	-	3.3V	-
36	USB0_DM	I/O	CN302-2	-
37	USB0_DP	I/O	CN302-3	-
38	VSS_USB	-	GND	-
39	P55	I	-	Built-in pull-up when not in use
40	P54	I	CN6-1 / CN303-1 / SW7-1	Built-in pull-up when not in use
41	P53	I	-	Built-in pull-up when not in use
42	P52	I	-	Built-in pull-up when not in use
43	P51	I	-	Built-in pull-up when not in use
44	P50	I/O	-	Input port when not used
45	PC7/UB	I	CN304-1 / CN305-10	Input port when not used
46	PC6	I/O	CN304-2	Input port when not used
47	PC5	I/O	CN304-3	Input port when not used
48	PC4	I/O	CN304-4	Built-in pull-up when not in use
49	PC3	I/O	CN304-9	Built-in pull-up when not in use
50	PC2	I/O	CN304-8	Built-in pull-up when not in use

Table 3-19 RX651MCU terminal connection 2/2

Terminal number	Terminal name MCU(RX651) side		Connection destination	Remark (Recommended setting when not in use)
51	PC1	I/O	CN304-5	Built-in pull-up when not in use
52	PC0	O	CN300-1	Output HIGH when not in use
53	PB7	O	CN300-4	Input port when not used
54	PB6/	I/O	CN300-6	Input port when not used
55	PB5	I	CN300-8	Built-in pull-up when not in use
56	PB4	I	CN300-2	Built-in pull-up when not in use
57	PB3	I	CN300-3	Built-in pull-up when not in use
58	PB2	I/O	CN300-5	Built-in pull-up when not in use
59	PB1	I/O	CN300-7	Built-in pull-up when not in use
60	VCC	-	3.3V	-
61	PB0	I/O	-	Built-in pull-up when not in use
62	VSS	-	GND	-
63	PA7	I/O	-	Input port when not used
64	PA6	I/O	-	Input port when not used
65	PA5	O	-	Input port when not used
66	PA4	I/O	RX651-70	Input port when not used
67	PA3	I/O	-	Built-in pull-up when not in use
68	PA2	I	-	Built-in pull-up when not in use
69	PA1	O	-	Built-in pull-up when not in use
70	PA0	I	RX651-66	Built-in pull-up when not in use
71	PE7	I	CN301-9	Built-in pull-up when not in use
72	PE6	I	CN301-10	Built-in pull-up when not in use
73	PE5	I	-	Built-in pull-up when not in use
74	PE4	I	-	Built-in pull-up when not in use
75	PE3	I	-	Built-in pull-up when not in use
76	PE2	I	-	Built-in pull-up when not in use
77	PE1	I	-	Built-in pull-up when not in use
78	PE0	I	-	Built-in pull-up when not in use
79	PD7	I	CN301-2	Built-in pull-up when not in use
80	PD6	I	CN301-3	Built-in pull-up when not in use
81	PD5	I/O	CN301-4	Built-in pull-up when not in use
82	PD4	I	CN301-5	Built-in pull-up when not in use
83	PD3/IRQ3	I/O	CN301-6	Built-in pull-up when not in use
84	PD2	I/O	CN301-8	Built-in pull-up when not in use
85	PD1	I/O	-	Built-in pull-up when not in use
86	PD0	I/O	CN301-11	Built-in pull-up when not in use
87	P47	I	SW301-4	Built-in pull-up when not in use
88	P46	I	SW301-3	Built-in pull-up when not in use
89	P45	I	SW301-2	Built-in pull-up when not in use
90	P44	I	SW301-1	Built-in pull-up when not in use
91	P43	I	SW302-4	Built-in pull-up when not in use
92	P42	I	SW302-3	Built-in pull-up when not in use
93	P41	I	SW302-2	Built-in pull-up when not in use
94	VREFL0	-	GND	-
95	P40	I	SW302-1	Built-in pull-up when not in use
96	VREFH0	-	3.3V	-
97	AVCC0	-	3.3V	-
98	P07	I	-	Built-in pull-up when not in use
99	AVSS0	-	GND	
100	P05	I	-	Built-in pull-up when not in use

3.3 Filter Board

This section describes the interface specifications and JP sets of the Filter board for RX-BPF.

3.3.1 Explanation of Connectors and JP of Filter Board

Figure 3-4 is the placement of connectors and JP, and the applications are shown in Table 3-20.

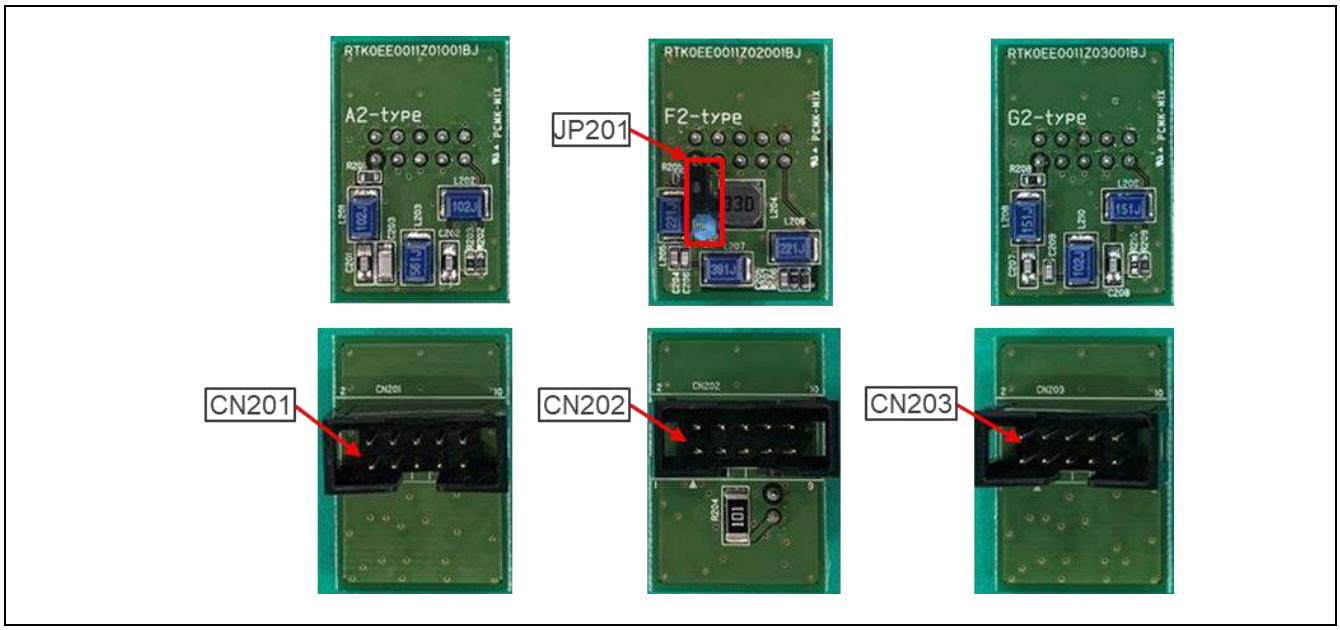

Figure 3-4 Connectors and JP for Filter Board

Table 3-20 Usages of Connectors and JP for Filter Board

Connector, JP name	Use
JP201	Selects whether to insert a low-pass noise suppressing filter (20kHz or less) on F2-type filter board. Short if used. Open if not used (factory default)
CN201	AC-PLC board-connection connector for A2-type Filter board
CN202	AC-PLC board-connection connector for F2-type Filter board
CN203	AC-PLC board-connection connector for G2-type Filter board

3.3.2 Filter setting for low-pass noise suppression JP (JP201)

JP201 is for selecting whether or not to insert a low-pass noise suppressing filter (20kHz or less) on F2-type filter board. Set it to short if it is used, and open if it is unused. The factory default is open.

3.3.3 AC-PLC board connector for A2-type (CN201)

CN201 is a connector that connects A2-type filter board to AC-PLC board.

3.3.4 AC-PLC board connector for F2-type (CN202)

CN202 is a connector that connects F2-type filter board to AC-PLC board.

3.3.5 AC-PLC board connector for G2-type (CN203)

CN203 is a connector that connects G2-type filter board to AC-PLC board.

3.4 PMOD conversion board

This section describes the PMOD conversion board. The PMOD1 connector (connector for Digilent Pmod ™ interface) on the AC-PLC board must be a male connector because it is a peripheral module board.

However, the PMOD1 connector is a female connector to avoid risks such as injury and electrostatic damage due to protrusions. Therefore, in order to use the AC-PLC board as a peripheral module board of Pmod ™, it is converted from female to male by the PMOD conversion board.

When connecting the PMOD conversion board to the PMOD1 connector, the orientation of the PMOD conversion board can be either PMOD2 side or PMOD3 side. Connect so that Pin 1 dot is on the upper left.

Figure 3-5 shows the PMOD conversion board.

Figure 3-5 PMOD conversion board

Revision history	CPX4 AC-PLC Evaluation Kit M02D2 RTK0EE0009D02001BJ User's Manual

Rev.	Date	Description	
		Page	Summary
1.00	July 01, 2021	—	First edition Issued

CPX4 AC-PLC Evaluation Kit M02D2 RTK0EE0009D02001BJ
User's Manual

Publication Date: Rev.1.00 July 01, 2021

Published by: Renesas Electronics Corporation

CPX4 AC-PLC Evaluation Kit M02D2 RTK0EE0009D02001BJ

Renesas Electronics Corporation

R30UZ0165EJ0100