

# DC-Power Line Communication (PLC) Evaluation Kit

## User's Guide

### Description

The JP167-PLCDCPOCKITZ kit enables quick prototyping and demonstration of an LED lighting system controlled over the DC power lines. PLC makes it possible to transmit control signals over power lines, thereby reducing the amount of wiring needed in the system and correspondingly lowering the associated costs and installation time. The Renesas PLC solution provides flexible protocol and frequency band control for varying countries thanks to its CPU + DSP dual core and allows long-distance communication of over 1km without a relay. Communication speeds up to 1Mbps are supported, and the AES128 cryptographic hardware engine provides high-level security if needed.

### Kit Contents

- DC-PLC Board x3
- Application Board x3
- Filer Board
- LED Illumination Bar x2
- AC Adaptor
- DC Jack Female Cables x4
- DC Plug Male Cable
- DC Divider Cable

### Features

- Superior robustness and long-distance communication over 1km, with speeds up to 1Mbps
- PLC communication reduces costs by saving wiring or other physical deployment
- Small module reference design (30 x 40mm) for easy integration into developing systems
- Users can add on sensors or control via PMOD for additional PLC applications

### Evaluation Kit

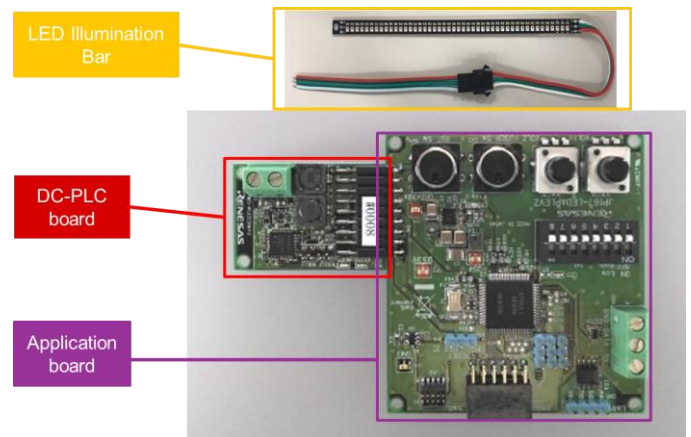


Figure 1. Evaluation Kit

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## 1. Overview

This is the user guide for Renesas JP167-PLCDCPOCKITZ DC-PLC evaluation kit (herein after called DC-PLC kit). The DC-PLC kit supports evaluation and development of Power Line Communication modules using the Renesas PLC modem IC: R9A06G061GNP.

The DC-PLC kit consists of the boards shown in Table 1.

**Table 1 DC-PLC kit configuration**

Board name	Part number	Description
DC-PLC board	<ul style="list-style-type: none"> <li>JP167-PLCDCREFZ</li> </ul>	<ul style="list-style-type: none"> <li>DC-PLC module board using R9A06G061GNP</li> <li>Connects to DC power lines for power supply and communication</li> </ul>
App board	<ul style="list-style-type: none"> <li>JP167-LEDAPLEVZ</li> </ul>	<ul style="list-style-type: none"> <li>Application board to demonstrate LED control via PLC using DC-PLC board</li> </ul>
Filter board	<ul style="list-style-type: none"> <li>RTG0EE0007Z07001BJ</li> </ul>	<ul style="list-style-type: none"> <li>Board for noise rejection and impedance improvement of power supply line</li> </ul>

### 1.1 PLC modem IC: R9A06G061GNP

R9A06G061 is a narrow-band power line communication modem IC that consists of an analog front-end (AFE), digital signal processing (DSP), and a microcontroller (MCU).

The high-performance DSP performs OFDM modulation and demodulation of the plc signal processing (PHY layer), and the MCU handles protocol conversion to/from the host interface.

R9A06G061 enables high-speed and stable long-distance communication for P2P (Peer to Peer) networks. In particular, the R9A06G061 improves the direct drive capability in order to expand to DC power supply system applications.

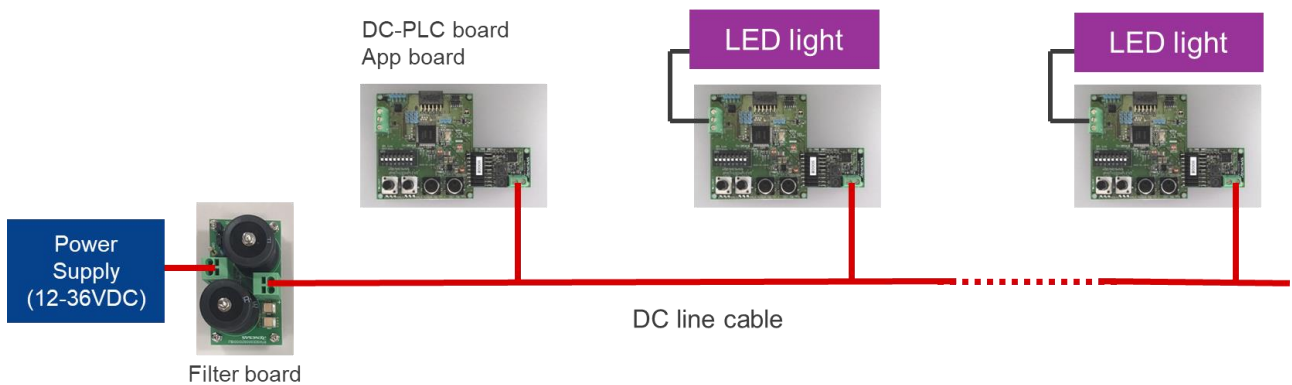
## 2. PLC demonstration: LED control via power line

The DC-PLC kit is shipped with the demo S/W written to control LED lights. The user can demonstrate LED control via power line immediately. Items needed for the demonstration are listed in Table 2.

Figure 2 shows an image of the LED control demonstration configuration.

**Table 2 LED demonstration item list**

Item	Quantity	Notes
DC-PLC board	2-5	Demonstration is possible with a minimum of 2 units. 3 or more units are required to control multiple LEDs.
App board	2-5	
Filter board	1	
LED light	1-4	Refer to Table 4 for LED light specification details
DC power supply	1	Capable of outputting 12V-36V DC
DC line cable	-	



**Figure 2 LED light control demonstration configuration**

### 2.1 Demonstration Procedure

Refer to the separate documentation “DC-PLC Evaluation kit Startup Guide (r12qs0055ej0100-cpx4.pdf)” for more information on setting up and demonstrating the kit.

### 3. H/W overview

#### 3.1 Specification

The DC-PLC kit specifications are shown in Table 3.

**Table 3 DC-PLC kit specification table**

Specification	
Input voltage	12-36V DC
Operating temperature	0 to 40°C guaranteed

LED light specifications for LEDs that can be connected to App board are shown in Table 4.

**Table 4 LED light specification table**

Specification	
Input voltage	5V DC
Rated power	5W max
LED control protocol	WS2812-2020
Operation-confirmed product	Mini NeoPixel LightBar

### 3.2 DC-PLC board details

#### 3.2.1 Block diagram

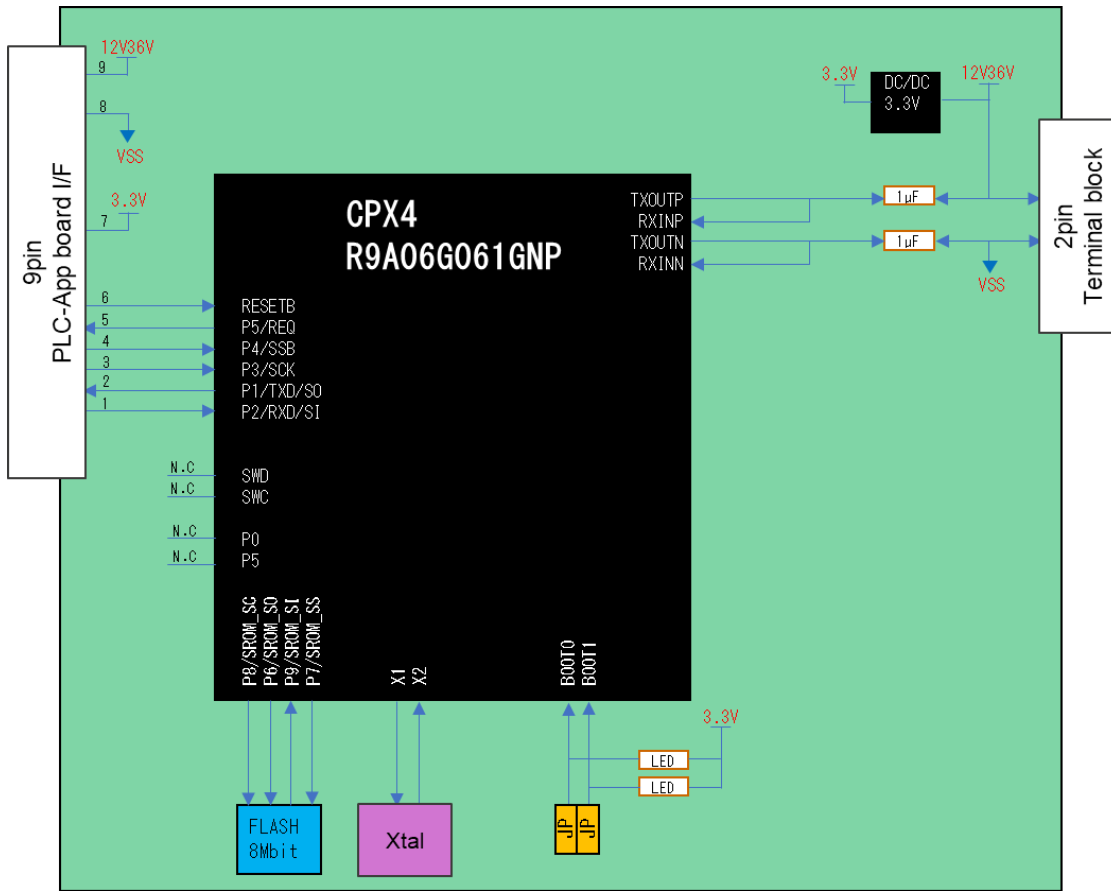


Figure 3 DC-PLC board block diagram

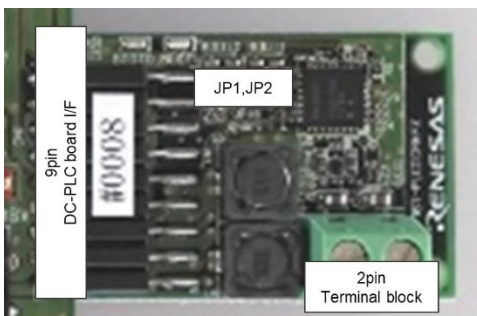


Figure 4 DC-PLC board overview

### 3.2.2 Interface

**Table 5 DC-PLC board interface**

Interface	Pin	Signal name	Direction	Description
2pin terminal block	1	12V36V	In	Power from DC line
	2	VSS	In	
9pin PLC-App board interface	1	P2/RXD/SI	In	Communication to App board
	2	P1/TXD/SO	Out	
	3	P3/SCK	In	
	4	P4/SSB	In	
	5	P5/REQ	Out	
	6	RESETB	In	RESET from App board
	7	3.3V	Out	Power to App board
	8	VSS	Out	
	9	12V36V	Out	

**Table 6 DC-PLC board jumper**

Interface	Default	Description
JP1	Open	R9A06G061GNP boot settings <ul style="list-style-type: none"> <li>• UART boot: JP1=Open JP2=Open</li> <li>• SPI boot: JP1=Short JP2=Open</li> <li>• SROM boot: JP1=Open JP2=Short</li> </ul>
JP2	Short	

### 3.3 App board details

#### 3.3.1 Block diagram

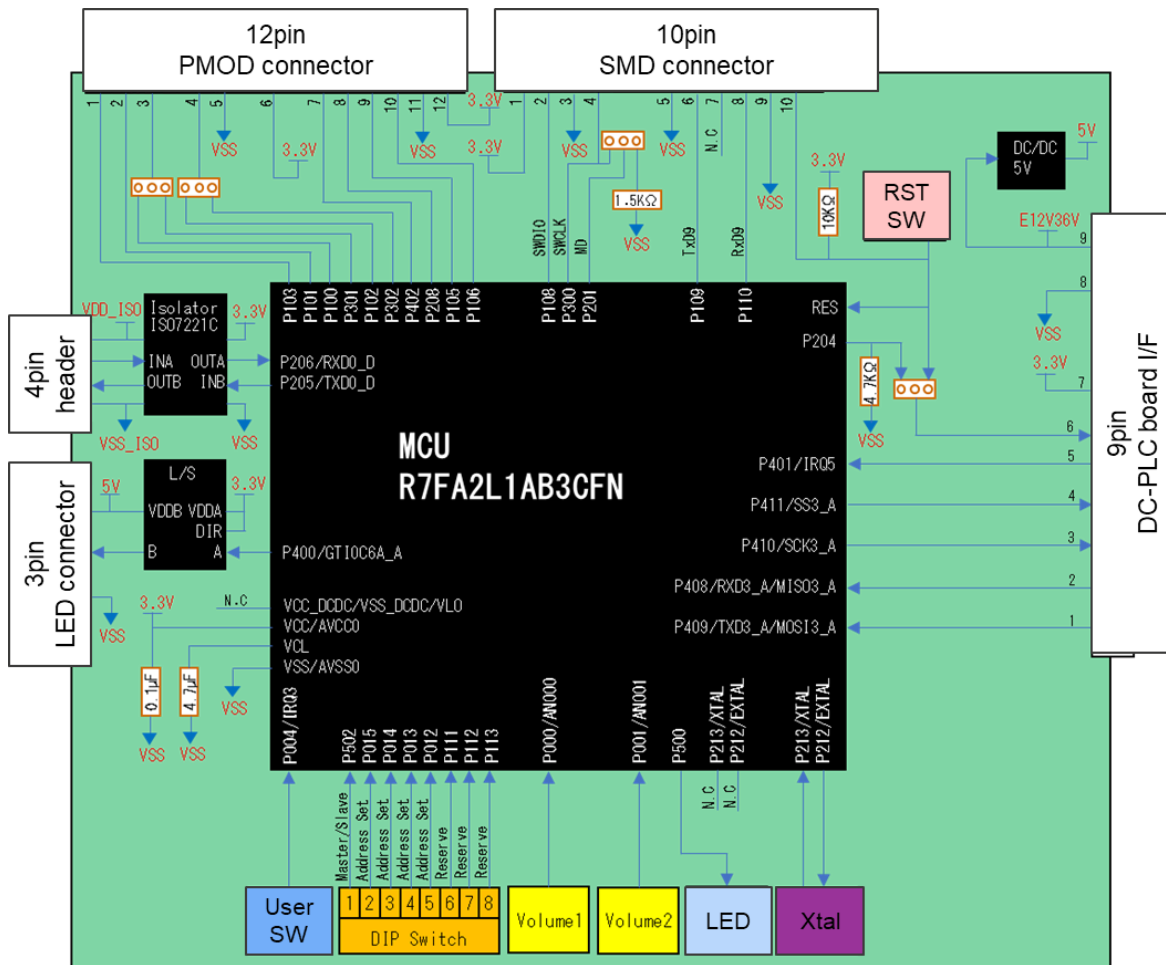


Figure 5 App board block diagram

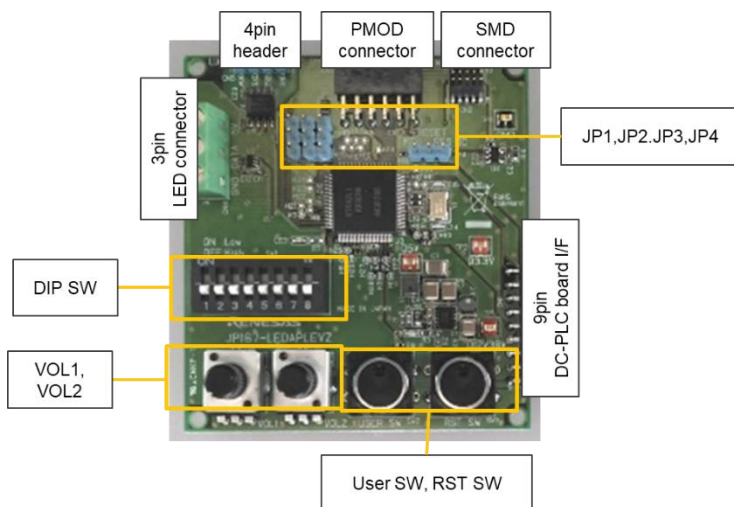


Figure 6 App board overview



### 3.3.2 Interface

**Table 7 App board interface**

Interface	Pin	Signal name	Direction	Description
9pin PLC-App board interface	1	P409/TXD3_A	Out	Communication to DC-PLC board
	2	P408/RXD3_A	In	
	3	P410/SCK3_A	Out	
	4	P411/SS3_A	Out	
	5	P401/IRQ5	In	
	6	RESETB	Out	RESET to DC-PLC board
	7	3.3V	In	Power from DC-PLC board
	8	VSS	In	
	9	12V36V	In	
3pin LED connector	1	+5V	Out	Communication to LED light
	2	DATA/P400	Out	
	3	VSS	Out	
4pin header	1	VDD/VDD_ISO	Out	UART interface with RA2L1
	2	P206/RXD0_D	In	
	3	P205/TXD0_D	Out	
	4	GND/VSS_ISO	Out	
12pin PMOD connector	1	SS/P103	-	PMOD interface with RA2L1
	2	MOSI/P101	-	
	3	MISO/*	-	
	4	SCK/*	-	
	5	GND/VSS	-	
	6	VCC/D3.3V	-	
	7	GPIO/INT/P402	-	
	8	GPIO/RESET/P208	-	
	9	GPIO/CS2/P105	-	
	10	GPIO/CS3/P106	-	
	11	GND/VSS	-	
	12	VCC/D3.3V	-	
10pin SWD connector	1	VCC/D3/3V	-	Debug interface for RA2L1
	2	SWDIO/P108	-	
	3	GND/VSS	-	
	4	SWCLK/MD/*	-	
	5	GND/VSS	-	
	6	TXD9/P109	-	
	7	N.C	-	
	8	RXD9/P110	-	
	9	GND/VSS	-	
	10	RESET MCU	-	

\* Refer to Table 8 for signal connection

**Table 8 App board jumper**

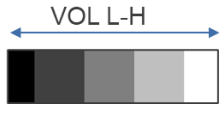
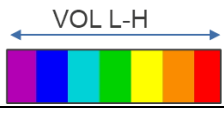

Interface	Default	Description
JP1	1-2 Short	1-2 Short: SWCLK/MD connects to P300, P201 2-3 Short: SWCLK/MD connects to P300
JP2	1-2 Short	1-2 Short: MISO connects to P100 2-3 Short: MISO connects to P301
JP3	1-2 Short	1-2 Short: SCK connects to P102 2-3 Short: SCK connects to P302
JP4	1-2 Short	1-2 Short: Reset by RA2L1 P204 2-3 Short: Reset by Reset IC

**Table 9 App board DIP Switch**

Interface	Signal name	Description	
DIPSW-1	P502	Application type	ON: Controller side OFF: Lighting side
DIPSW-2	P015	<ul style="list-style-type: none"> <li>● Controller side: Target address</li> <li>● Lighting side: Own address</li> </ul>	ON: Available OFF: Unavailable
DIPSW-3	P014		
DIPSW-4	P013		
DIPSW-5	P012		
DIPSW-6	P111	-	-
DIPSW-7	P112	-	-
DIPSW-8	P113	PLC mode	ON: Turbo mode OFF: Normal mode

Refer to section 3.3.3 for more details

**Table 10 App board Volume/Switch**

Interface	Signal name	Description	
VOL1	P100	LED brightness control	
VOL2	P101	LED color control	
User SW	P004	LED auto illumination SW	The target LED automatically changes color for a certain period. 
RST SW	P001	Reset SW	

### 3.3.3 DIP Switch setting details

#### 3.3.3.1 DIP SW1 (Application type)

Set SW1 to ON for the board controlling the LED lights (Controller side) and OFF for the board connected to the LED light (Lighting side).

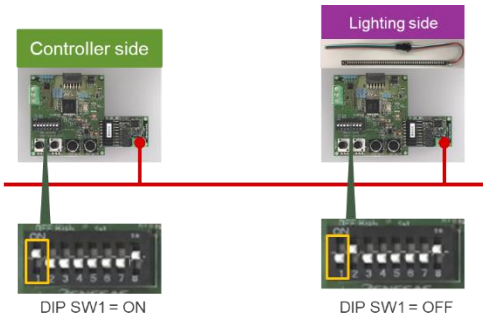


Figure 7 DIP SW1 setting

#### 3.3.3.2 DIP SW2-5 (Address)

DIP SW2-5 are the addresses that identify multiple LED lights as shown in Table 11 and Figure 8.

Table 11 DIP SW address

Interface	Address	Controller side	Lighting side
DIPSW-2	LED light #1	The address that is turned ON is controlled as the target. If several are turned on, they are controlled simultaneously	The address that is turned on sets this board's address.
DIPSW-3	LED light #2		
DIPSW-4	LED light #3		
DIPSW-5	LED light #4		

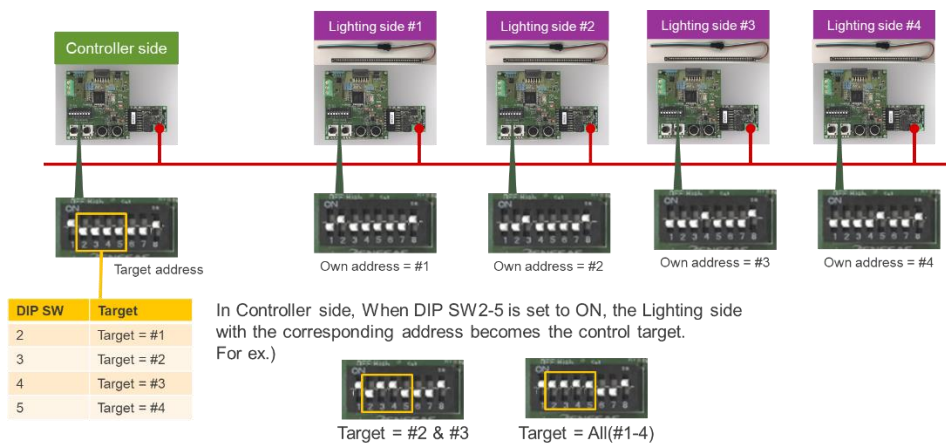


Figure 8 DIP SW2-4 setting

#### 3.3.3.3 DIP SW8 (PLC mode)

Turbo mode is a PLC mode that supports high-speed communication, while Normal mode is a more reliable PLC communication mode. If communication is not possible in Turbo mode, please select Normal mode.

## 4. S/W overview

### 4.1 S/W configuration

Figure 9 shows the DC-PLC kit S/W configuration. User Application S/W is implemented in the RA2L1 on the App board. PLC firmware is a binary file and cannot be modified by the user.

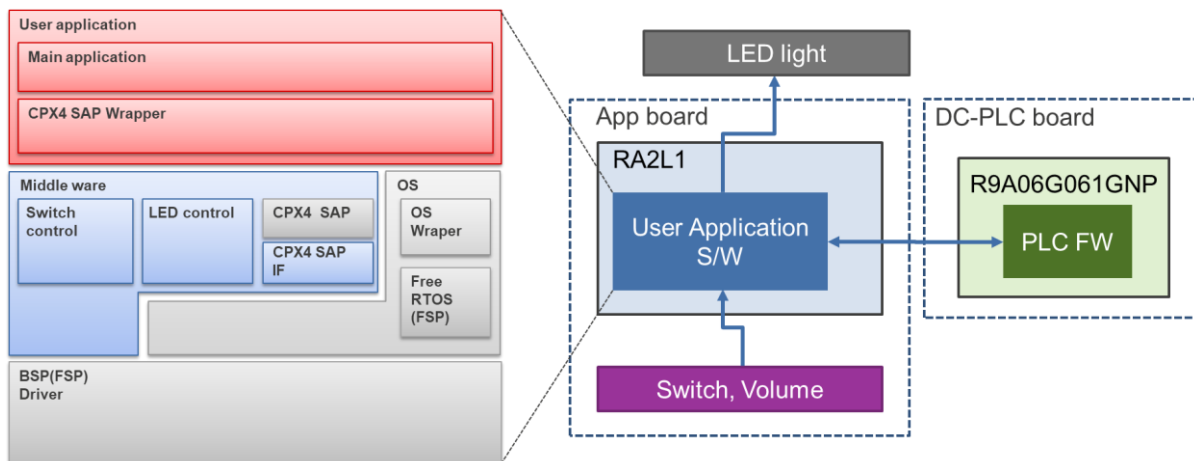


Figure 9 S/W configuration

### 4.2 User application S/W development environment

Table 12 User application S/W development environment

Item	Version	
IDE	e2studio	2021-07(21.7.0)
Toolchain	GCC ARM Embedded	10.3.1.20210621
Language	C	C99
Software package	FSP(Flexible Software Package)	3.1.0
	CPX4 SAP	-
	CPX4 FW	g3b_mac_cpx4_4band_dc_v0012_21102021
MCU	RA2L1	R7FA2L1AB3CFN

### 4.3 MCU terminal setting

Pin No	Pin	Function	Direction	Notes
1	P400	GTIOC6A_A	OUT	GTOCA (LED control PWM output)
2	P401	-	-	Reserved (for CPX4 SPI comm.)
3	P402	-	-	PMOD
4	P403	-	-	Not used
5	P406	-	-	Not used
6	P714	-	-	Not used
7	VCL	-	-	-
8	P215/XCIN	-	-	Not used
9	P214/XCOUT	-	-	Not used
10	VSS	-	-	-
11	P213/XTAL	XTAL	OUT	
12	P212/EXTAL	EXTAL	IN	
13	VCC	-	-	-
14	P708	-	-	Not used
15	P415	-	-	Not used
16	P411	-	-	Reserved (for CPX4 SPI comm.)
17	P410	-	-	Reserved (for CPX4 SPI comm.)
18	P409	TXD3_A	OUT	For CPX4 UART comm. Tx
19	P408	RXD3_A	IN	For CPX4 UART comm. Rx
20	P407	-	-	Not used
21	VSS_DCDC	-	-	Not used
22	VLO	-	-	Not used
23	VCC_DCDC	-	-	Not used
24	P208	-	-	PMOD
25	P207	-	-	Not used
26	P206	RxD0_D	IN	For external UART comm. Tx
27	P205	TxD0_D	OUT	For external UART comm. Rx
28	P204	P204	OUT	For CPX4 RESET control
29	RES	-	-	-
30	P201/MD	MD	IN	Debug interface

Pin No	Pin	Function	Direction	Notes
31	P200	-	-	Not used
32	P306	-	-	Not used
33	P305	-	-	Not used
34	P304	-	-	Not used
35	P808	-	-	Not used
36	P809	-	-	Not used
37	P303	-	-	Not used
38	P302	-	-	PMOD
39	P301	-	-	PMOD
40	P300/SWCLK	SWCLK	IN	Debug interface
41	P108/SWDIO	SWDIO	IN/OUT	Debug interface
42	P109	TxD9	OUT	Debug interface
43	P110	RxD9	IN	Debug interface
44	P111	P111	IN	DIP SW
45	P112	P112	IN	DIP SW
46	P113	P113	IN	DIP SW
47	P114	-	-	Not used
48	P115	-	-	Not used
49	VCC	-	-	-
50	VSS	-	-	-
51	P601	-	-	Not used
52	P600	-	-	Not used
53	P107	-	-	Not used
54	P106	-	-	PMOD
55	P105	-	-	PMOD
56	P104	-	-	Not used
57	P103	-	-	PMOD
58	P102	-	-	PMOD
59	P101	-	-	PMOD
60	P100	-	-	PMOD

Pin No	Pin	Function	Direction	Notes
61	P500	P500	OUT	Operation check LE (Lo active)
62	P501	-	-	Not used
63	P502	P502	IN	DIP SW
64	P503	-	-	Not used
65	P504	-	-	Not used
66	P015	P015	IN	DIP SW
67	P014	P014	IN	DIP SW
68	P013	P013	IN	DIP SW
69	P012	P012	IN	DIP SW
70	AVCC0	-	-	-
71	AVSS0	-	-	-
72	P011/VREFL0	-	-	Not used
73	P010/VREFH0	-	-	Not used
74	P006	-	-	Not used
75	P005	-	-	Not used
76	P004	P004/IR03	IN	PushSW
77	P003	-	-	Not used
78	P002	-	-	Not used
79	P001	AN001	IN	VolumeSW
80	P000	AN000	IN	VolumeSW

### 4.4 User application details

#### 4.4.1 Task

Table 13 User application task list

Task name	description
APP_MAIN	Application function processing task
APP_CB	Callback processing task
CPIF_TX	PLC Tx processing task
CPIF_RX	PLC Rx processing task

#### 4.4.2 Operating sequence (Controller side)

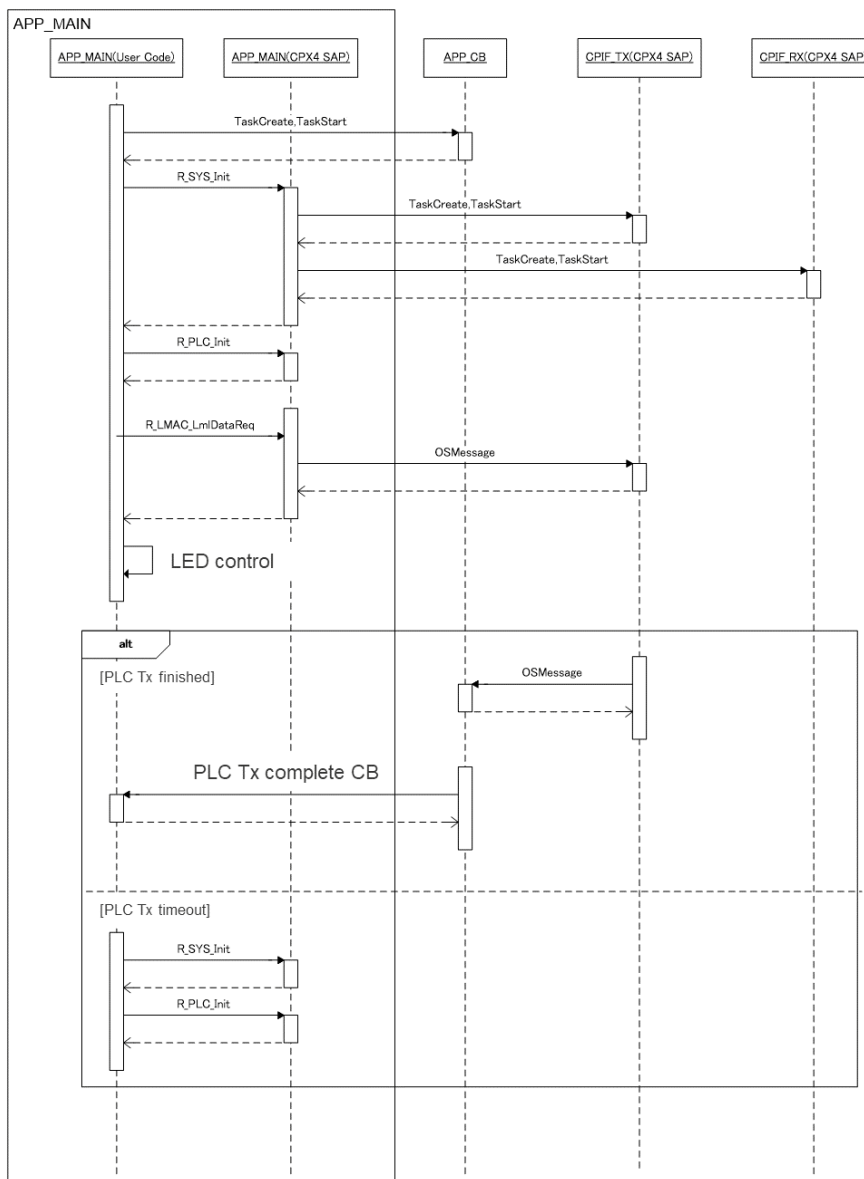


Figure 10 Operating sequence chart (Controller side)



### 4.4.3 Operating sequence (Lighting side)

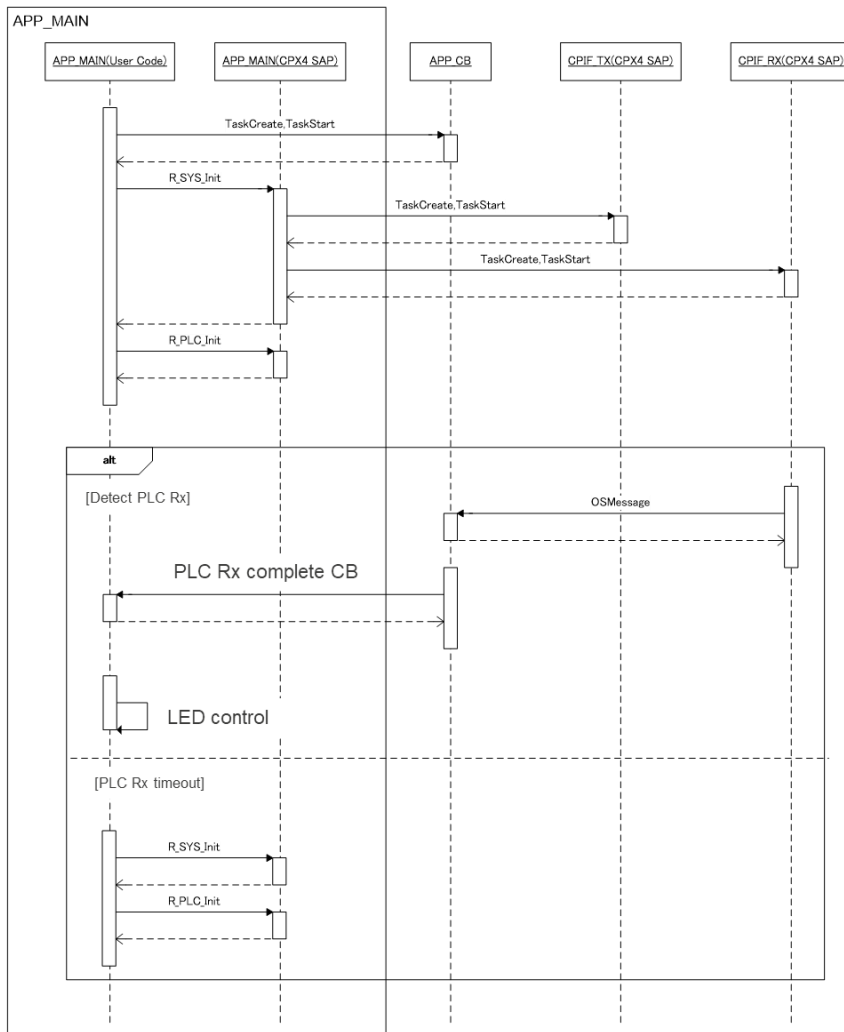


Figure 11 Operating sequence chart (Lighting side)

## 4.5 PLC setting

Table 14 PLC setting

Item	Setting
Band plan	FCC
Modulation	Turbo mode: 64QAM (Coherent) Normal mode: ROBO (Differential)
Payload	3bytes of data as follows: [1]: Target address [2]: LED brightness data [3]: LED color data

**Revision History**

Rev.	Date	Description	
		Page	Summary
1.00	Dec. 20, 2022	-	1 <sup>st</sup> edition
-			

## General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

The following usage notes are applicable to all Microprocessing 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 microprocessing 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.

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