RA2L2 Group

Monitoring of Environment Sensors with the EK-RA2L2 (Example of Porting from the USB Type-C Reference Design for RA2L2 MCUs)

Introduction

This application note describes the monitoring of environment sensors by using the EK-RA2L2 based on the sample code of the USB Type-C reference design for RA2L2 MCUs.

Assuming an application for monitoring environment sensors, this system supports USB communications with a PC, USB Type-C configuration channel (CC) detection used for judging USB-C connection, the monitoring of environment sensors (light sensor and temperature and humidity sensor), and the display of data on a Pmod OLED.

Main Features of the RA2L2 Used in This System

- Determination of the state of connection by using USB Type-C CC detection
- Intermittent operation for obtaining measurements by environment sensors (light sensor and temperature and humidity sensor) by using the RTC
- Control of saving sensing data in data flash memory
- Transmitting the data saved in data flash memory to the PC by CDC communications with the use of USB 2.0 Full-Speed communications
- Communications between the sensors and OLED device by using the I^3C or SPI
- Display of the USB status, display of the date and time, and realtime display of sensing data on an OLED
- Date and time setting by using the RTC and switches (connected as GPIO keys)

Devices and Hardware Used in Confirming Operation

Item	Product
Evaluation kit	Renesas EK-RA2L2 Mounted MCU: Renesas RA2L2 (R7FA2L2094CFM)
Temperature and humidity sensor Pmod board	Renesas QCIOT-HS4001POCZ Mounted sensor: Renesas HS4001*
Light sensor Pmod board	Renesas QCIOT-ISL76682POCZ Mounted sensor: Renesas ISL76682
Pmod OLED	Digilent Pmod OLED (410-222) Mounted controller: SSD1306

Software Used

- Integrated development environment: e^2 studio 2025-12
- C compiler: GCC Arm Embedded 13.2.1.arm-13-7
- FSP (Flexible Software Package): v6.3.0

Related Documents

- RA2L2 MCUs USB Type-C Reference Design User's Manual: R12UZ0203
- USB Type-C Reference Design for RA2L2 MCUs Application Note: R01AN7984
- RA2L2 Group User's Manual: Hardware: R01UH1080
- Evaluation Kit for RA2L2 Microcontroller Group EK-RA2L2 v1 User's Manual: R20UT5472
- QE for USB Usage Guide: R20AN0143

Related Links

- Web page for EK-RA2L2 Products
- Web page for RA2L2 Products
- Web page for USB Type-C Reference Design for RA2L2 MCUs
- Web page introducing QE for USB

Note: Renesas has announced the discontinuation of the HS4001. "MEMS Vision #MVH4001D" is the replacement.
PLC250010: End-of-Life (EOL) process for selected part numbers

Contents

1. Outline of This System and Functional Comparison with the USB Type-C Reference Design for RA2L2 MCUs

Based on the sample code of the USB Type-C reference design for RA2L2 MCUs, the RA2L2 MCU USB Type-C for the EK-RA2L2 (hereafter referred to as this system) provides the monitoring of results from environment sensors on a Pmod OLED. The environment sensors are a temperature and humidity sensor and a light sensor, which are also on Pmod boards connectable to the EK-RA2L2.

This chapter gives an outline of this system and the USB Type-C reference design for RA2L2 MCUs, which is the basis of this system. This chapter also provides a functional comparison with the USB Type-C reference design for RA2L2 MCUs.

1.1 Overview

This system uses the 48-MHz Arm Cortex-M23 entry-level USB-equipped RA2L2 general-purpose microcontroller that is mounted on the EK-RA2L2 evaluation kit.

In this system, the USB Type-C interface, which is an on-chip peripheral of the RA2L2, detects the orientation of an inserted USB-C plug and proceeds with USB Type-C CC detection. The USB 2.0 Full-Speed (hereafter referred to as FS) function transmits data from the light sensor and temperature and humidity sensor through USB communications with the PC. The EK-RA2L2 is equipped with Pmod connectors, and data are transmitted to and received from Pmod modules, specifically the light sensor and digital temperature and humidity sensor, and the OLED. The OLED screen displays the data from the sensors, the state of the USB-C connection, and the state of USB communications.

1.2 Features

- Utilizes the sample code of the USB Type-C reference design for RA2L2 MCUs to achieve demonstration operations matching the specifications of that system on the EK-RA2L2.
- Supports two types of demo use cases utilizing the main features of the RA2L2.
  - Two demo use cases: Connection to a charger and connection to a PC
  - USB Type-C CC detection and USB FS
- Supports the sensing demo for two types of environment sensors
  - Sensing by environment sensors (light sensor and temperature and humidity sensor)
  - Monitoring functions: Monitoring in a PC demo application and real-time display of the results of monitoring on a Pmod OLED

1.3 System Configuration

The EK-RA2L2, light sensor, temperature and humidity sensor, and Pmod OLED are used in this system. Figure 1-1 shows the system configuration.

For communications with the MCU (RA2L2), an I³C interface is used for the light sensor and temperature and humidity sensor and an SPI is used for the Pmod OLED.

Note that pins 5-6 on J40 and J41 of the EK-RA2L2 should be closed because the USB 2.0 Type-C function is to be used. For details, refer to section 2.4, USB Type-C CC Detection.

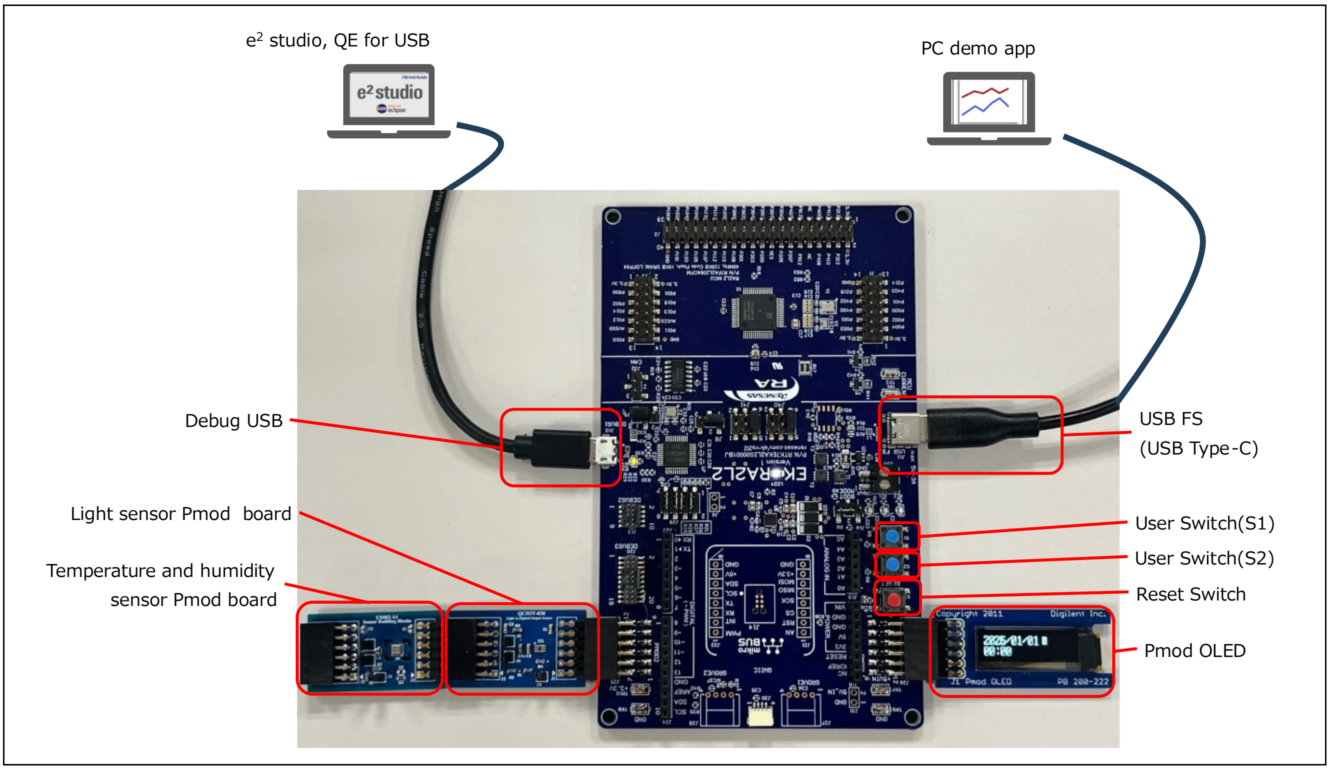


Figure 1-1 System Configuration

1.4 Outline of System Operations

1. When power*[1] is supplied, initialization of the system is started.
2. After initialization has finished, the demo title is displayed on the OLED screen for three seconds.
3. The system is placed in date and time setting mode, in which operations are as follows:
    - The date and time for setting appears on the OLED screen.
    - Press the S1 and S2 user switches to set the date and time.
4. After the date and time have been set, the system is placed in sensing demo mode, in which operations are as follows:
    - The temperature and humidity data are acquired from the temperature and humidity sensor and the illuminance data are acquired from the light sensor at 1-second intervals.
    - The acquired date and time, temperature and humidity, and illuminance data are displayed on the OLED screen.
    - The acquired date and time, temperature and humidity, and illuminance*[2] data are stored in data flash memory at 5-second intervals.
    - The display on the OLED screen (display of sensing data or USB connection state) can be switched by pressing the S1 user switch.
    - Making or breaking of the USB FS (USB Type-C) connection is detected, and notification of the state of the connection is displayed on the OLED screen for three seconds.

<Additional functions>

- When a PC is connected to the USB FS and the PC demo application is started
  The date and time, temperature and humidity, and illuminance*[2] data that were stored in data flash memory can be sent to the PC demo application and then graphically displayed on the PC screen.
- When the e^2 studio and QE for USB are started
  By using the USB VBUS monitor of QE for USB, the voltage and current values of the VBUS monitor can be graphically displayed in the e^2 studio.

Note 1. Power is supplied through the debug USB connector.

Note 2. For the illuminance data, the maximum, minimum, and average values within each five-second interval are stored in data flash memory.

1.5 System Block Diagram

Figure 1-2 shows a system block diagram of the board used in this system. Figure 1-3 shows the configuration of connection between the EK-RA2L2 and Pmod boards.

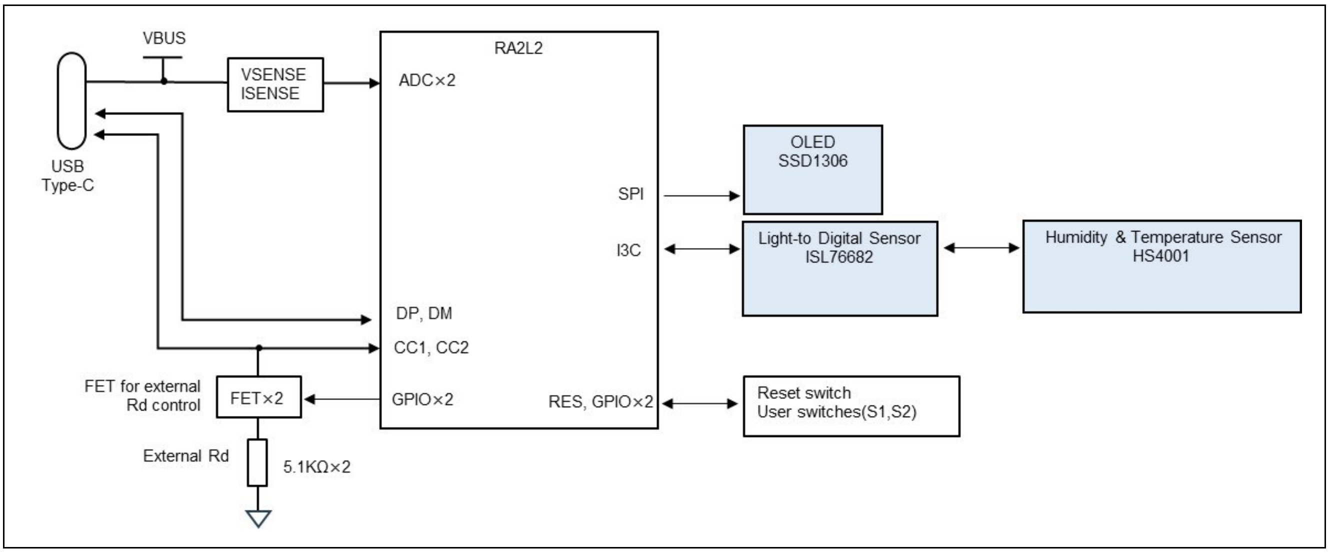


Figure 1-2 System Block Diagram

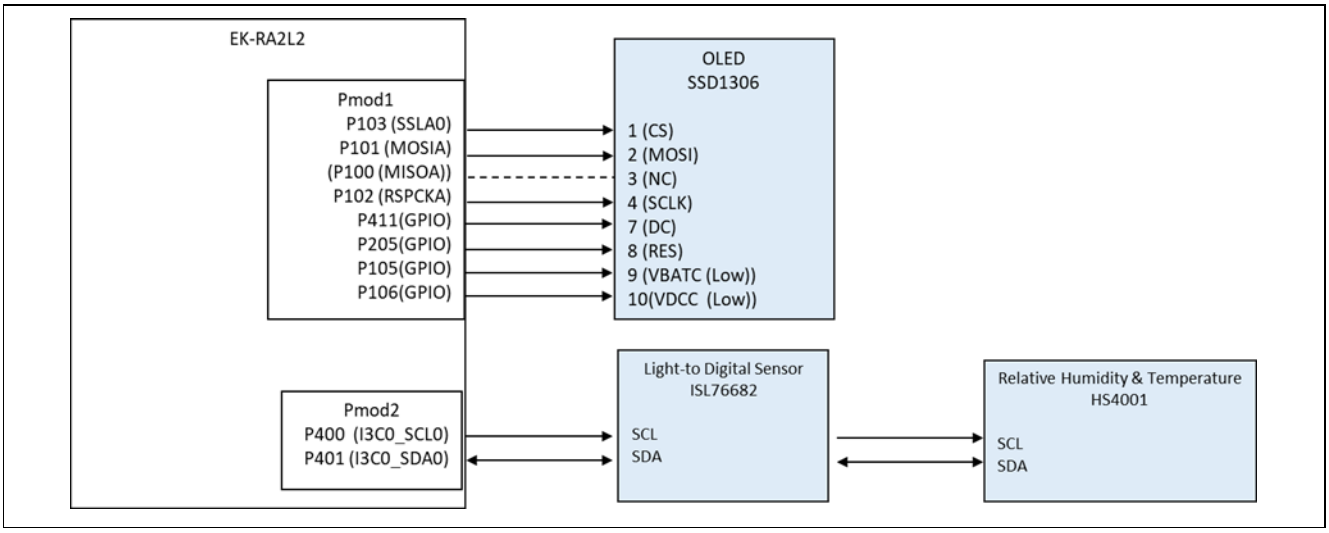


Figure 1-3 Configuration of Connection between the EK-RA2L2 and Each Pmod Board

1.6 Outline of Hardware Specifications

Table 1-1 lists the hardware specifications of this system in outline.

Table 1-1 Outline of Hardware Specifications

Item	Specifications
Board part number	RTK7EKA2L2S00001BJ
MCU	RA2L2: R7FA2L2094CFM (Code flash memory: 128 Kbytes, RAM: 16 Kbytes, Data flash memory: 4 Kbytes, PKG: 64-pin LQFP)
Clocks	High-speed on-chip oscillator (48-MHz operation): System clock and peripheral module clocks 32.768-kHz crystal resonator: RTC clock
Switches	User switches (S1 and S2) and reset switch
Sensors	Temperature and humidity sensor Pmod board (Renesas: QCIOT-HS4001POCZ) × 1* Light sensor Pmod board (Renesas: QCIOT-ISL76682POCZ) × 1
Display	128 × 32-pixel graphic OLED display (Digilent: Pmod OLED (410-222))

Note: Renesas has announced the discontinuation of the HS4001. “MEMS Vision #MVH4001D” is the replacement.

1.7 List of MCU Pin Assignments and Pin Settings

Table 1-2 lists the MCU pin assignments and pin settings of this system.

Table 1-2 MCU Pin Assignments and Pin Settings

Pin No.	Pin Name	Signal	Pin Setting Mode	Internal Pull-Up/Pull-Down Setting	Active Level	Function
1	P400	I3C0_SCL0	Peripheral mode	None	—	PMOD2_SCL
2	P401	I3C0_SDA0	Peripheral mode	None	—	PMOD2_SDA
3	P402	—	Disabled	—	—	—
4	P403	GPIO	Input mode	None	—	PMOD2_RESET
5	VCL	—	—	—	—	4.7-µF capacitor
6	P215	—	Disabled	—	—	—
7	P214	—	Disabled	—	—	—
8	VSS	—	—	—	—	VSS
9	P213	—	Disabled	—	—	—
10	P212	—	Disabled	—	—	—
11	VCC	—	—	—	—	VCC
12	P411	GPIO	Output mode (initial low output)	None	—	OLED_DC
13	P410	—	Disabled	—	—	—
14	P409	—	Disabled	—	—	—
15	P408	—	Disabled	—	—	—
16	USB_DM	USB_DM	—	—	—	USB communications
17	USB_DP	USB_DP	—	—	—	USB communications
18	P913	USB_CC1	Analog mode	None	—	USB Type-C CC detection (CC1)
19	P912	USB_CC2	Analog mode	None	—	USB Type-C CC detection (CC2)
20	P407	USB_VBUS	Peripheral mode	None	—	VBUS detection
21	P207	—	Disabled	—	—	—
22	P206	GPIO	Input mode	None	—	PMOD2_INT
23	P205	GPIO	Output mode (initial low output)	None	—	OLED_RES
24	P204	—	Disabled	—	—	—
25	RES	—	—	—	—	Reset switch
26	P201	—	Disabled	—	—	—
27	P200	—	Disabled	—	—	—
28	P304	—	Disabled	—	—	—
29	P303	—	Disabled	—	—	—
30	P302	—	Disabled	—	—	—
31	P301	—	Disabled	—	—	—
32	P300	—	Disabled	—	—	—
33	P108	—	Disabled	—	—	—
34	P109	GPIO	Output mode (initial low output)	None	Low	External Rd control for CC1
35	P110	GPIO	Output mode (initial low output)	None	Low	External Rd control for CC2
36	P111	—	Disabled	—	—	—
37	P112	—	Disabled	—	—	—
38	P113	—	Disabled	—	—	—
39	VCC	—	—	—	—	VCC

40	VSS	—	—	—	—	VSS
41	P107	—	Disabled	—	—	—
42	P106	GPIO	Output mode (initial low output)	None	—	OLED_VDCC
43	P105	GPIO	Output mode (initial low output)	None	—	OLED_VBATC
44	P104	—	Disabled	—	—	—
45	P103	GPIO	Output mode (initial low output)	None	—	OLED_CS
46	P102	SCI0_SCK0	Peripheral mode	None	—	OLED_SCLK
47	P101	SCI0_TXD0	Peripheral mode	None	—	OLED_MOSI
48	P100	SCI0_RXD0	Peripheral mode	None	—	OLED_NC
49	P500	—	Disabled	—	—	—
50	P501	—	Disabled	—	—	—
51	P502	—	Disabled	—	—	—
52	P015	GPIO	Input mode	None	Low	S2 user switch
53	P014	—	Disabled	—	—	—
54	P013	ADC0_AN008	Analog mode	None	—	VBUS monitoring - ISENSE
55	P012	ADC0_AN007	Analog mode	None	—	VBUS monitoring - VSENSE
56	AVCC0	—	—	—	—	VCC
57	AVSS0	—	—	—	—	VSS
58	P011	—	Disabled	—	—	—
59	P010	—	Disabled	—	—	—
60	P004	GPIO	Input mode	None	Low	S1 user switch
61	P003	—	Disabled	—	—	—
62	P002	—	Disabled	—	—	—
63	P001	—	Disabled	—	—	—
64	P000	—	Disabled	—	—	—

1.8 For Reference: Outline of and Comparison with the USB Type-C Reference Design for RA2L2 MCUs

1.8.1 USB Type-C Reference Design for RA2L2 MCUs

The USB Type-C reference design for RA2L2 MCUs is a solution intended for small-size battery-powered applications with the USB Type-C interface, such as USB data loggers, True Wireless Stereo (wireless earphone) charging cases, and PC peripheral devices. In this reference design, the RA2L2 32-bit MCU with the USB Type-C CC detection function is used to implement USB Type-C detection operations presupposing use of the functionality in real applications.

Running each of the demonstrations allows users to easily experience the main features of the RA2L2, such as the USB FS, various types of serial communications, and low-power modes, together with the USB Type-C CC detection operation.

For details, refer to the following Web page for the USB Type-C reference design for RA2L2 MCUs.

RTK7A2L2UCD00000BJ - RA2L2 MCUs USB Type-C Reference Design | Renesas

1.8.2 Functional Comparison

The results of comparing the functions of this system with those of the USB Type-C reference design for RA2L2 MCUs are listed in Table 1-3.

Table 1-3 Functional Comparison

Function	USB Type-C Reference Design for RA2L2 MCUs	This System
USB Type-C CC detection	Possible	Possible
Demo use cases	Stand-alone (running from a battery) Connected to a charger Connected to a PC	Connected to a charger Connected to a PC
Demo mode	Sensing demo mode (temperature and humidity values and motions) Mouse demo mode	Sensing demo mode (temperature and humidity values and illuminance values)
Low-power operation	Sleep mode Software standby mode	Sleep mode
Date and time setting operation	Operation of the joystick	Operation of the user switches
Sensors	Temperature and humidity sensor Motion sensor	Temperature and humidity sensor Light sensor
Switches	Joystick (4-way + center press) Power switch Mode switch LCD switch Reset switch	User switches (S1 and S2) Reset switch
Interfaces	USB Type-C™ × 1 Pmod™ interface × 1 Debugging interface (E2 emulator Lite (E2 Lite) connector) × 1 Expansion interface × 1	USB Type-C™ × 1 Pmod™ interface × 2 *

Note: For the interfaces of the EK-RA2L2, refer to the user's manual of the EK-RA2L2.

1.8.3 Comparison of the System Configuration

Figure 1-4 shows the demonstration board of the USB Type-C reference design for RA2L2 MCUs. Figure 1-5 shows a system configuration using the EK-RA2L2.

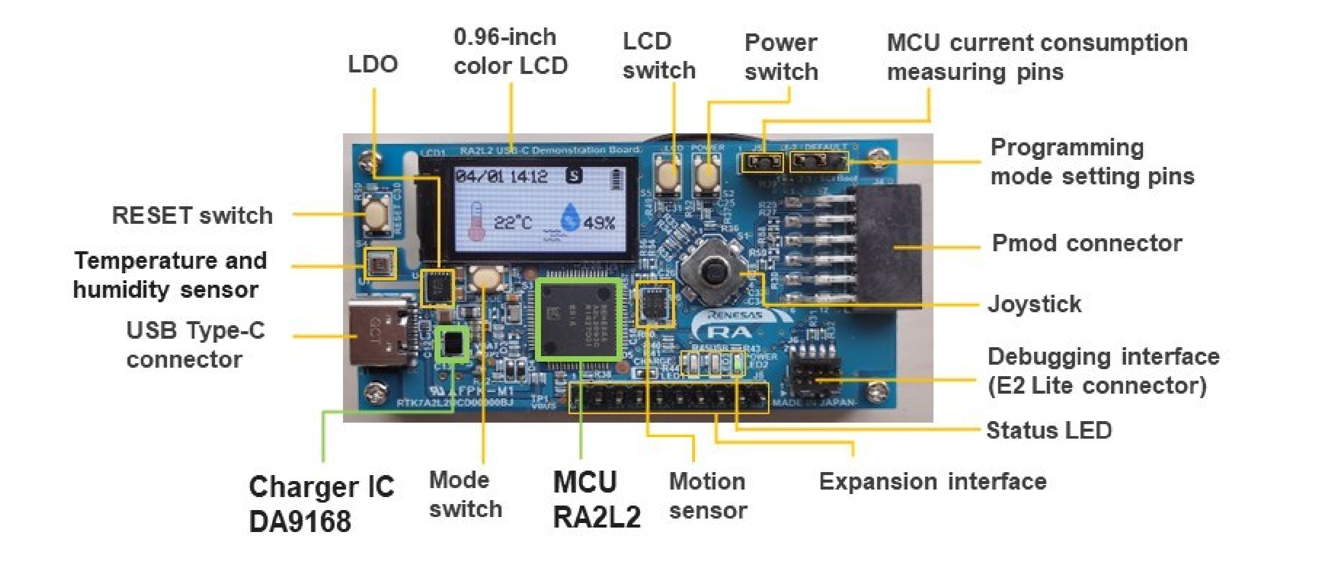


Figure 1-4 Demonstration Board of the USB Type-C Reference Design for RA2L2 MCUs

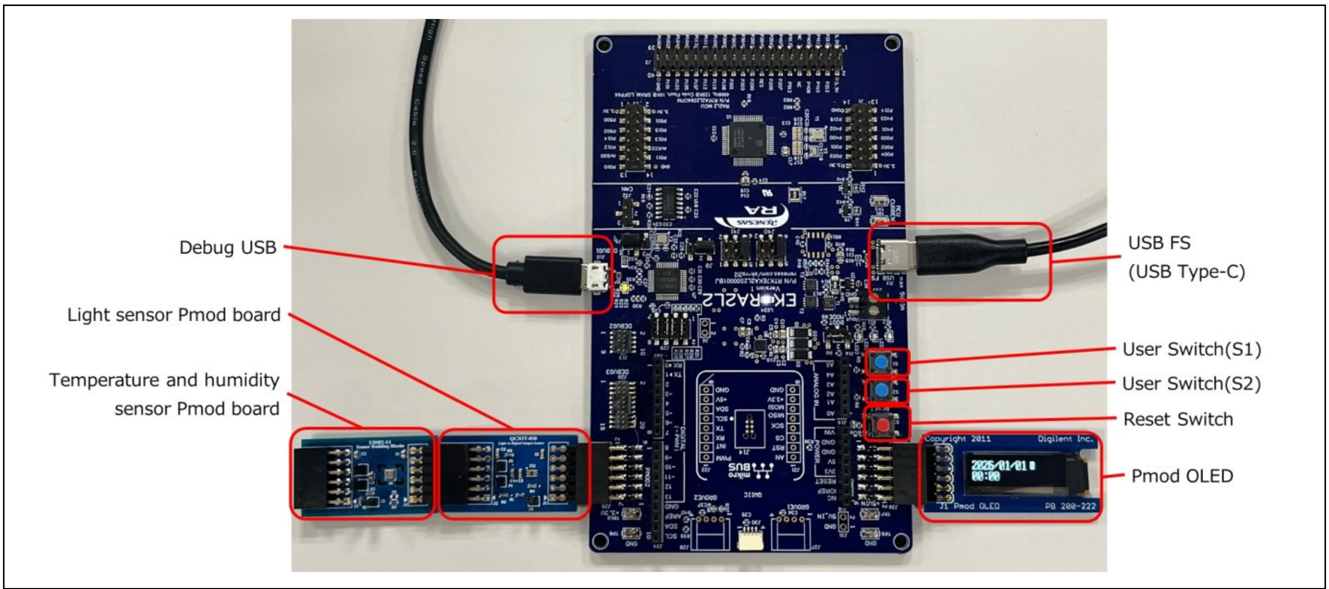


Figure 1-5 System Configuration Using the EK-RA2L2

2. Specifications of USB Type-C Detection Operations

This system uses the on-chip USB Type-C interface of the RA2L2 for USB Type-C CC detection. This chapter describes the specifications of the RA2L2's on-chip USB Type-C interface and the specifications of the operations of the USB Type-C hardware and software implemented in this system.

2.1 Specifications of the Standard of USB Type-C CC Detection

When devices are connected through a USB Type-C cable, the source device applies voltage to the Rp resistor in the source device and Rd resistor in the sink device and the voltage on the Rd resistor is measured to detect the default USB (0.5 A), 1.5-A source, or 3.0-A source current.

Table 2-1 Differences in the Threshold Voltage (V) on the Sink CC Pins

Source Current Detection	Power Supply	USB Type-C Cable and Connector Specifications — Threshold Voltage (V) on Sink CC Pins		RA2L2 CC Detection Circuit — Voltage Detection Threshold (V)
		Old Standard Release 2.3	New Standard Release 2.4	
Default USB	0.5 A @5 V	0.25	0.277	0.15
1.5-A source	1.5 A @5 V	0.66	0.613	0.613
3.0-A source	3.0 A @5 V	1.23	1.165	1.165

For example, if the sink device has detected the 3.0-A source current, a 15-W (3 A at 5 V) source device (such as a charger or a Type-C port of a PC) is connected to it. An example of the system operation after this detection is to send modified settings from the MCU to the charger IC or power-supply IC in the sink device through serial communications so that the charging current or receiving current is to be increased and fast charging or 15-W USB bus power operation is enabled.

2.2 Specifications of USB Type-C CC Detection Using the RA2L2

The USB Type-C interface module in the RA2L2 incorporates dedicated hardware circuits for detection that complies with the Universal Serial Bus Type-C Cable and Connector Specification Release 2.4 and supports the following functions.

- Detecting connection or disconnection of a USB port that complies with the USB Type-C Specification Release 2.4
- Providing an Rd resistor for each of the CC1 and CC2 lines and detecting the current supply capability of the source (default USB, 1.5-A source, or 3.0-A source current) by measuring the voltage on the Rd resistor

Figure 2-1 gives an overview of USB Type-C connections with the RA2L2.

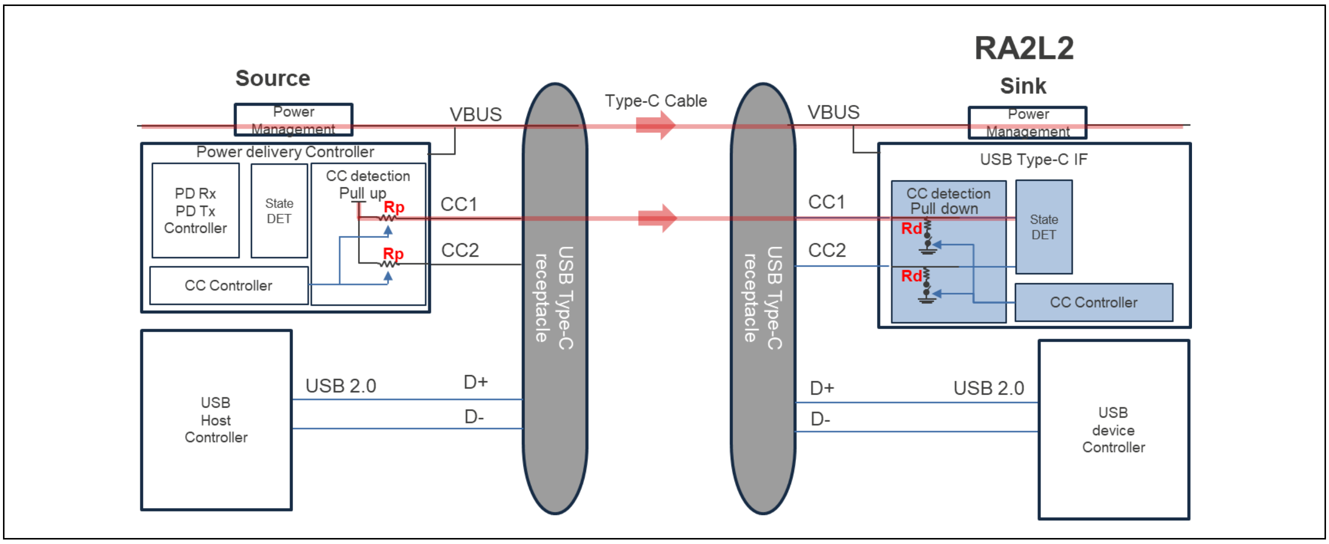


Figure 2-1 Overview of USB Type-C Connections Using the RA2L2

Figure 2-2 is a block diagram of the USB Type-C interface in the RA2L2.

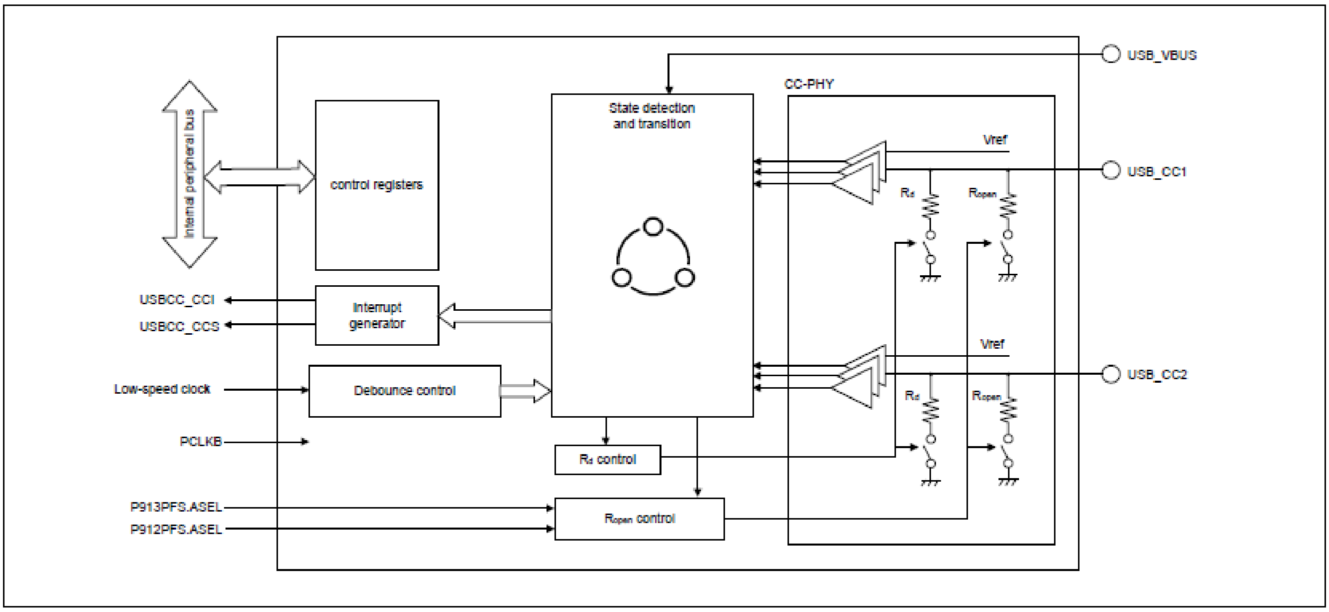


Figure 2-2 Block Diagram of the USB Type-C Interface in the RA2L2

The USB Type-C interface in the RA2L2 has a Type-CC connection state and status register (TCS register). The results of a USB Type-C detection operation can be read from the bits of this register. Table 2-2 lists the specifications of the TCS register. For details, refer to section 26.2.5, TCS: Type-CC Connection State and Status Register, in the RA2L2 Group User's Manual: Hardware (R01UH1080).

Table 2-2 Specifications of the TCS Register

Bit	Symbol	Function	R/W
0	SRCD	Detection of Source Connection 0: Source is not connected (connection status not in Attached.SNK) 1: Source is connected (connection status in Attached.SNK)	R
1	VRD15D	Detection of Power1.5 Source Connection 0: Power1.5 source is not connected 1: Power1.5 source is connected	R
2	VRD30D	Detection of Power3.0 Source Connection 0: Power3.0 source is not connected 1: Power3.0 Source is connected	R
3	PLUG	Connection of Plug Orientation 0: CC1 is connected 1: CC2 is connected	R*1
7:4	CNS[3:0]	Status of Connection State 0000: Disabled 0001: Unattached.SNK 0010: AttachWait.SNK 0100: Attached.SNK (PowerDefault.SNK) 0101: Attached.SNK (Power1.5.SNK) 0110: Attached.SNK (Power3.0.SNK) Others: Undefined	R
9:8	CC1S[1:0]	Status of CC1 00: Open (below maximum vRa) 01: Default USB (above minimum vRd-Connect) 10: Power1.5 (voltage above minimum vRd-Connect, and within the range of vRd-1.5) 11: Power3.0 (voltage above minimum vRd-Connect, and within the range of vRd-3.0)	R
11:10	CC2S[1:0]	Status of CC2 00: Open (below maximum vRa) 01: Default USB (above minimum vRd-Connect) 10: Power1.5 (voltage above minimum vRd-Connect, and within the range of vRd-1.5) 11: Power3.0 (voltage above minimum vRd-Connect, and within the range of vRd-3.0)	R
12	VBUSS	Status of VBUS 0: VBUS is off 1: VBUS is on	R
30:13	—	These bits are read as 0.	R

Note 1. This is valid only when the connection state is Attached.SNK in Sink-only mode (MEC.MODE=0).

2.3 Specifications of the USB Type-C in the EK-RA2L2

Figure 2-3 shows the configuration of the circuits in the USB block, which includes the USB Type-C interface, in the EK-RA2L2.

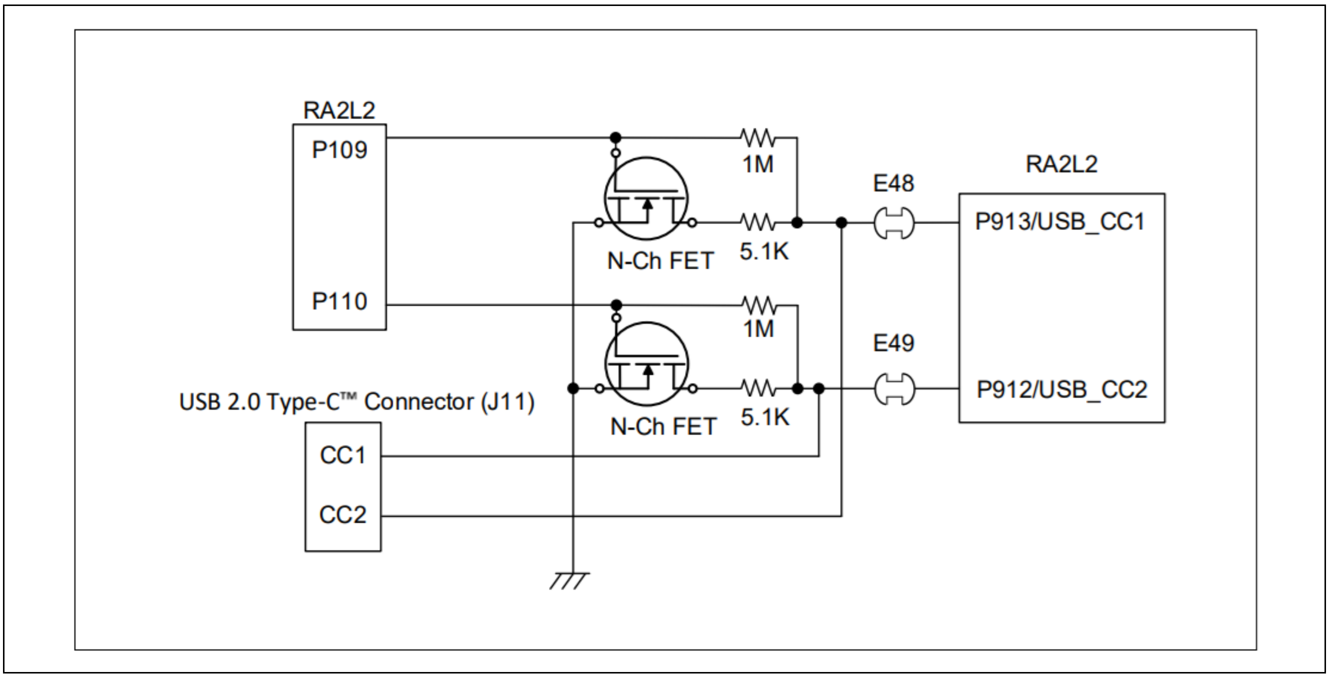


Figure 2-3 Configuration of the Circuits in the USB Block

2.4 USB Type-C CC Detection

The USB Type-C standard prescribes that a USB Type-C source device such as a PC or a charger shall always detect the pull-down resistor, Rd, on each of the CC lines in a sink device (EK-RA2L2) when the sink device is connected to the source device through a USB Type-C port. After the source device has detected the Rd pull-down resistor, the device starts VBUS output to the sink device.

The RA2L2 has the Rd1 pull-down resistor in the USB Type-C Interface but the EK-RA2L2 incorporates the external Rd2 pull-down resistor on the demo board so that the source device can detect the Rd pull-down resistor regardless of whether the RA2L2 has been activated.

To use the USB Type-C function in this system (EK-RA2L2), the external Rd2 pull-down resistor should be disabled in the way stated below and the on-chip Rd1 pull-down resistor should be enabled.

- Procedure for using the USB 2.0 Type-C function in the EK-RA2L2
  - Close pins 5 and 6 of J40 and J41.
  - Output the low level from P109 and P110 to disable the external Rd2 pull-down resistor.

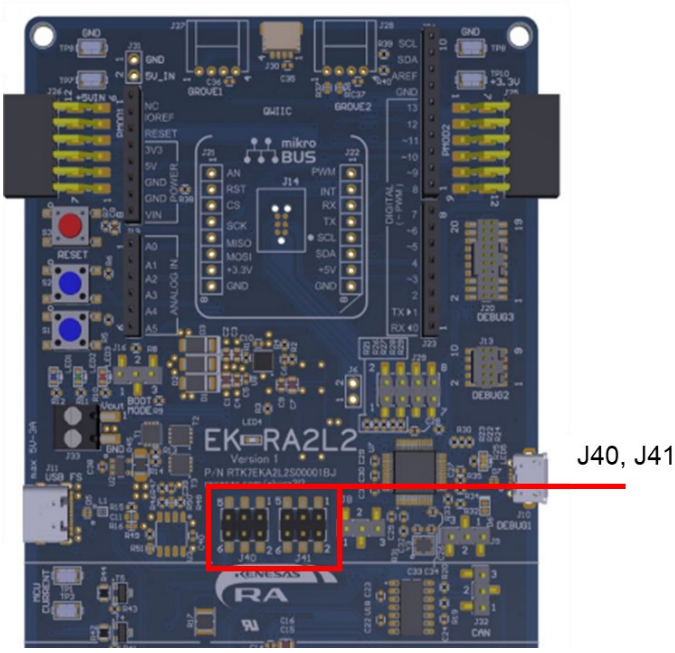


Figure 2-4 Jumpers for Setting: J40 and J41

Upon detection of the enabled on-chip Rd1 pull-down resistor, the source turns VBUS on and the RA2L2 begins the USB sequence. Note that the EK-RA2L2 should be used in a self-powered configuration (power is supplied from a source other than USB Type-C) so that the CC detection function in the EK-RA2L2 is usable.

In this system, power is supplied through the debug USB connector.

3. Hardware

3.1 EK-RA2L2 Evaluation Kit

The EK-RA2L2 evaluation kit incorporating the RA2L2 MCU is used as the evaluation board.

For details of the EK-RA2L2, refer to the following Web page for the product.

EK-RA2L2 - Evaluation Kit for RA2L2 MCU Group | Renesas

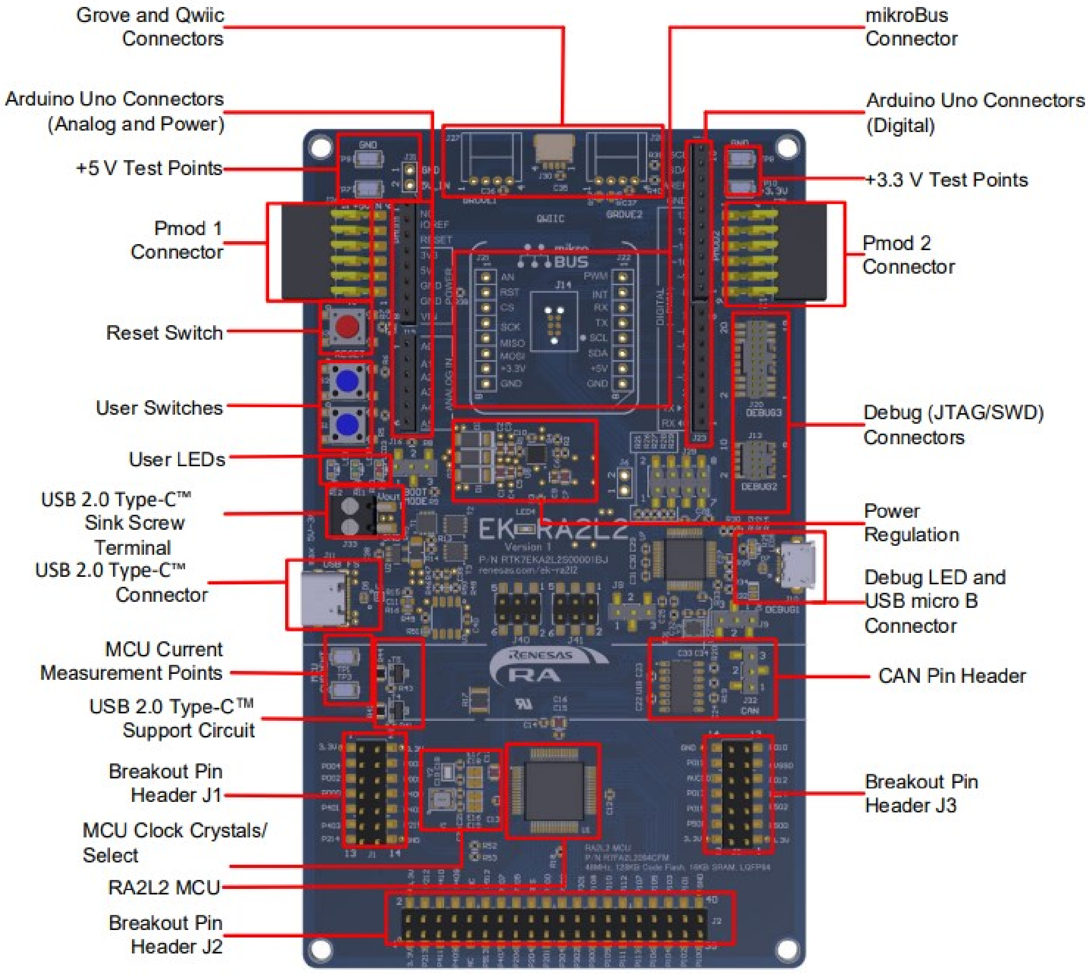


Figure 3-1 Top View of the EK-RA2L2 Evaluation Kit

3.2 Temperature and Humidity Sensor Pmod Board

The QCIOT-HS4001POCZ made by Renesas is used as the temperature and humidity sensor Pmod board. The QCIOT-HS4001POCZ incorporates the HS4001 temperature and humidity sensor.

This Pmod board has 0x54 as its slave address.

For details of the QCIOT-HS4001POCZ temperature and humidity sensor Pmod board, refer to the following Web page for the product.

QCIOT-HS4001POCZ - Relative Humidity Sensor Pmod™ Board | Renesas

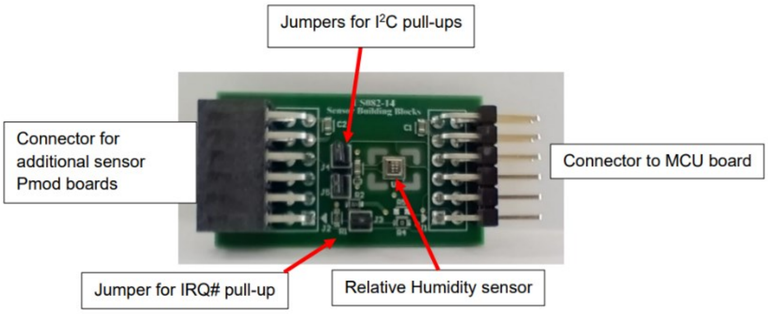


Figure 3-2 QCIOT-HS4001POCZ Temperature and Humidity Sensor Pmod Board

3.3 Light Sensor Pmod Board

The QCIOT-ISL76682POCZ made by Renesas is used as the light sensor Pmod board. The QCIOT-ISL76682POCZ Pmod board incorporates the ISL76682 light-to-digital sensor.

The slave address for this Pmod board is selectable. In this system, the slave address 0x44 is selected for use through the default pin settings (pins 2 and 3 of J5 are closed).

For details of the QCIOT-ISL76682POCZ light sensor module, refer to the following Web page for the product.

QCIOT-ISL76682POCZ - Light-to-Digital Sensor Pmod Board | Renesas

Figure 3-3 QCIOT-ISL76682POCZ Light Sensor Pmod Board

3.4 Pmod OLED

The 410-222 display made by Digilent is used as the Pmod OLED. This Pmod OLED incorporates the SSD1306 made by Solomon Systech (International) Limited and supports the SPI interface.

For details of the 410-222 Pmod OLED, refer to the following Web page for the product.

Pmod OLED: 128 x 32 Pixel Monochromatic OLED Display - Digilent

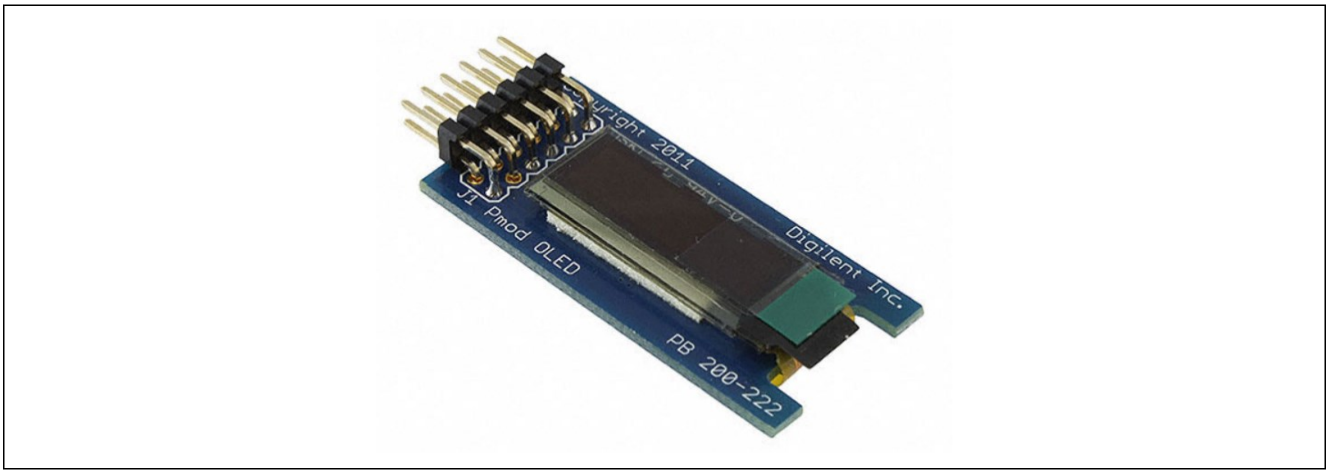


Figure 3-4 410-222 Pmod OLED

The Pmod OLED has an OLED panel with 128 pixels horizontally × 32 pixels vertically. Figure 3-5 shows the structure of the dots on the OLED panel.

VRAM is used for drawing on the panel and it has a total of 512 bytes for 128 dots horizontally × 8 dots vertically × 4 pages. Figure 3-6 shows the structure of the VRAM.

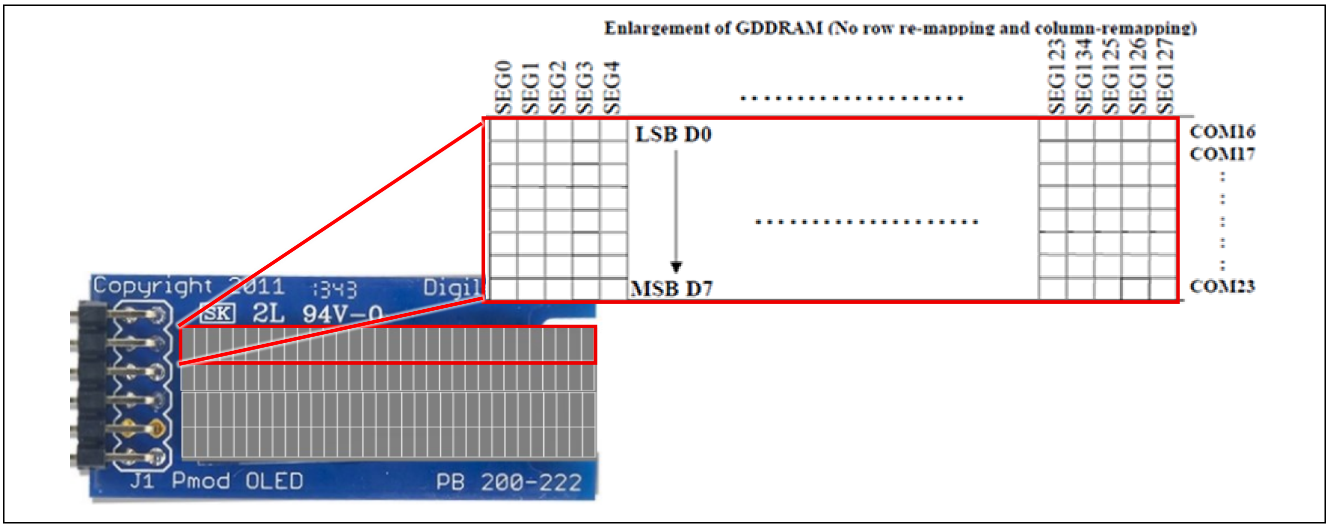


Figure 3-5 Structure of the Dots on the OLED Panel

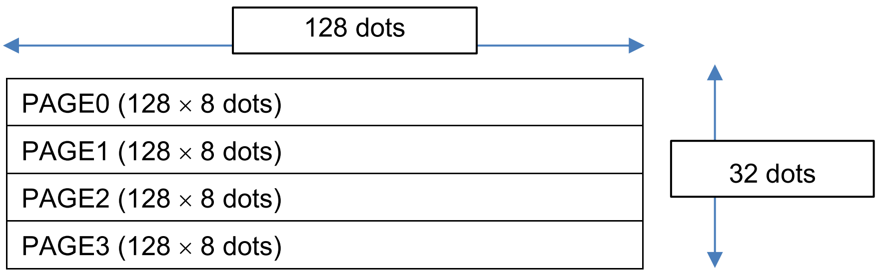


Figure 3-6 Structure of the VRAM for the OLED

4. Specifications of Software Operations (Demonstration Operations)

The sample code for this system demonstrates not only USB Type-C detection but also the operations of the overall system intended for an application that handles monitoring through environment sensors. This chapter describes the specifications of the software operations. Sections 4.1 to 4.4 give an overview of software operations and section 4.5 and subsequent sections describe the specifications of the individual functions.

4.1 Flowchart of the Main Processing

Figure 4-1 is a flowchart of the main processing of the sample code. The OLED drawing process is separated from the main cycle to improve the speed of drawing. The VBUS monitoring processing is also separated from the main cycle because the monitoring processing runs in a different cycle from the main cycle. Note that the main cycle is generated by using the RTC periodic interrupt at 1/128-second intervals.

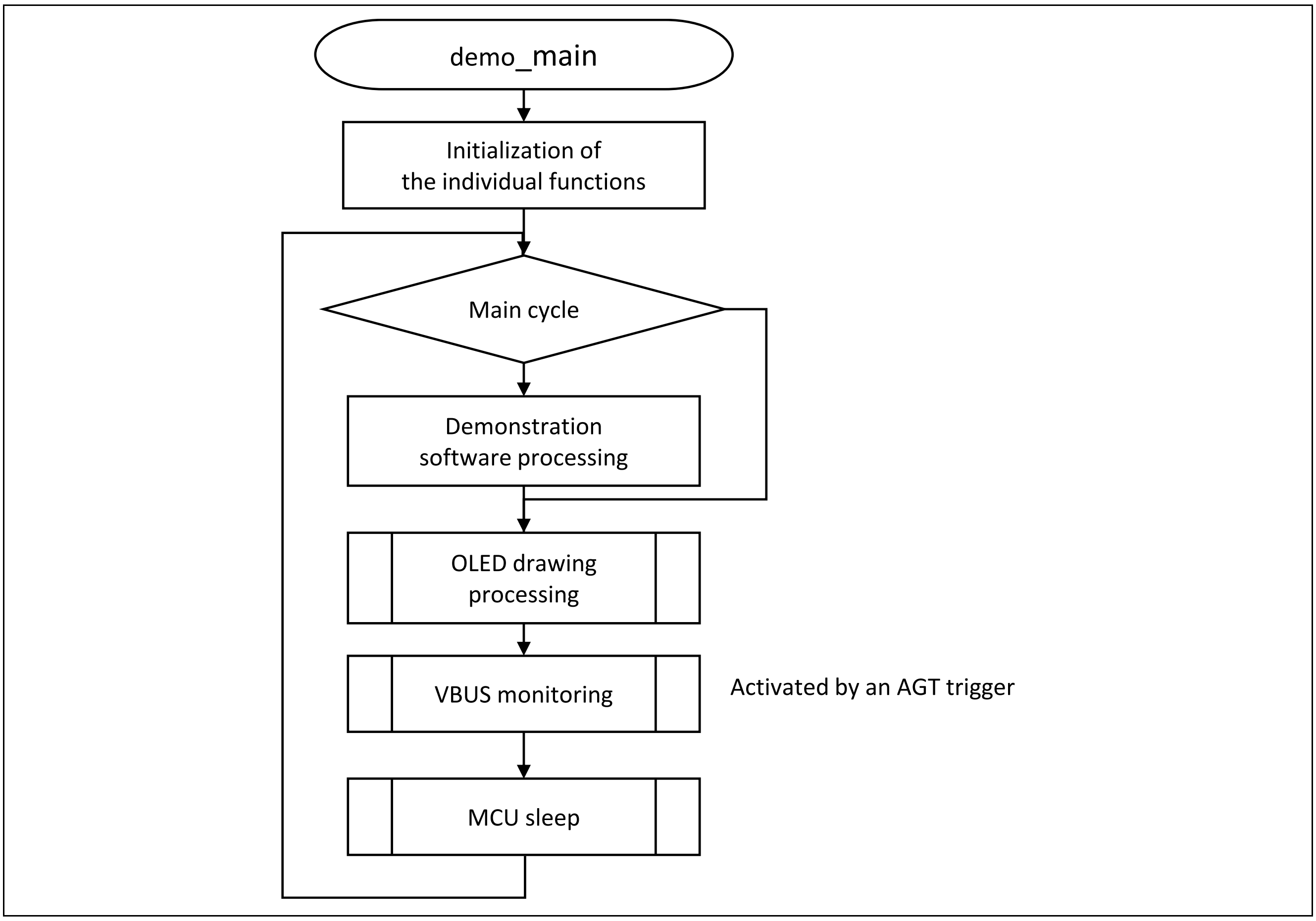


Figure 4-1 Flowchart of the Main Processing

4.2 Overview of Demonstration Operations and State Transitions

Table 4-1 shows an overview of the demonstration operations of the sample code.

Table 4-1 Overview of the Demonstration Operations

Demonstration Operation	Overview
Date and time setting mode	Mode for setting the date and time by using the user switches.
Sensing demo mode	Mode for displaying the results of detection by the temperature and humidity sensor and light sensor on the OLED panel. In addition, the data from the sensors can be sent to a PC by connecting the board as a USB CDC device to the PC.
USB notification	Mode for displaying the results of USB Type-C CC detection and the state of USB connection on the OLED panel as USB notification when a USB connection is made or cut off. The notification automatically ends in three seconds and execution returns to the previous demo mode.

Figure 4-2 shows the state transitions of the entire sample code.

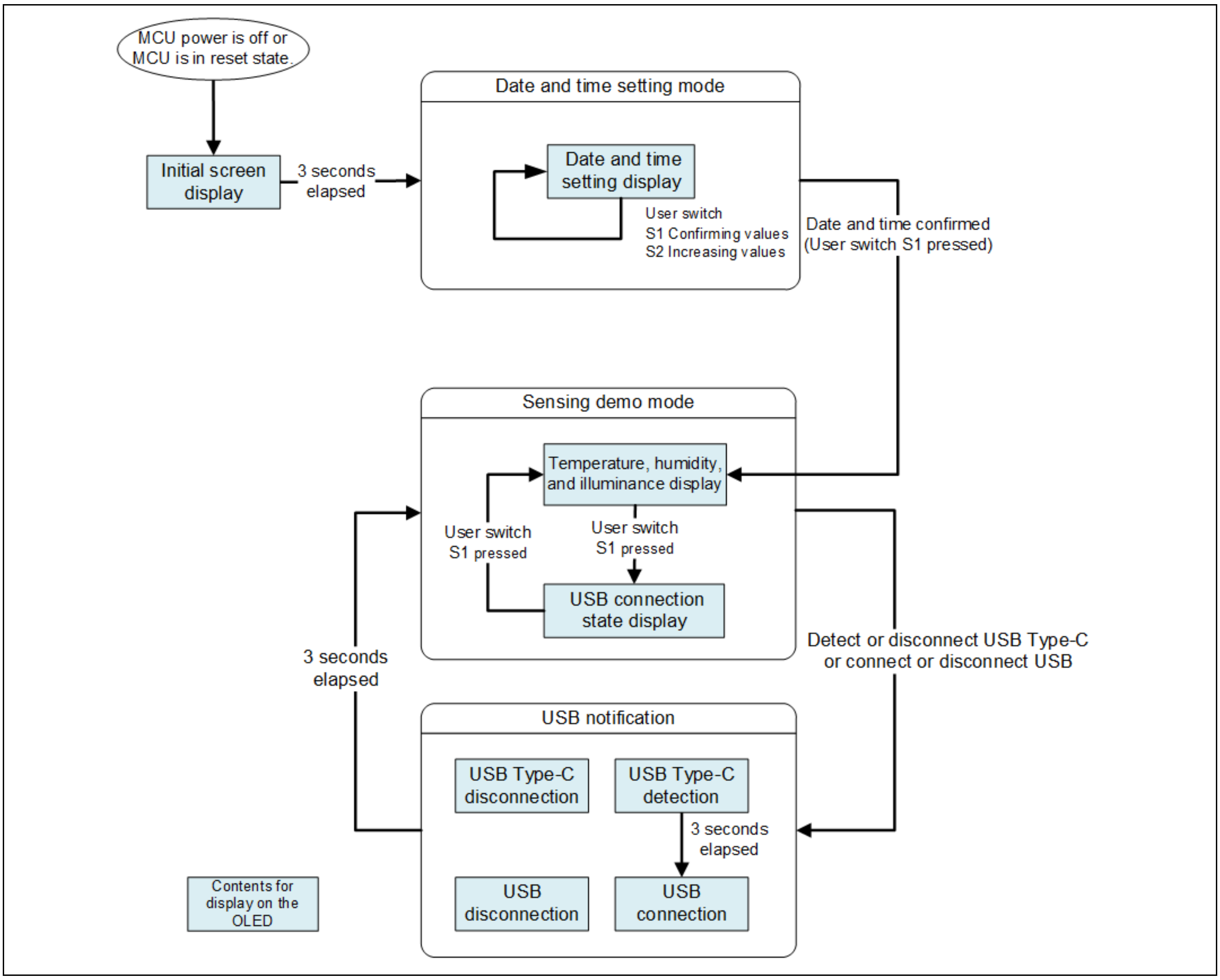


Figure 4-2 State Transitions of the Entire Sample Code

Table 4-2 lists the states of the major functions in the individual demo modes.

Table 4-2 States of the Major Functions in the Individual Demo Modes

Operation Mode	Sensing	OLED Display	USB Notification (OLED Display)	USB Type-C Interface*	USB FS
Date and time setting mode	Stopped	On	Off	Operating	Operating
Sensing demo mode	Operating	On	On	Operating	Operating

Note: On-chip USB Type-C interface in the RA2L2.

4.3 Software Structure

Figure 4-3 shows the overall structure of the sample code software.

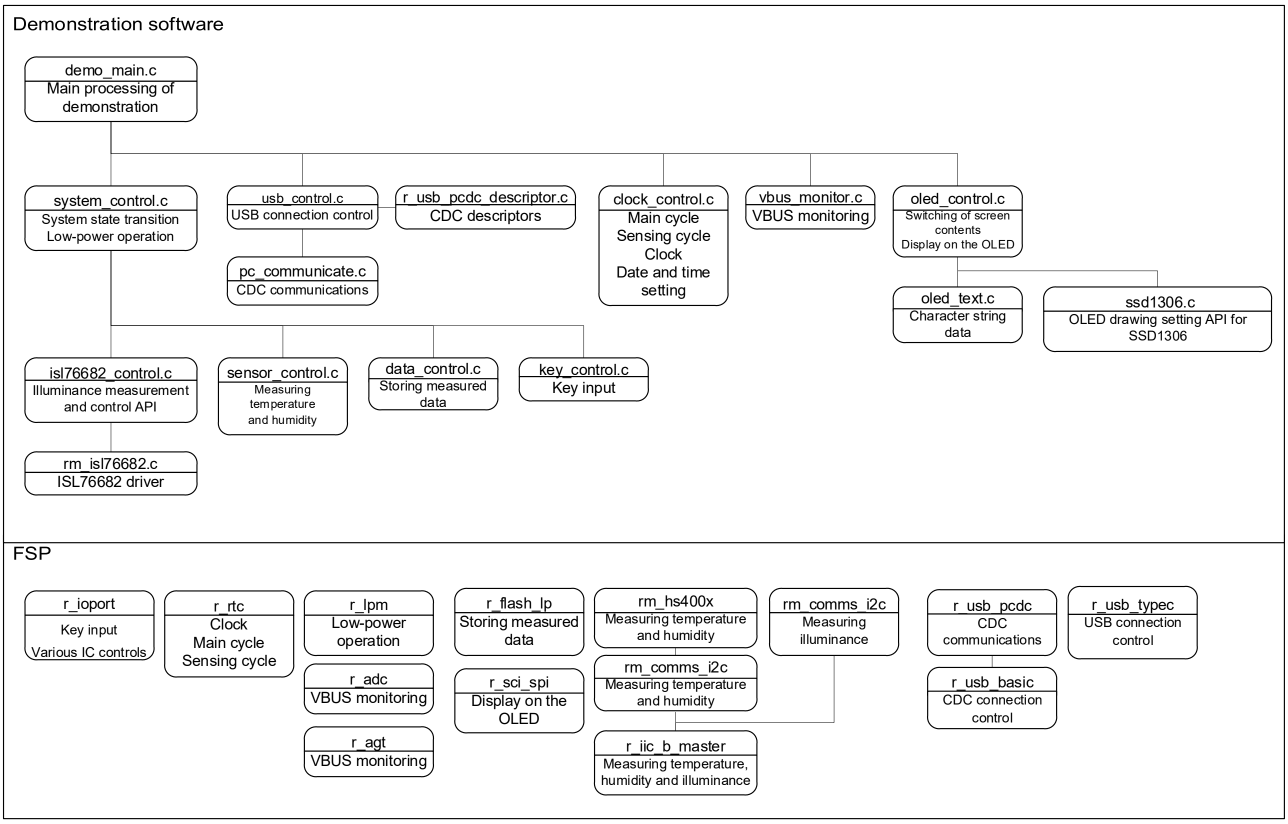


Figure 4-3 Overall Structure of the Sample Code Software

4.4 Structure of Folders and Files

Table 4-3 shows the overall structure of the sample code folders and files and gives descriptions of the files.

Table 4-3 Structure of Folders and Files

Folder or File Name	Description
ek_ra2l2_usb_demo_sample	
|— src |— hal_entry.c	
|— demo	
|— demo_main.c	Main processing of demonstration
|— demo_main.h	Header file for demo_main.c
|— clock	
| |— clock_control.c	Main cycle, sensing cycle, clock, and date and time setting
| |— clock_control.h	Header file for clock_control.c
|— data	
| |— data_control.c	Storing measured data
| |— data_control.h	Header file for data_control.c
|— key	
| |— key_control.c	Key input
| |— key_control.h	Header file for key_control.c
|— light	
|— isl76682	
| | |— ra_isl76682_profile.h	Definitions of the ISL76682 profile
| | |— rm_isl76682.c	ISL76682 driver
| | |— rm_isl76682.h	Header file for rm_isl76682.c
| | |— rm_isl76682_api.h	Definitions of the ISL76682 API
| |— isl76682_control.c	Illuminance measurement and control API
| |— isl76682_control.h	Header file for isl76682_control.c
|— oled	
| |— oled_control.c	Switching of screen contents and displaying on OLED
| |— oled_control.h	Header file for oled_control.c
| |—oled_text.c	Character string data
| |— oled_text.h	Header file for oled_text.c
| |— ssd1306.c	OLED drawing setting API for the SSD1306
| |— ssd1306.h	Header file for ssd1306.c
|— sensor	
| |— sensor_control.c	Measurement of temperature and humidity
| |— sensor_control.h	Header file for sensor_control.c

|— sys	
| |— system_control.c	System state transition and low-power operation
| |— system_control.h	Header file for system_control.c
|— usb	
| |— pc_communicate.c	CDC communications
| |— pc_communicate.h	Header file for pc_communicate.c
| |— r_usb_pcdc_descriptor.c	CDC descriptors
| |— usb_control.c	USB connection control
| |— usb_control.h	Header file for usb_control.c
|— vbus	
| |— vbus_monitor.c	VBUS monitoring
| |— vbus_monitor.h	Header file for vbus_monitor.c

4.5 System Control

This section describes the specifications of the system control for the entire sample code. The RTC periodic interrupt at 1/128-second intervals is used to generate the main cycle of the system. The duration of long-pressing of the user switches, the OLED drawing time, 1-second sensing cycle, and 5-second data storage cycle are also counted in units of this main cycle.

4.5.1 Processing Structure

Figure 4-4 shows the structure of the system control processes.

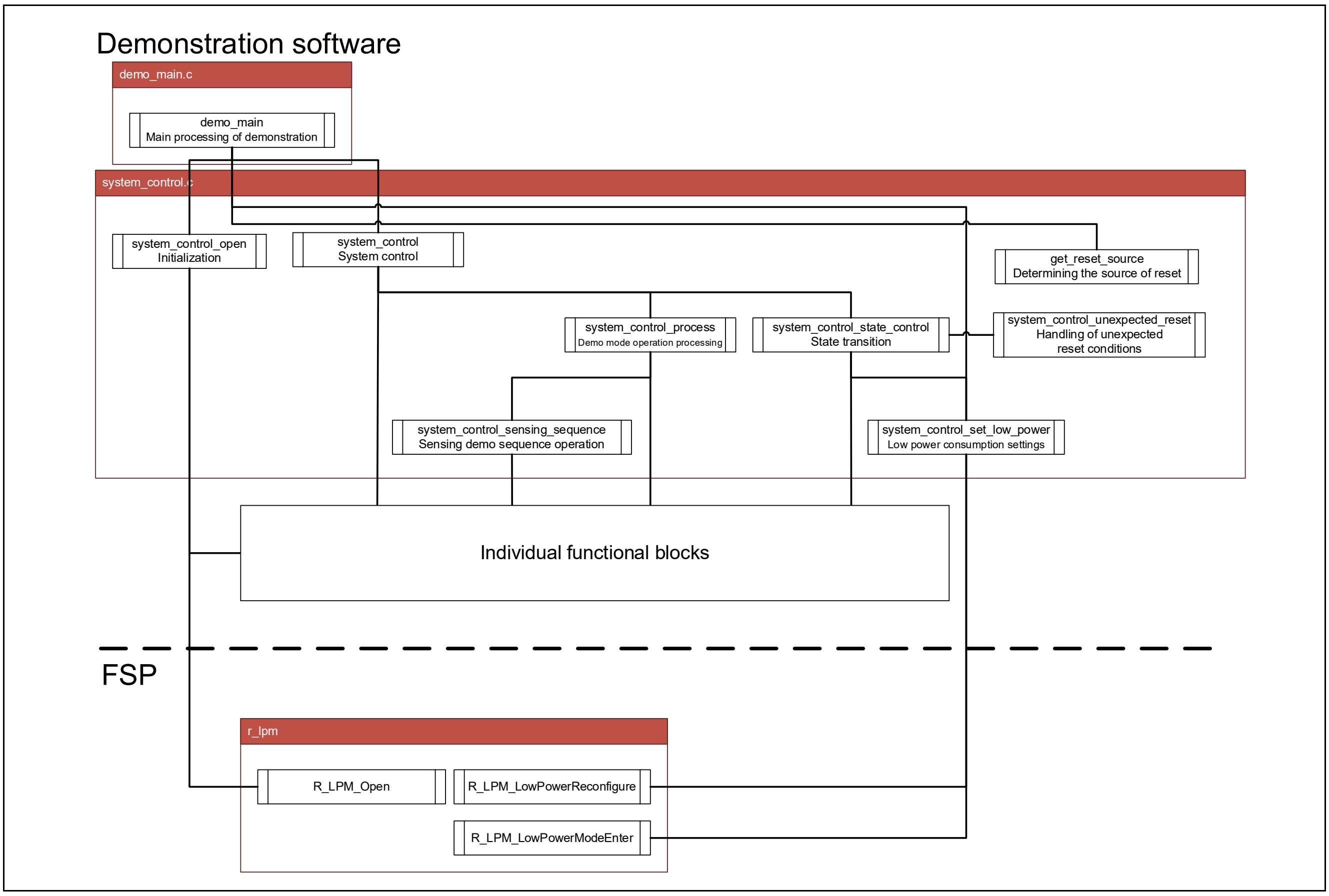


Figure 4-4 Structure of the System Control Processes

4.5.2 State Transitions

Figure 4-5 shows the state transitions for system control. After the demonstration starts to operate, the source of the preceding reset is determined. If it was a reset through the RES pin, power-on reset, or software reset, the system is placed in date and time setting mode. After the date and time have been set, the system is placed in sensing demo mode.

If the source of the reset was none of the above, the system is stopped. Apply a reset again in such cases.

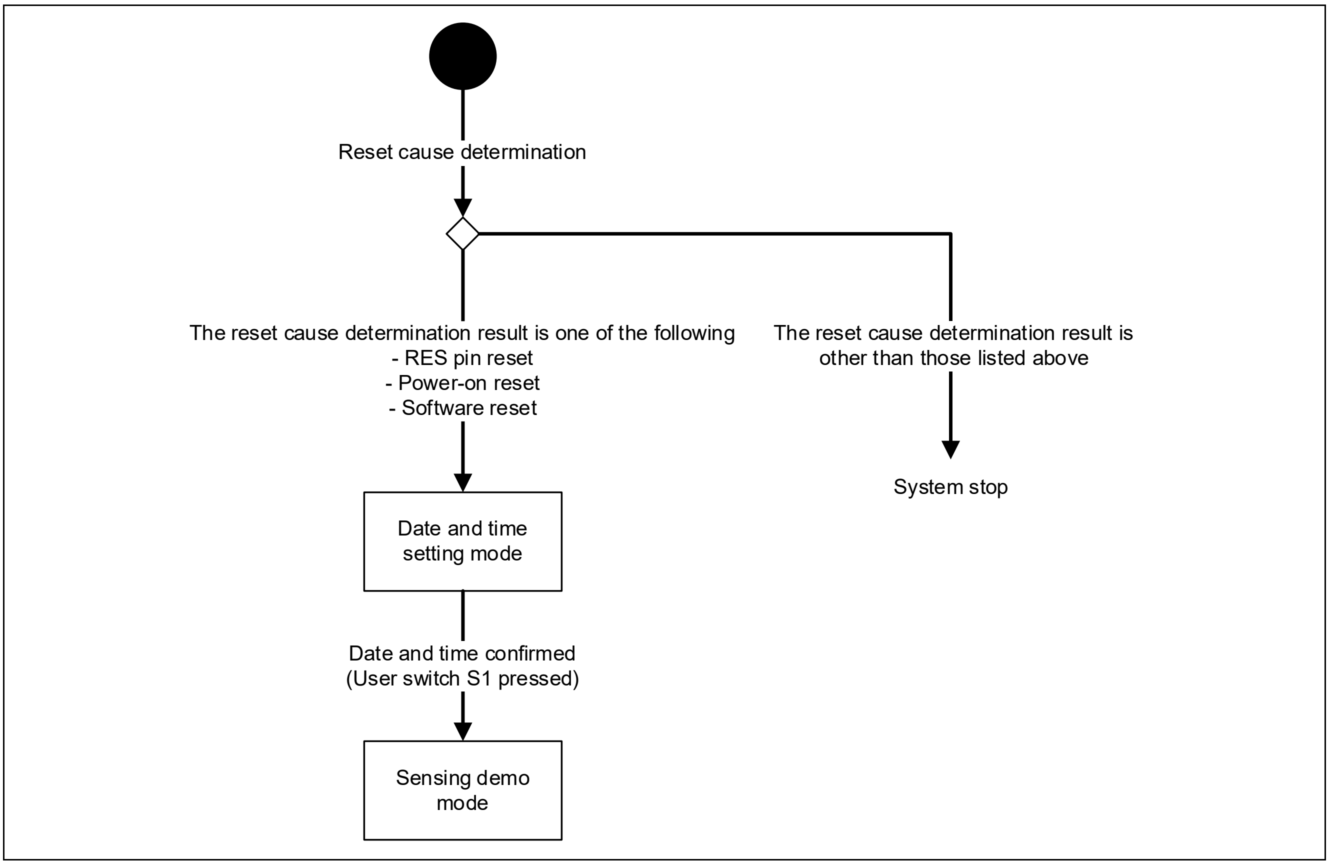


Figure 4-5 State Transitions for System Control

4.5.3 Low-Power Operation

Figure 4-6 shows the state transitions for low-power operation and Table 4-4 lists the states of operation of the peripheral modules in the individual operating modes of the MCU.

In sensing demo or date and time setting mode, the MCU is placed in sleep mode while no execution is in progress after the processing of each peripheral module at main cycle intervals has ended. The MCU is released from sleep mode by an RTC interrupt for main cycle generation or a timer interrupt for VBUS monitoring.

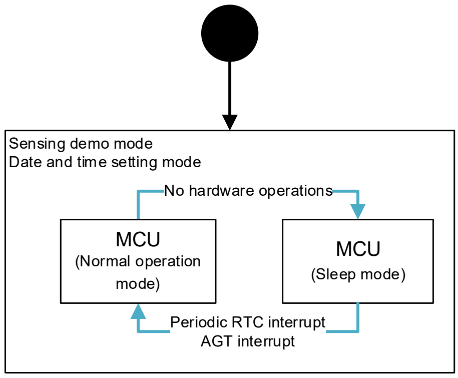


Figure 4-6 State Transitions for Low-Power Operation

Table 4-4 States of Operation of the Peripheral Modules in the Individual Operating Modes of the RA2L2

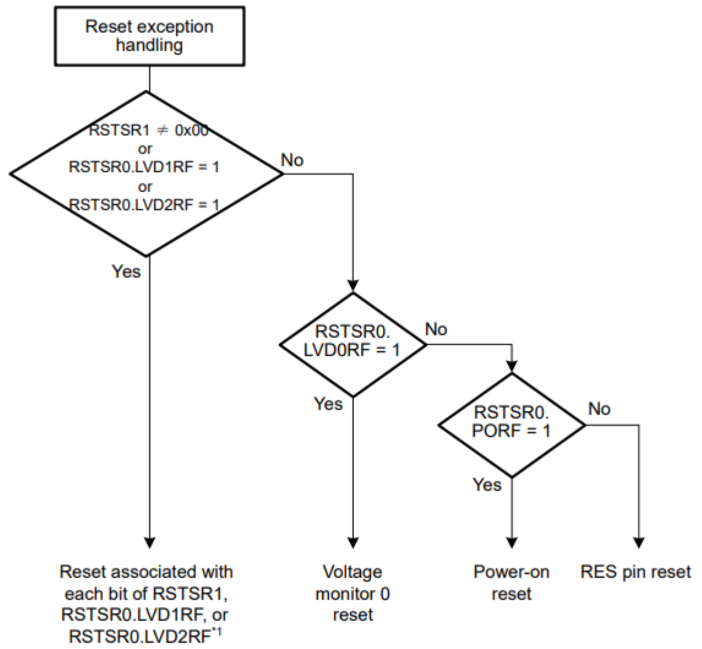
Item	Normal Operation Mode	Sleep Mode
Sub-clock oscillator	Operating	Operating
High-speed on-chip oscillator	Operating	Operating
CPU	Operating	Stopped
SRAM	Operating	Operating
Flash memory	Operating	Operating
Realtime clock	Operating	Operating
Low power asynchronous general purpose timer	Operating	Operating
12-bit A/D converter	Operating	Operating
Serial communications interface	Operating	Operating
I3C bus interface	Operating	Operating
USB2.0 full-speed module	Operating	Operating
USB Type-C interface	Operating	Operating
I/O ports	Operating	Operating

4.5.4 Determining the Source of the Reset

The RSTSR0 and RSTSR1 registers of the RA2L2 are read to determine the source of the reset. In this system, operation only begins if the source was a reset through the RES pin, a power-on reset, or a software reset. The system is stopped if the reset was due to any other source.

Note that this system (EK-RA2L2) cannot satisfy the conditions required for separate detection by the RA2L2 of a power-on reset, so the source of the reset when the power to the board is turned on is judged to be a reset through the RES pin.

Figure 4-7 shows a sample flow for determining the source of a reset in the RA2L2. For details of the reset conditions and the flow for determining the source of a reset, refer to the RA2L2 Group User's Manual: Hardware.



Note 1. When resets are generated simultaneously by two or more sources, the two or more corresponding reset flags will be set to 1.

Figure 4-7 Sample Flow for Determining the Source of a Reset

4.6 Key Input

The inputs from the user switches (S1 and S2) are monitored at intervals of the main cycle in date and time setting mode and in sensing demo mode. When the level input from a switch matches twice in succession, the input value is considered to be confirmed. Long-pressing is also supported in date and time setting mode. Note that the reset switch is used for a hardware reset and the key input control processing does not handle the input from the switch. Table 4-5 lists the specifications of the key input.

Table 4-5 Specifications of the Key Input

Switch	Block Using the Input	Function in Date and Time Setting Mode	Function in Sensing Demo Mode	Active Level
Reset switch	Hardware	—	—	Low
User switch S1	System control, date and time control, and OLED control*	Confirming values	Switching the contents of the OLED display	Low
User switch S2	System control, date and time control, and OLED control*	Increasing values	—	Low

Note: The date and time control and OLED control blocks receive key input through the system control block.

4.6.1 Processing Structure

Figure 4-8 shows the structure of the key input processes.

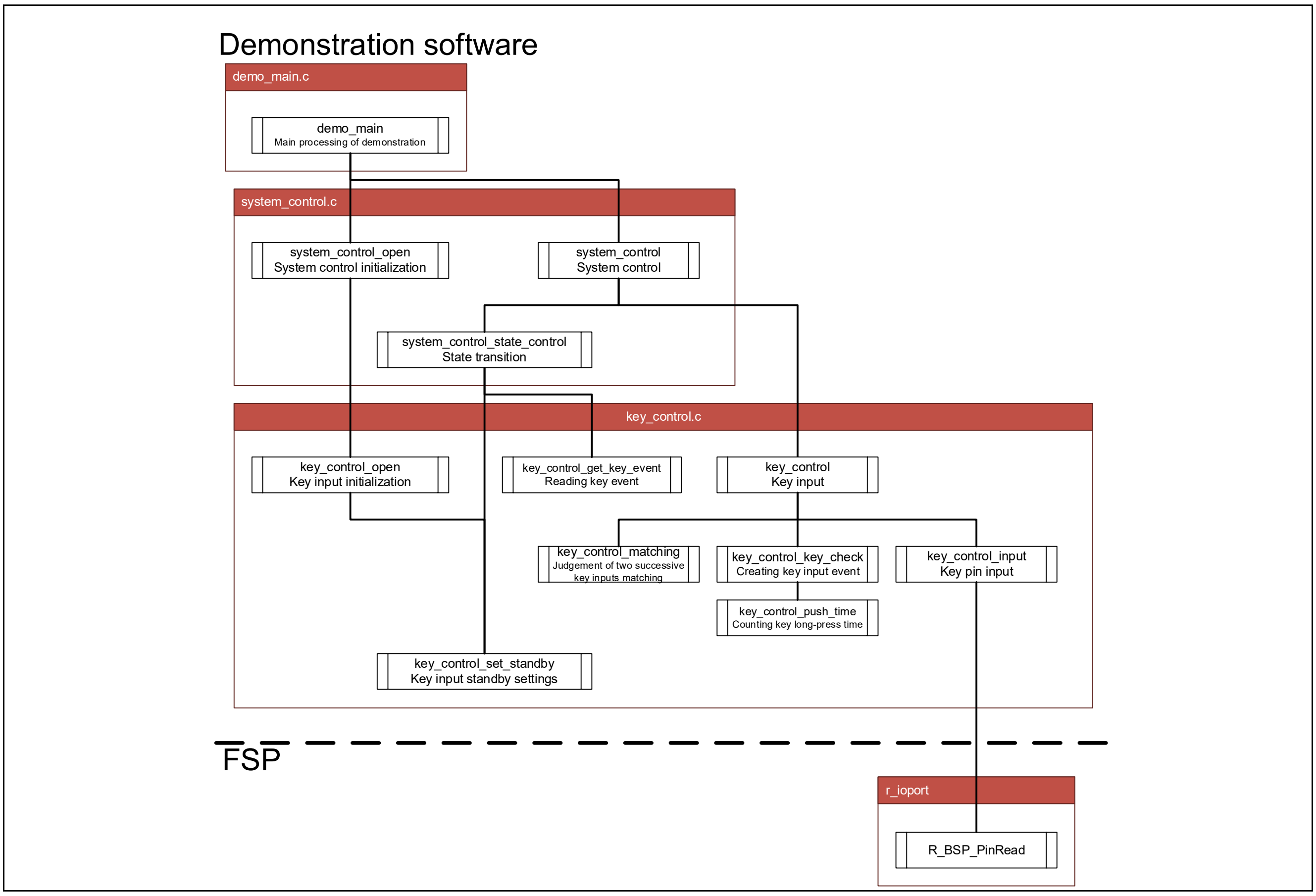


Figure 4-8 Structure of the Key Input Processes

4.6.2 Processing to Determine Long-Pressing

In date and time setting mode, long-pressing as well as single-pressing is supported to reduce the burden of repeated key input.

Long-pressing is checked in two steps. Pressing a user switch for two seconds is judged to be a long press. After that, the state of pressing is checked every 500 ms to see if long-pressing is continued.

4.7 Date and Time Control

The RTC is used to control the date and time. The time is handled in the 24-hour system. The periodic RTC interrupt at 1/128-second intervals is used to generate the main cycles.

4.7.1 Processing Structure

Figure 4-9 shows the structure of the date and time control processes.

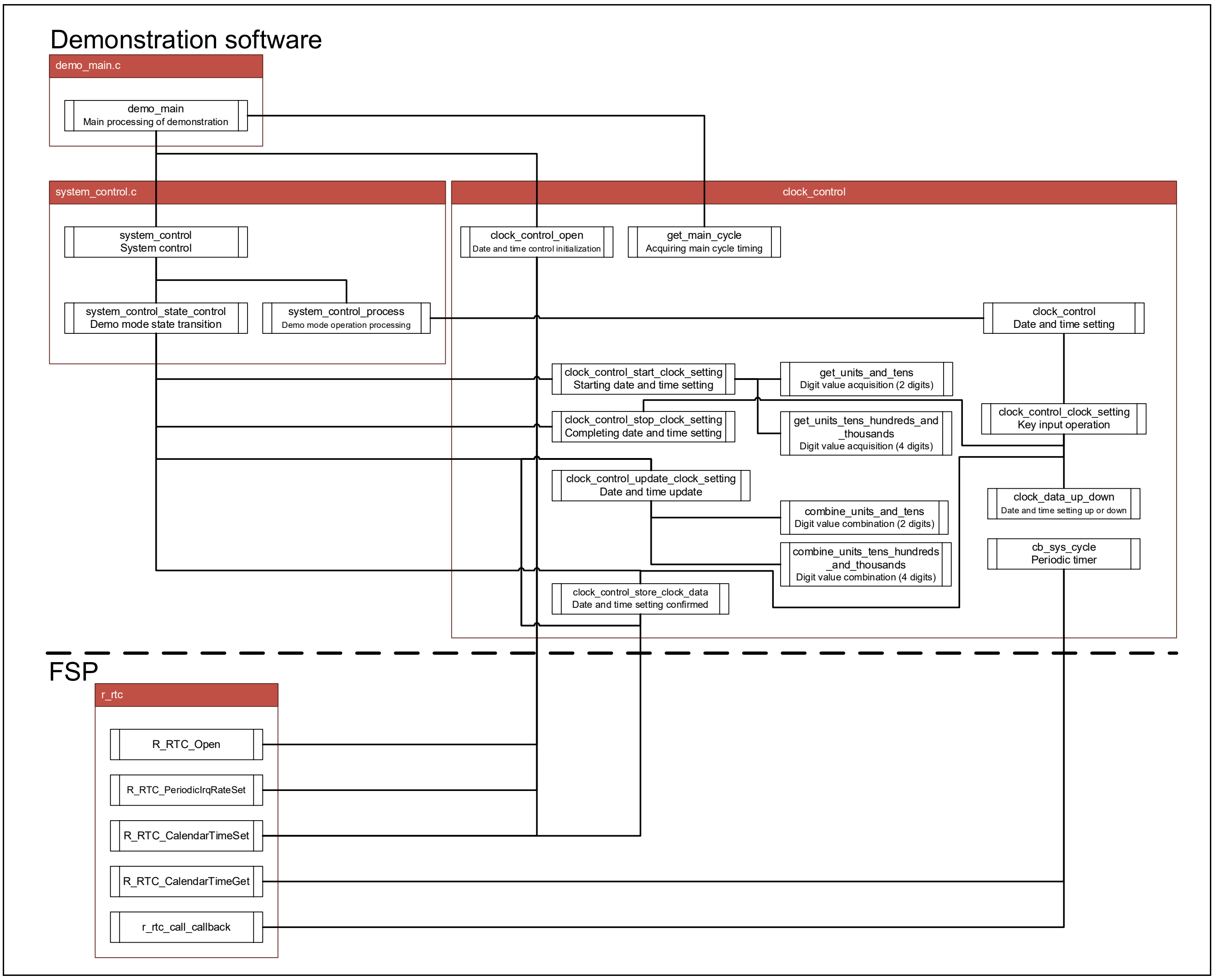


Figure 4-9 Structure of the Date and Time Control Processes

4.7.2 Date and Time Setting

When the supply of power begins, the initial screen is displayed on the OLED for three seconds, after which the system is automatically placed in date and time setting mode.

In this mode, user switches S1 and S2 are used to modify the date and time from the default values. The default date and time are January 1, 2026, and 00:00. Single-pressing and long-pressing of the user switches are supported.

Modify digit by digit for the year (through the single-year digit), month, day, hour, and minute. Pressing S1 confirms the value and pressing S2 increases the value. After the value for the single-minute digit of the minutes value has been confirmed, date and time setting is completed. Note that the seconds value is not a target of setting here but counting begins from 0 seconds upon completion of the date and time setting.

After date and time setting is completed, the specified date and time are reflected in the RTC and the process of setting is complete. After that, the system is placed in sensing demo mode.

Figure 4-10 is an overview of the date and time setting operations.

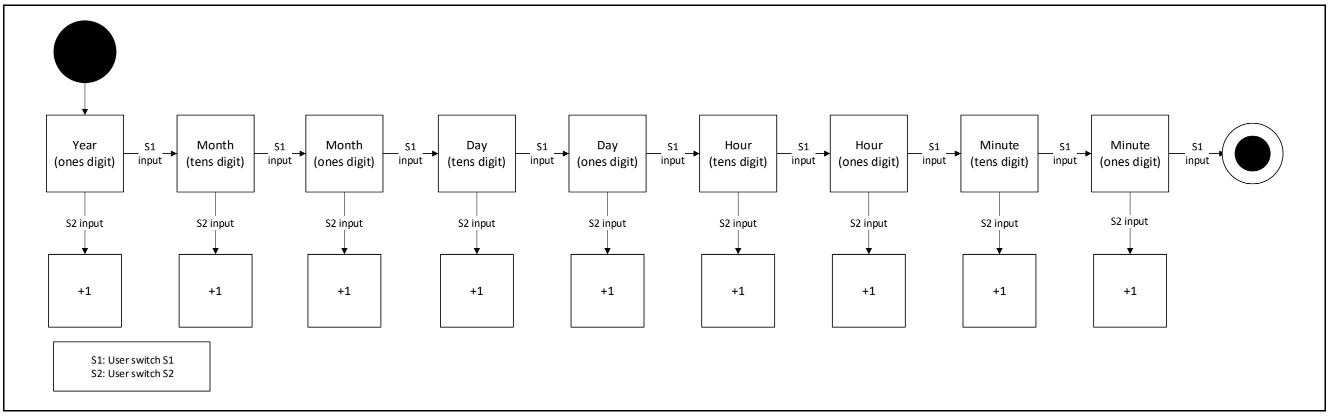


Figure 4-10 Overview of Date and Time Setting Operations

4.8 OLED Display

The sample code uses the OLED display control functions and OLED module driver to draw image data for various icons and text data, which have been converted to C source code, on the OLED panel.

4.8.1 Processing Structure

Figure 4-11 shows the structure of the OLED display processes.

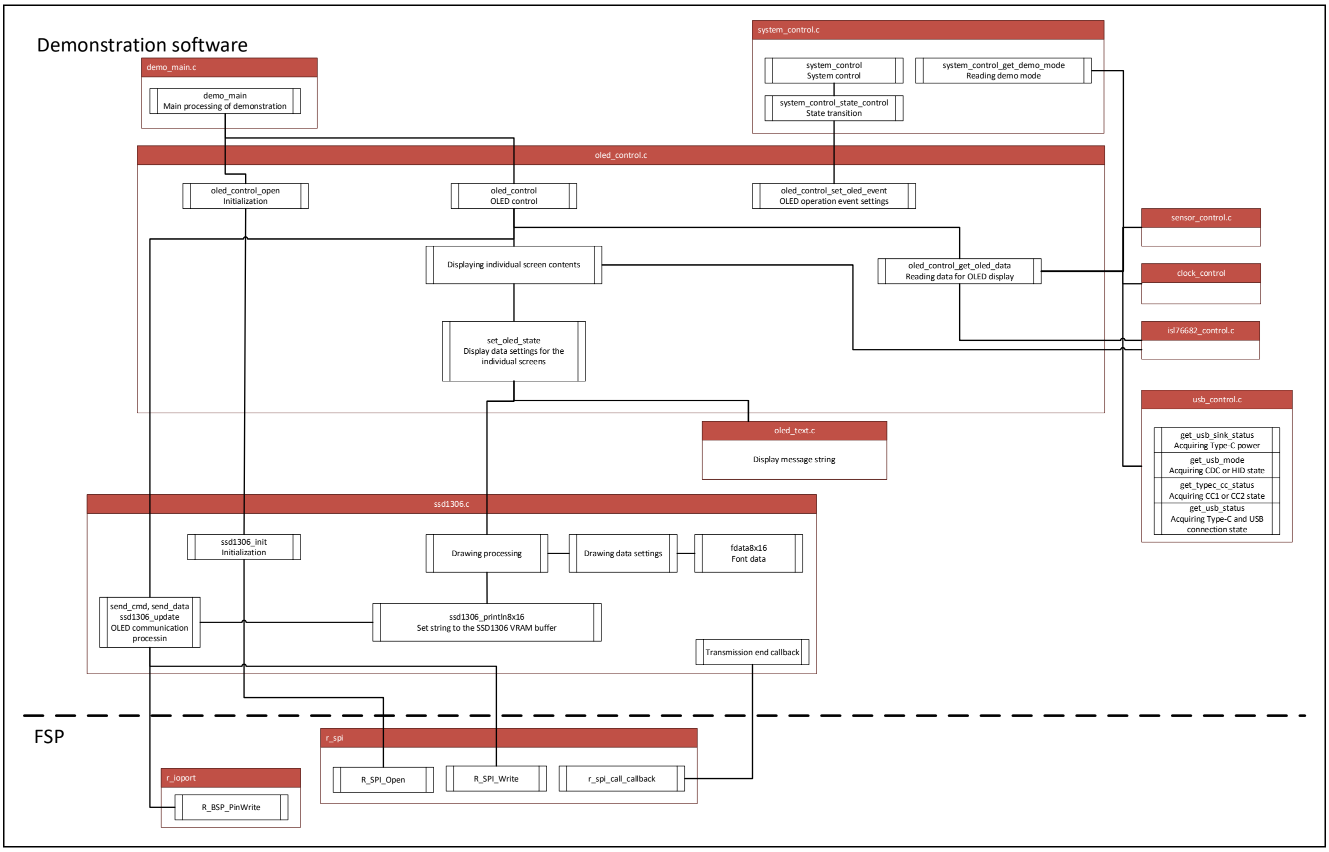


Figure 4-11 Structure of the OLED Display Processes

4.8.2 State Transitions

Figure 4-12 shows the state transitions for the display on the OLED. The screen contents displayed are switched by reception of a switch input notification from the system control process and of changes in the connection state from the USB control process.

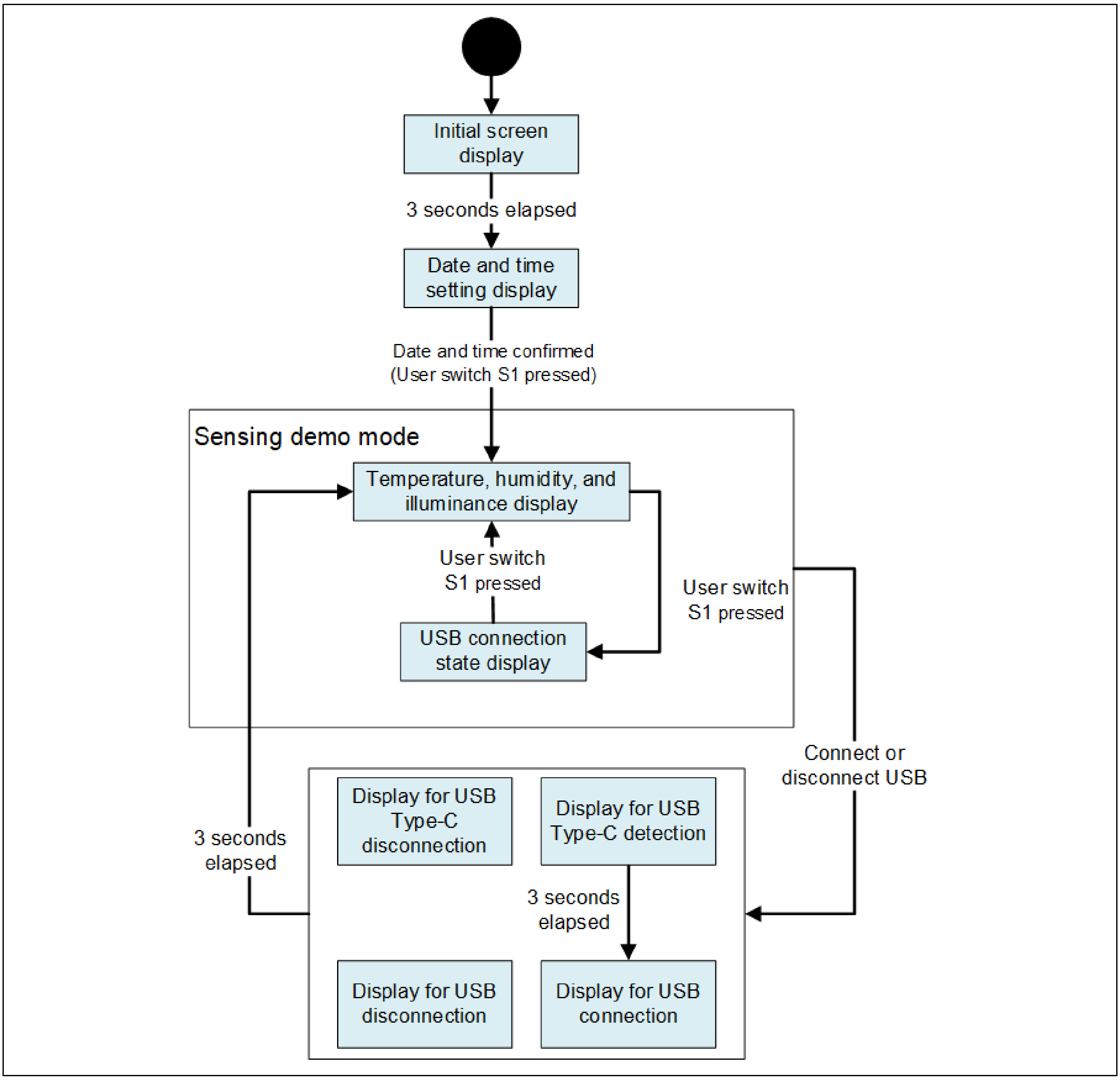


Figure 4-12 State Transitions for OLED Display

4.8.3 OLED Drawing Areas and Character Strings to be Displayed

In general, one character is composed of 8 × 16 dots. A screen can display 16 characters horizontally and two lines vertically.

The screen is divided into 32 areas horizontally and 4 areas vertically. The cursor location values x and y, which indicate one of the areas, are used to specify the display location.

As x is specified in 4-dot units and y is specified in 8-dot units, the ranges of the cursor location values are x = 0 to 31 and y = 0 to 3.

Only four characters [ ], ['], [,], and [.] are composed of 4 × 16 dots to implement “kerning” processing.

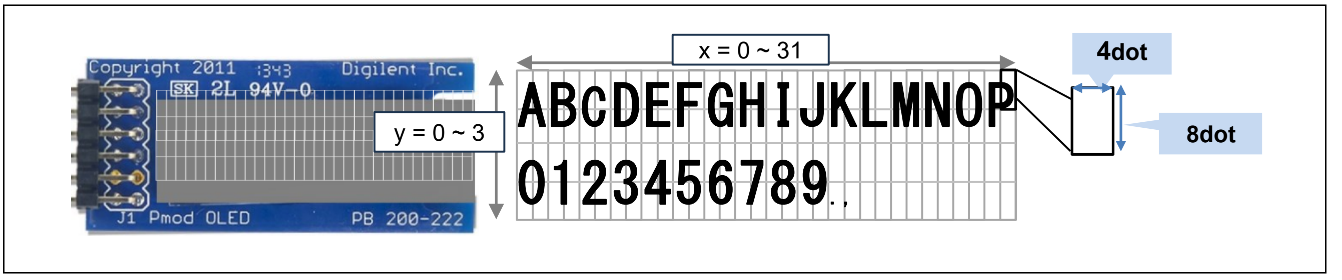


Figure 4-13 Configuration of the OLED Screen

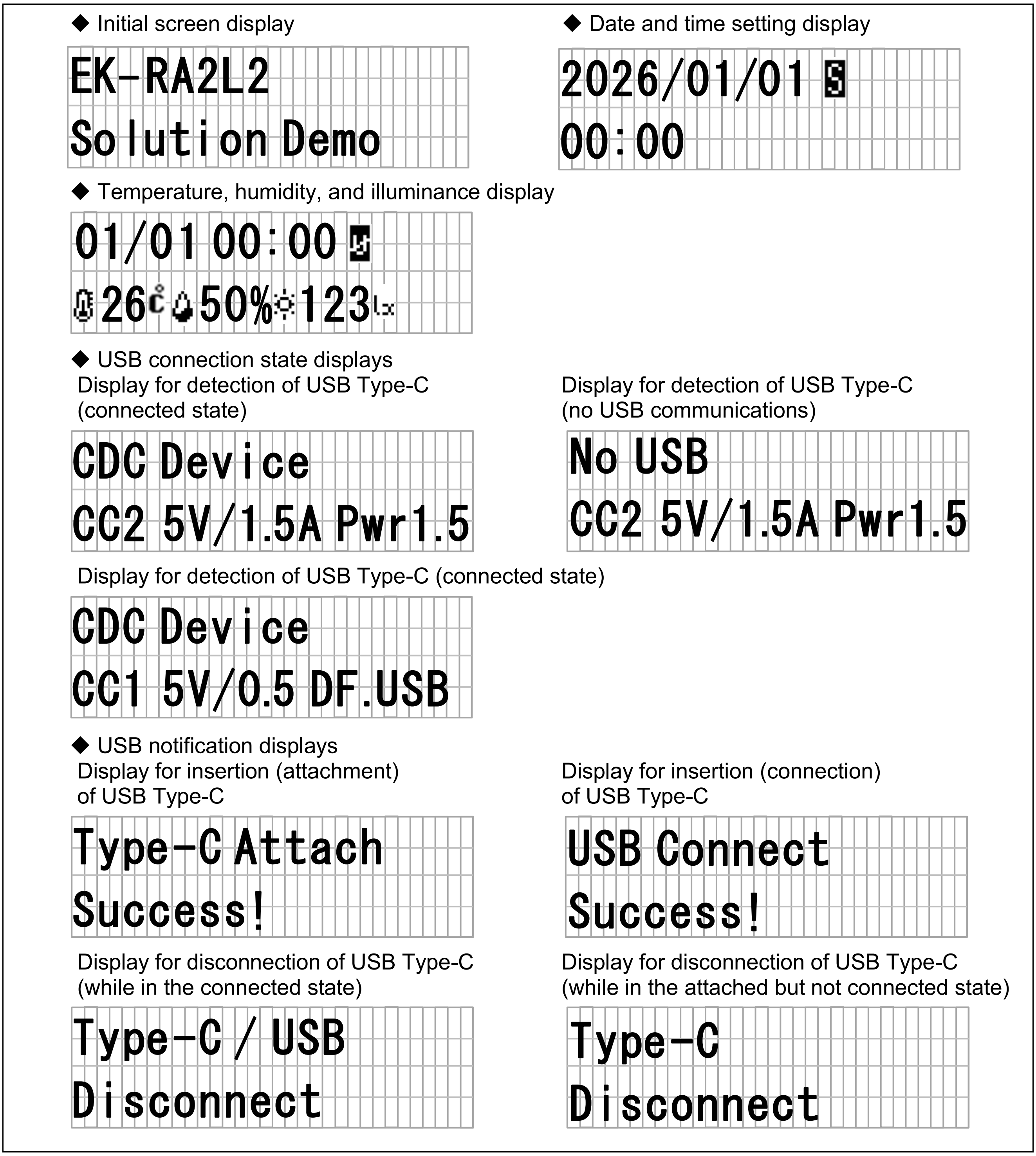


Figure 4-14 Examples of Character Strings Displayed on the OLED

Figure 4-15 shows examples of displays on the OLED and Figure 4-16 shows examples of the flows of USB notifications (for the connection of a charger and of a PC).

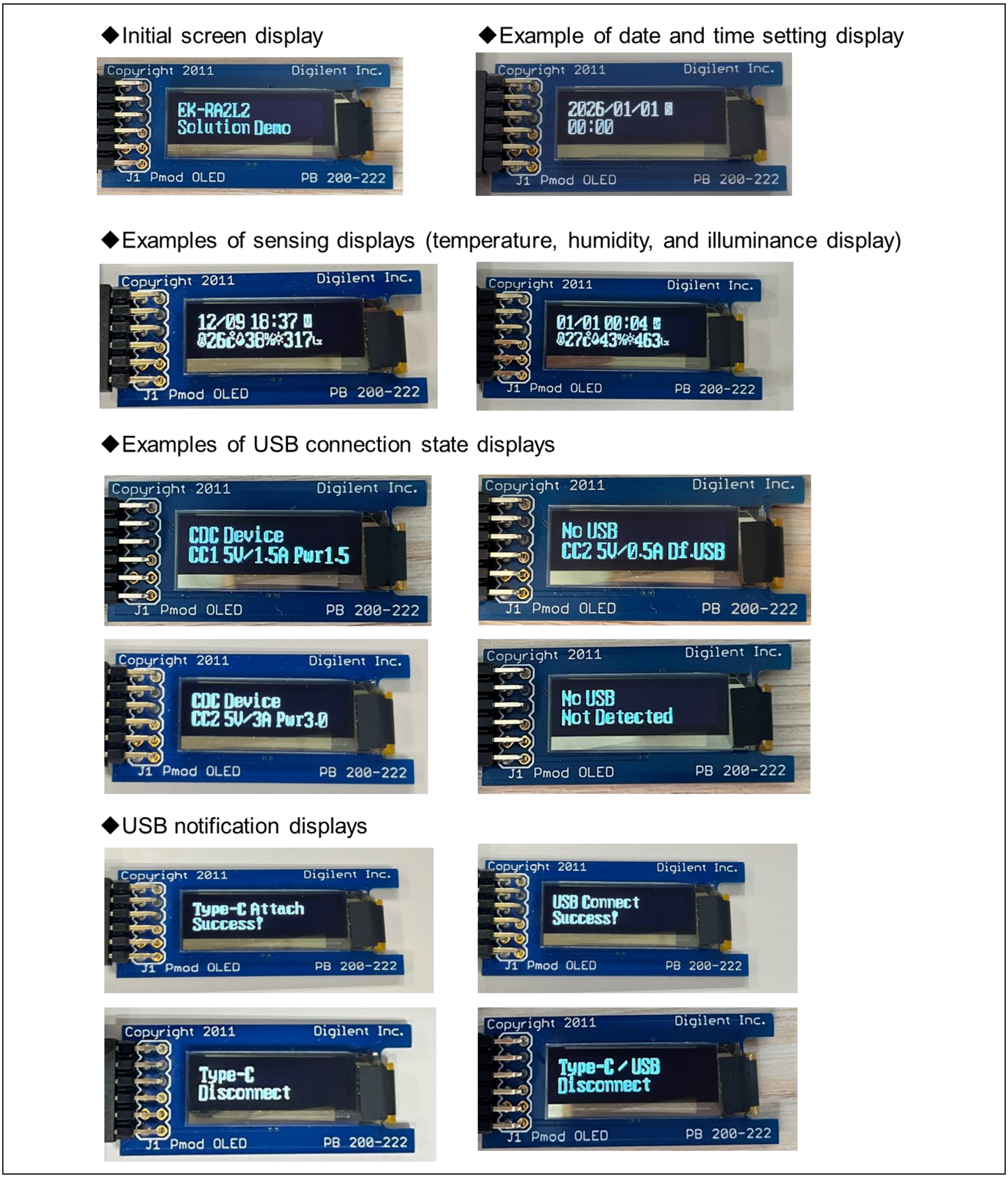


Figure 4-15 Examples of Displays on the OLED

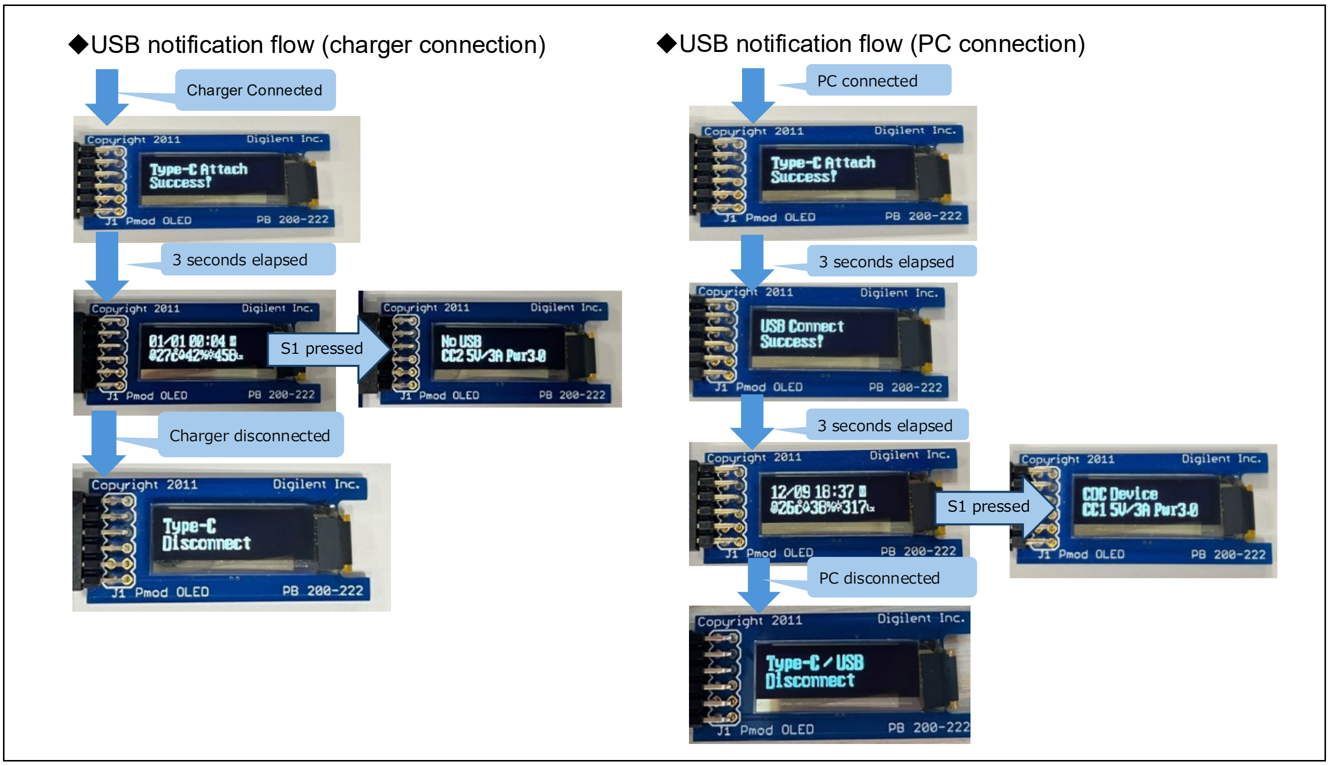


Figure 4-16 Examples of the Flows of USB Notification (for the Connection of a Charger and of a PC)

4.8.4 Font Data

Font data for ASCII codes 0x20 to 0x86 are created as 8 × 16 dots. 0x20 is a space and 0x80 to 0x86 are assigned to icons.

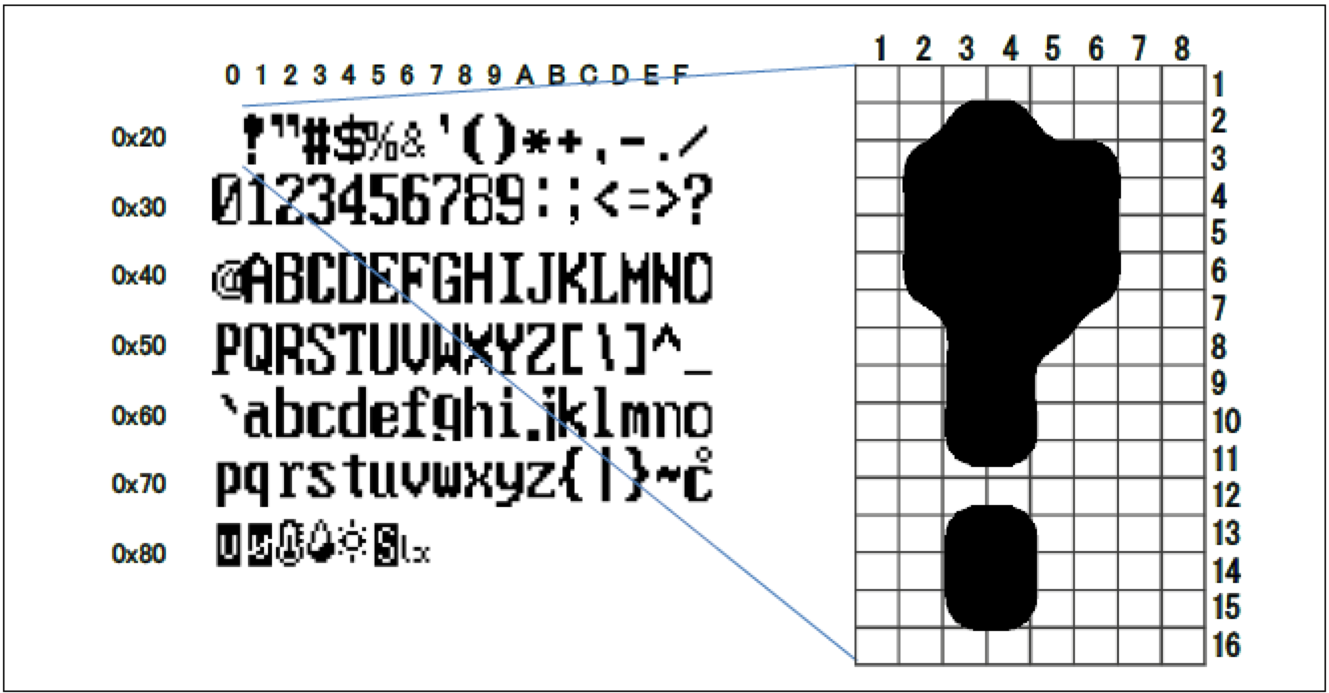


Figure 4-17 Font Data Defined in this System

The font data are defined in ssd1306.c. Each character (glyph) is represented by a total of 16 bytes, which consists of 8 bytes for the upper half and 8 bytes for the lower half.

```
static const uint8_t g_fdata8x16[] =
{
    // ascii_code_8x16_1_4dot.bmp
    0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x3C, 0xFE, 0xFE, 0x7C, 0x3C, 0x00, 0x00,     // SP !
    0x0E, 0x0E, 0x7E, 0x00, 0x0E, 0x0E, 0x7E, 0x00, 0x30, 0xFC, 0xFC, 0x30, 0xFC, 0xFC, 0x30, 0x00,     // ”  #
    0x70, 0xF0, 0x98, 0x98, 0xFE, 0x98, 0x98, 0x38, 0xF8, 0x88, 0xF8, 0x00, 0xC0, 0x30, 0x08, 0x00,     // $  %
    0x00, 0x00, 0x60, 0x98, 0x98, 0x60, 0x00, 0x00, 0x00, 0x0E, 0x3E, 0x00, 0x00, 0x00, 0x00, 0x00,     // &  ’
    0x00, 0xF0, 0xF8, 0xFC, 0x0E, 0x02, 0x00, 0x00, 0x00, 0x02, 0x0E, 0xFC, 0xF8, 0xF0, 0x00, 0x00,     // (  )
    0x80, 0xA0, 0xE0, 0xC0, 0xE0, 0xA0, 0x80, 0x00, 0x00, 0x80, 0x80, 0xE0, 0xE0, 0x80, 0x80, 0x00,     // *  +
    0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x80, 0x80, 0x80, 0x80, 0x80, 0x80, 0x00,     // ,  −
    0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x80, 0xC0, 0x60, 0x30, 0x00,     // .  /
    0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x3B, 0x3B, 0x00, 0x00, 0x00, 0x00,     // SP !
    0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x06, 0x3F, 0x3F, 0x06, 0x3F, 0x3F, 0x06, 0x00,     // ”  #
    0x0C, 0x18, 0x19, 0x19, 0x7F, 0x19, 0x19, 0x0F, 0x00, 0x10, 0x0C, 0x03, 0x00, 0x1F, 0x11, 0x1F,     // $  %
    0x00, 0x06, 0x09, 0x08, 0x09, 0x06, 0x0A, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,     // &  ’
    0x00, 0x07, 0x0F, 0x1F, 0x38, 0x20, 0x00, 0x00, 0x00, 0x20, 0x38, 0x1F, 0x0F, 0x07, 0x00, 0x00,     // (  )
    0x01, 0x05, 0x07, 0x03, 0x07, 0x05, 0x01, 0x00, 0x00, 0x01, 0x01, 0x07, 0x07, 0x01, 0x01, 0x00,     // *  +
    0x00, 0x1C, 0x7C, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x01, 0x01, 0x01, 0x01, 0x01, 0x01, 0x00,     // ,  −
    0x00, 0x18, 0x18, 0x00, 0x00, 0x00, 0x00, 0x00, 0x0C, 0x06, 0x03, 0x01, 0x00, 0x00, 0x00, 0x00,     // .  /
```

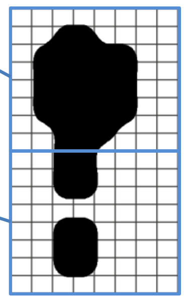


Figure 4-18 Arrangement of Font Data

4.8.5 Icons to be Displayed

This system uses seven 8- × 16-pixel icons.

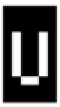
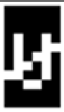
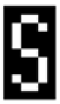
Item	Icon	Width	Height	Remark
1		8	16	USB Type-C is connected.
2		8	16	USB Type-C is not connected.
3		8	16	This is displayed in date and time setting mode.
4		8	16	Temperature icon
5		8	16	Humidity icon
6		8	16	Illuminance icon
7		8	16	Unit of illuminance, lux

Figure 4-19 Types and Meanings of Icons to be Displayed

The following shows an example of the date, time, temperature, humidity, and illuminance being displayed. This includes display of the icons for USB being disconnected, temperature, humidity, illuminance, and lux.

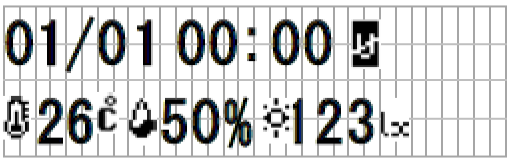


Figure 4-20 Example of a Display Including Icons

4.8.6 Flowchart of OLED Drawing

A screen is composed of PAGE0 to PAGE3, for a total of 512 bytes of VRAM. The image buffer for that size is defined as uint8_t rambuffer[512] in the program.

Transferring data from rambuffer to the OLED VRAM leads to display of the data on the OLED.

The OLED display sequence specifies the display data for a screen in rambuffer according to the mode, each of which is indicated by a case statement. The rambuffer data specified by the display sequence are actually displayed on the OLED panel by using the OLED data transfer sequence, which is described on the next page.

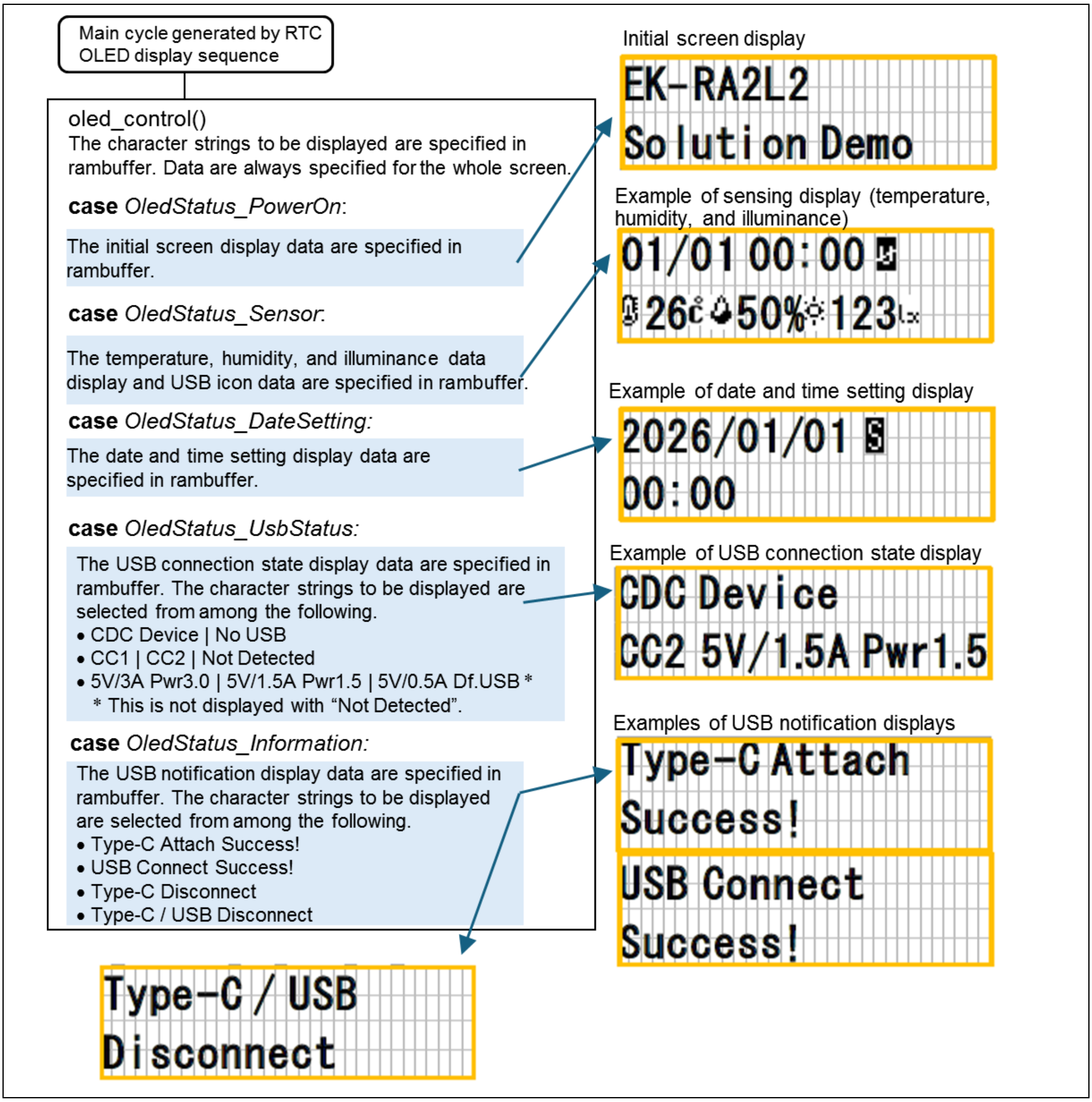


Figure 4-21 Examples of Displayed Character Strings

The OLED data transfer sequence is used to actually display on the OLED panel the rambuffer data for a screen that were specified by the OLED display sequence.

As shown in Figure 3-6, Structure of the VRAM for the OLED, in section 3.4, one OLED screen is composed of four pages. The OLED data transfer sequence (ssd1306_update_process()) function sends the rambuffer data for only one page (1/4 screen) to the OLED panel. This function is called four times to complete the display of one OLED screen.

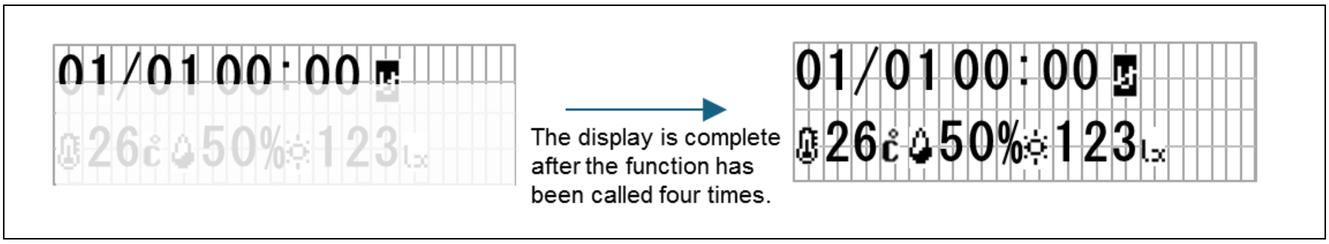


Figure 4-22 Calling the OLED Data Transfer Sequence Four Times

Figure 4-23 illustrates the data transfer for one page (1/4 of the screen).

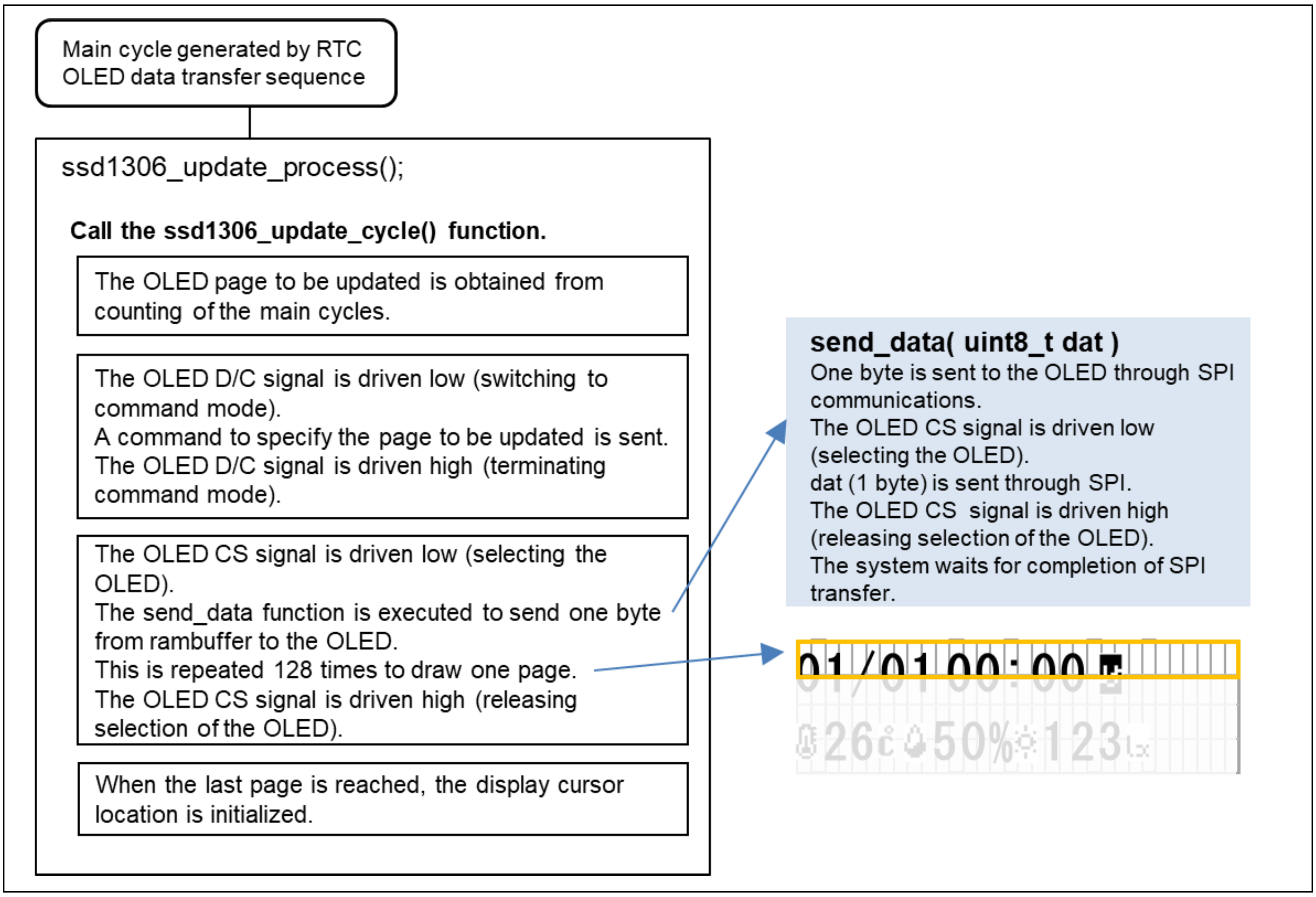


Figure 4-23 OLED Data Transfer Sequence (Example of Displaying PAGE0 Only)

4.9 Temperature and Humidity Sensor Control

This system uses the HS4001 temperature and humidity sensor made by Renesas. The HS400X driver in the FSP is used without change in the sample code to control the sensor.

The results of measurement are acquired from the temperature and humidity sensor at 1-second intervals in sensing demo mode. Other process blocks can read each of the integer and fractional parts of the results in the int8_t type. Only the latest results from the sensor can be read.

4.9.1 Processing Structure

Figure 4-24 shows the structure of the processes of temperature and humidity sensor control.

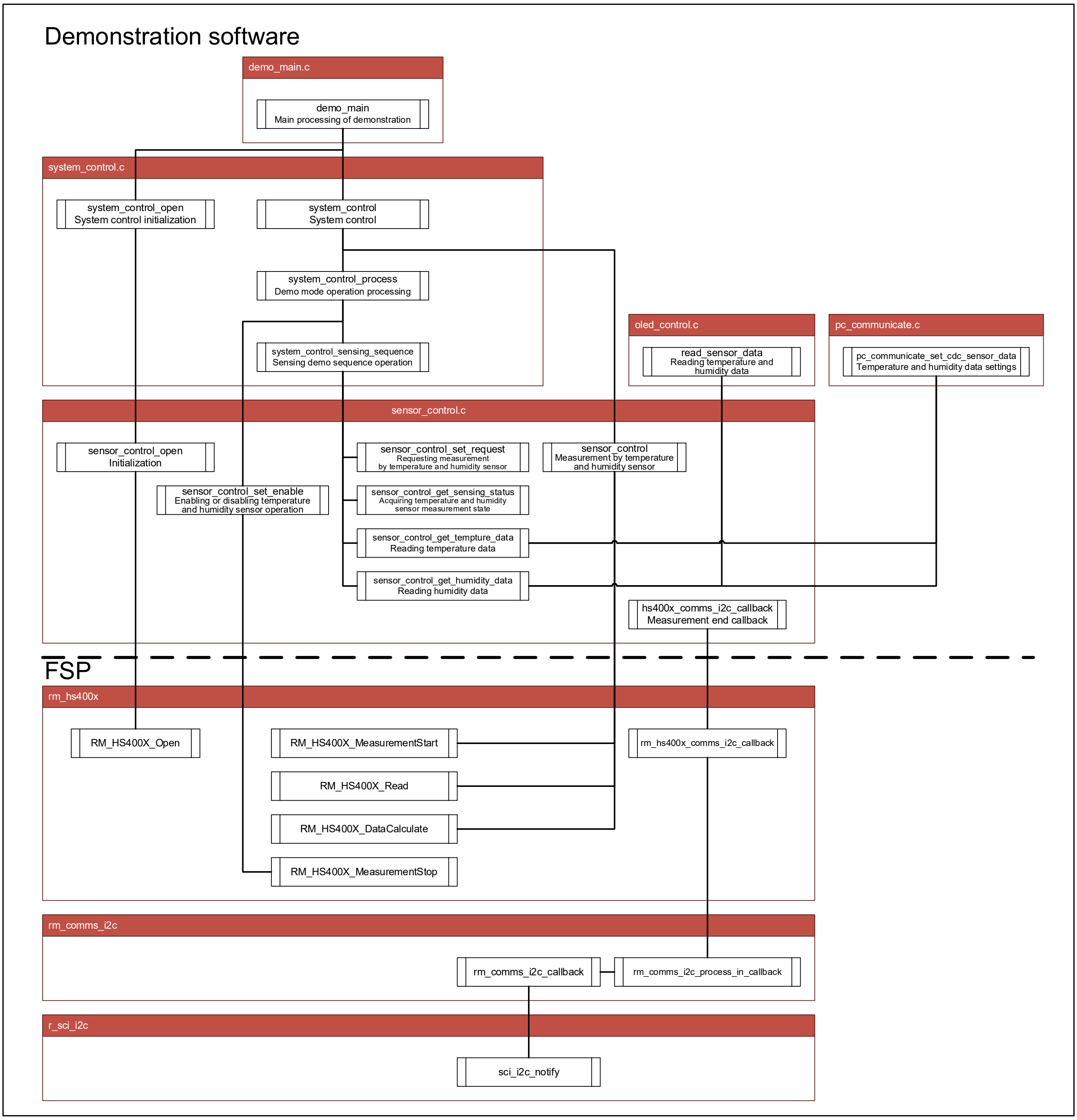


Figure 4-24 Structure of the Temperature and Humidity Sensor Processes

4.10 Light Sensor Control

This system uses the ISL76682 light-to-digital sensor made by Renesas.

The results of measuring illuminance are acquired from the light sensor at 1-second intervals in sensing demo mode. The latest measured value from the sensor and the maximum, minimum, and average values of the results measured over five seconds can be read.

The registers of the ISL76682 are specified as shown in Table 4-6.

Table 4-6 Register Settings in the ISL76682

Address	Register Name	Bit	Parameter	Operation
00h	COMMAND	RANGE0	1	Range 4 (Range 4 = 0.96 lux to 64,000 lux)
		RANGE1	1	
		RES0	0	Internal timing, 16-bit ADC data output
		RES1	0	
		RES2	0	
		LIGHT	0	Ambient light sensing
		MODE	1	Continuous measurement
		EN	1	Enable the device
01h	$DATA_{LSB}$	D0 to D7	00h	Default
02h	$DATA_{MSB}$	D8 to D15	00h	Default

4.10.1 Processing Structure

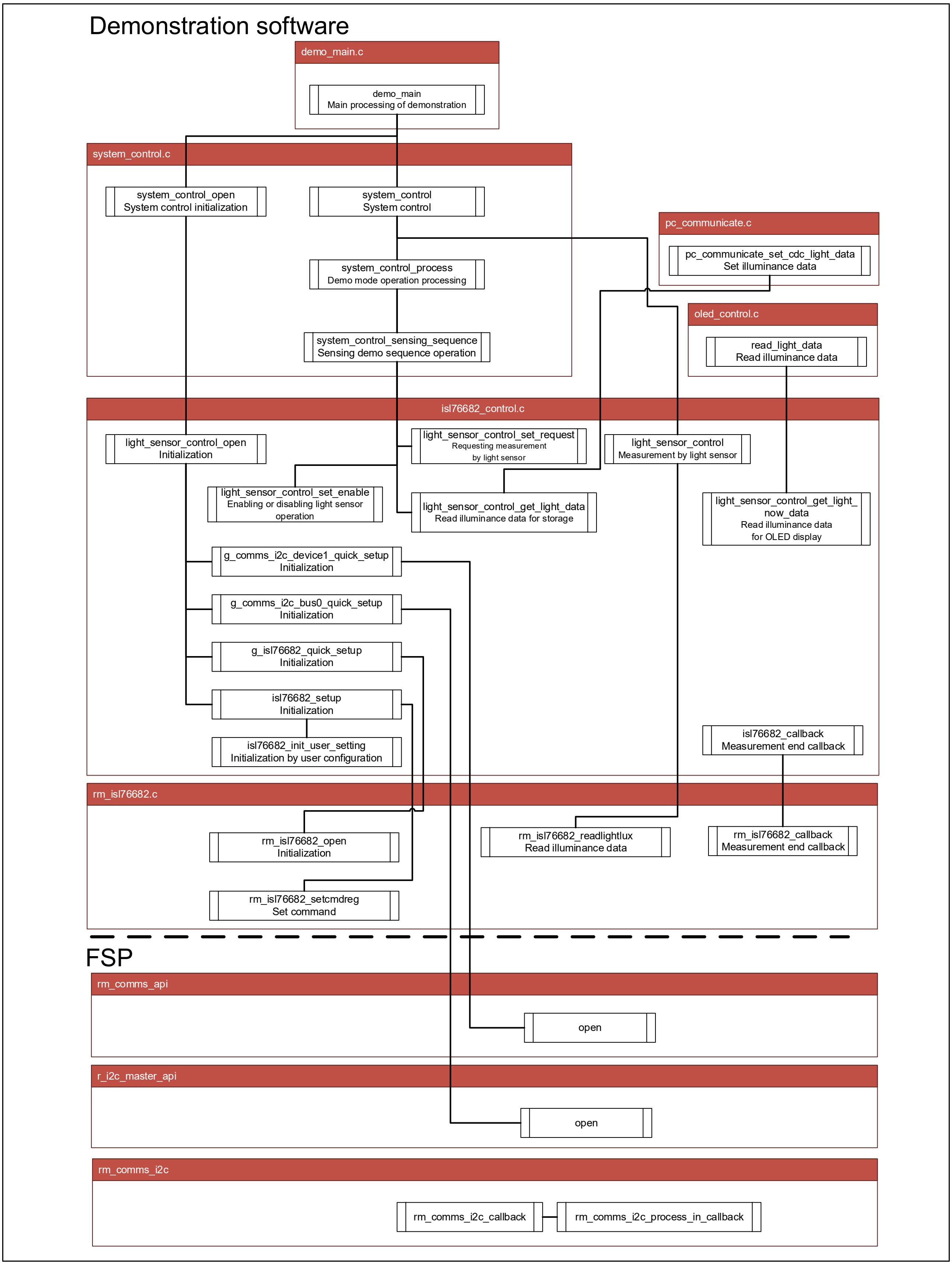


Figure 4-25 Structure of the Light Sensor Control Processes

4.11 Data Control

The sample code stores the data measured by the temperature and humidity sensor and light sensor in data flash memory at 5-second intervals.

For the temperature and humidity data, the values measured within one second after the time of the latest storage are stored. For the illuminance data, the maximum, minimum, and average values of the results measured over five seconds are stored. The date and time of storage are appended to the stored data.

The stored data can be read in order from oldest to latest. Once a value is read, the value cannot be read again. If the date and time setting is changed, all stored data are erased.

4.11.1 Processing Structure

Figure 4-26 shows the structure of the data control processes.

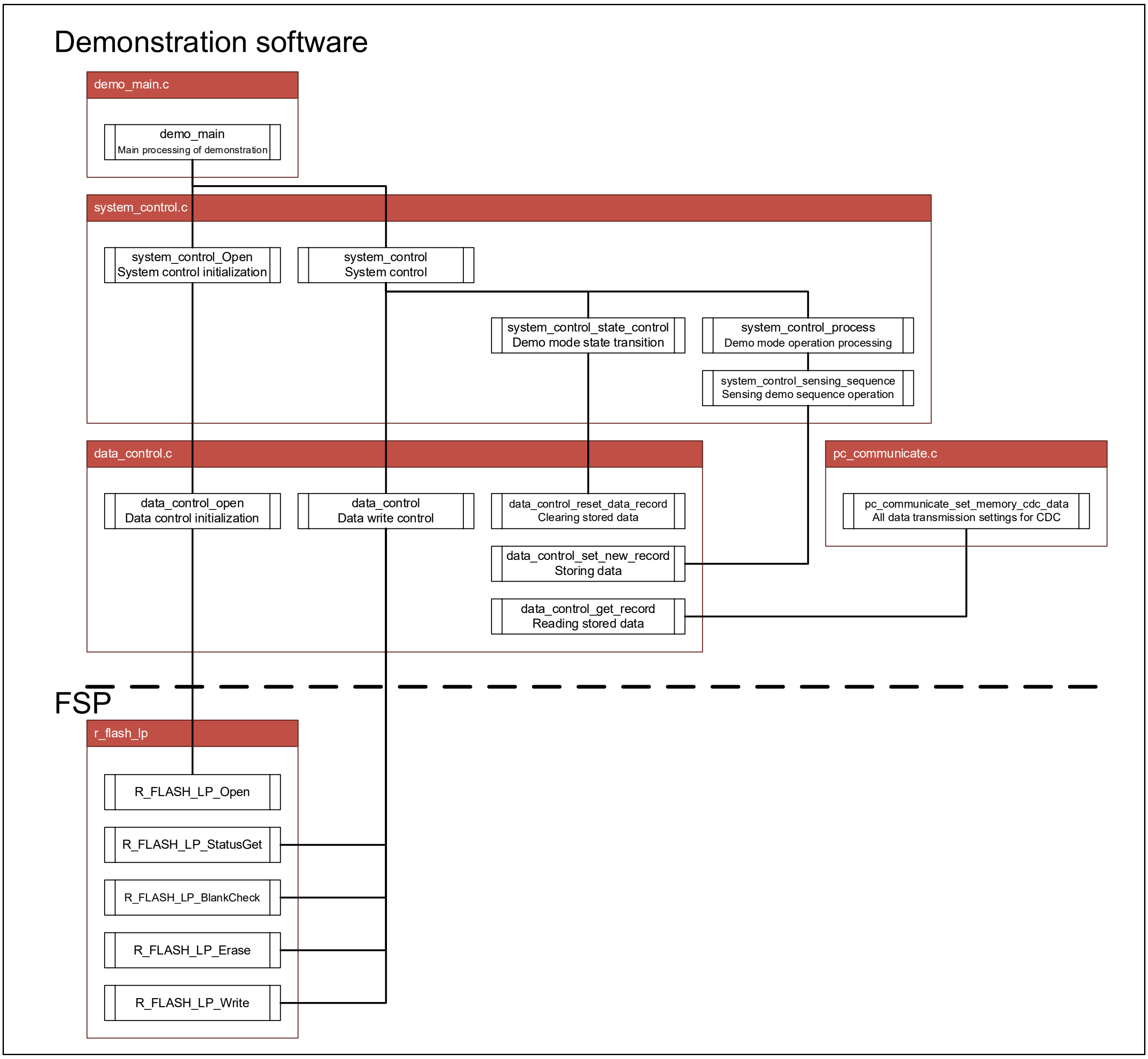


Figure 4-26 Structure of the Data Control Processes

4.11.2 Format of Data Records to be Stored

Table 4-7 shows the format of the data records to be stored.

Table 4-7 Format of the Data Records to be Stored

Stored Data Item	Data Type	Data Length	Data Range	Remark
Date (year)	uint8_t	1	0x00 to 0x99	BCD
Date (month)	uint8_t	1	0x01 to 0x12	BCD
Date (day)	uint8_t	1	0x01 to 0x31	BCD
Date (hour)	uint8_t	1	0x00 to 0x23	BCD
Date (minute)	uint8_t	1	0x00 to 0x59	BCD
Date (second)	uint8_t	1	0x00 to 0x59	BCD
Temperature (integer part)	int8_t	1	-40 to 125	
Temperature (fractional part)	int8_t	1	-99 to 99	
Humidity (integer part)	int8_t	1	0 to 100	
Humidity (fractional part)	int8_t	1	0 to 99	
Maximum illuminance value (integer part)	uint16_t	2	0 to 64000	
Minimum illuminance value (integer part)	uint16_t	2	0 to 64000	
Average illuminance value (integer part)	uint16_t	2	0 to 64000	
Dummy data	int16_t	2	0	Dummy
Dummy data	int16_t	2	0	Dummy
Dummy data	int16_t	2	0	Dummy

4.11.3 Allocation of Records in Data Flash Memory

Records are stored in data flash memory such that they do not overlap block boundaries. Table 4-8 shows the allocation of records in data flash memory.

Table 4-8 Record Allocation in Data Flash Memory

Address	Block	Record ID	Remark
0x000	0	0	
0x016		1	
:		:	
0x3DE		45	
0x3F4			Unused space
0x400	1	46	
0x416		47	
:		:	
0x7DE		91	
0x7F4			Unused space
0x800	2	92	
0x816		93	
:		:	
0xBDE		137	
0xBF4			Unused space
0xC00	3	138	
0xC16		139	
:		:	
0xFDE		183	
0xFF4			Unused space

4.11.4 Record Control

Before a record is stored, if the record is the first record of the block, the block is checked to see whether it is empty. If the block is not empty, the block is erased. Figure 4-27 is an overview of the record control operation.

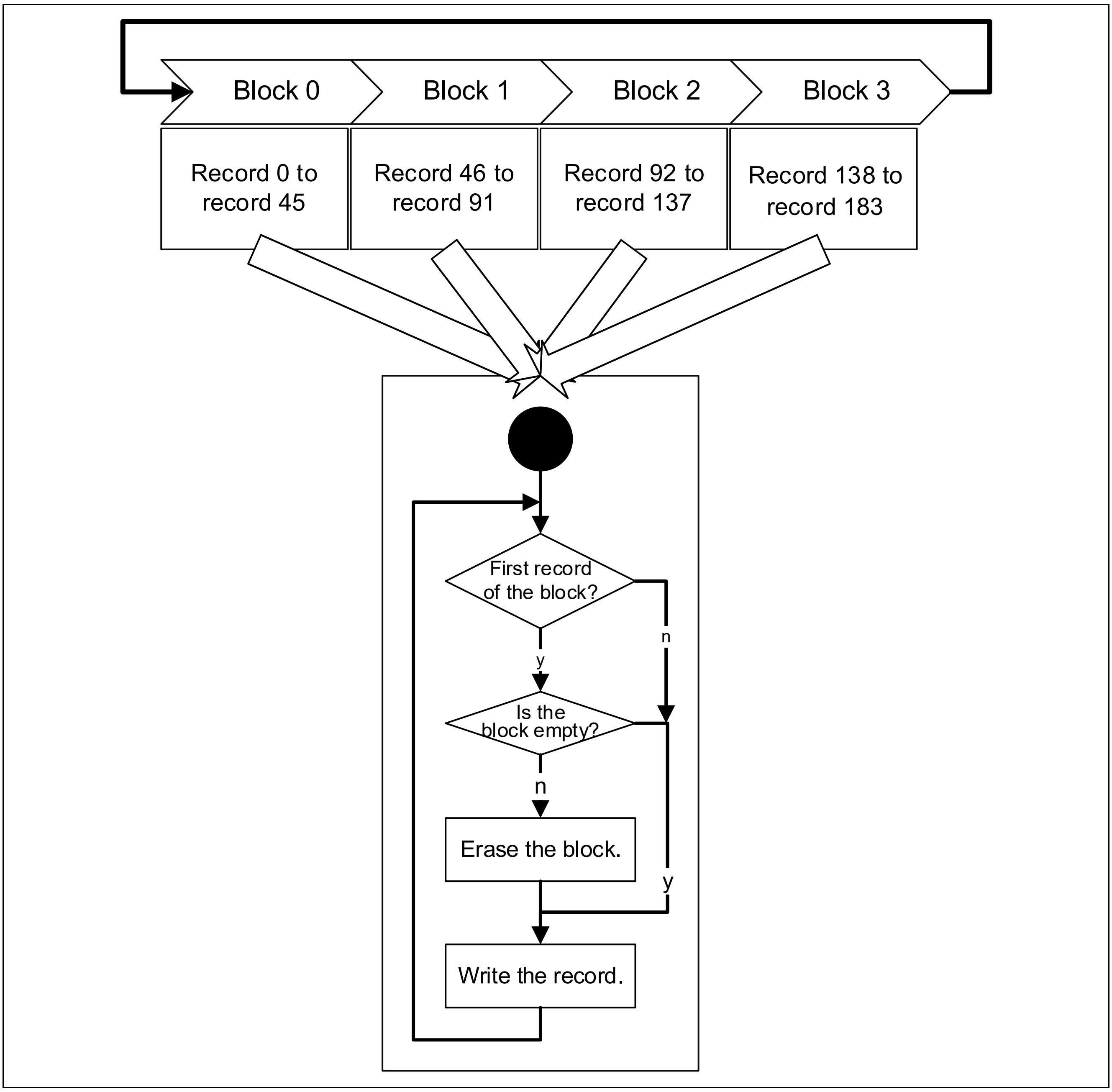


Figure 4-27 Overview of Record Control Operation

4.11.5 Control of Read Operations

Stored data are read in order from oldest to latest every time a read operation is requested. The state of whether each stored record has been read is controlled and a record that has been read is not read again.

If the latest record has already been read, a response indicating that there are no data to be read is returned. If the block that includes the oldest record is to be erased before a new record is stored, the oldest record in the next block that is not to be erased is handled as the oldest data.

Figure 4-28 is an overview of the control of read operations.

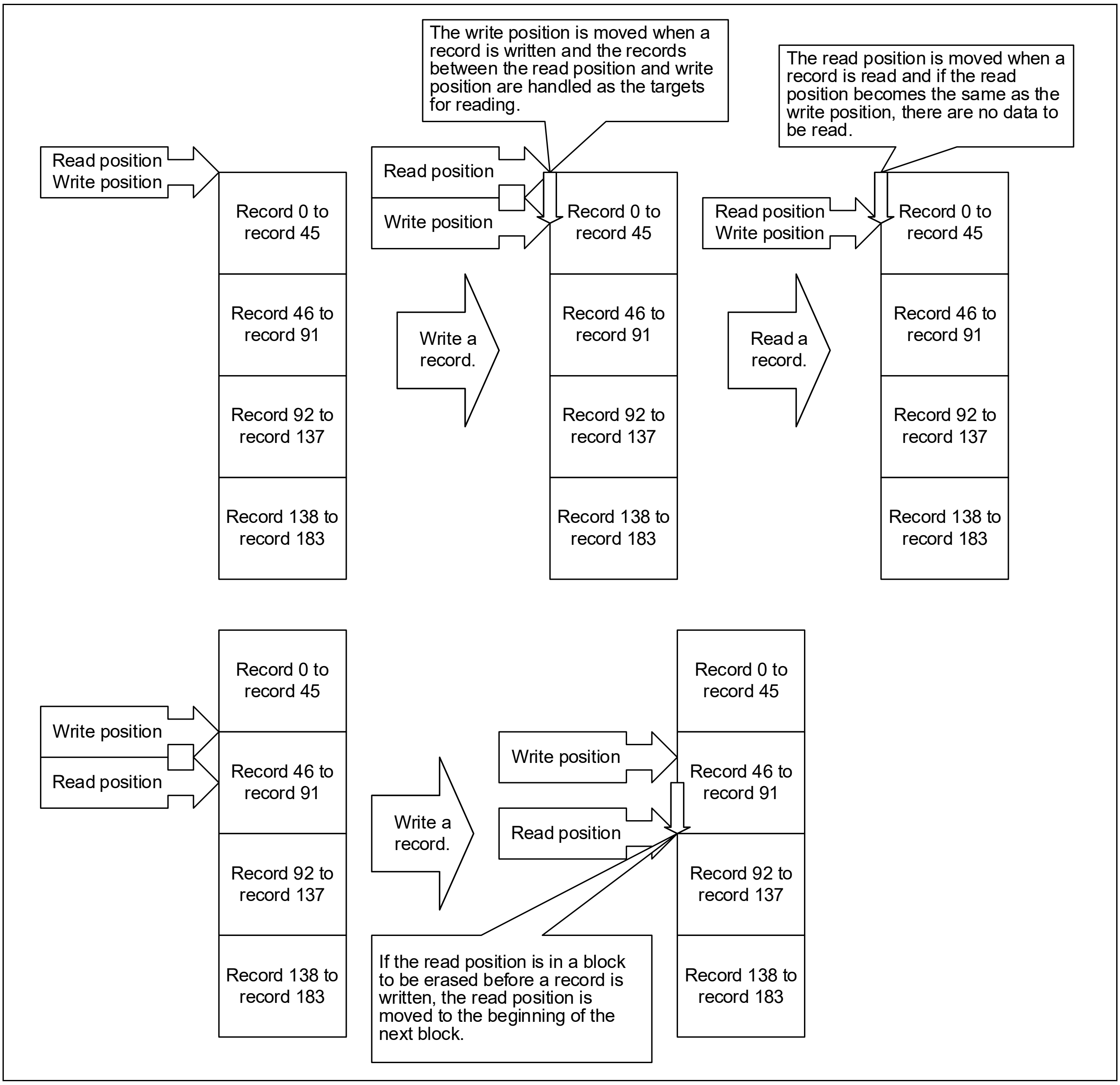


Figure 4-28 Overview of Control of Read Operations

4.12 USB Control

The following describes the specifications of the operations of the USB Type-C and USB FS software in this system.

4.12.1 Processing Structure

Figure 4-29 shows the structure of the processes for controlling USB Type-C and USB FS connections.

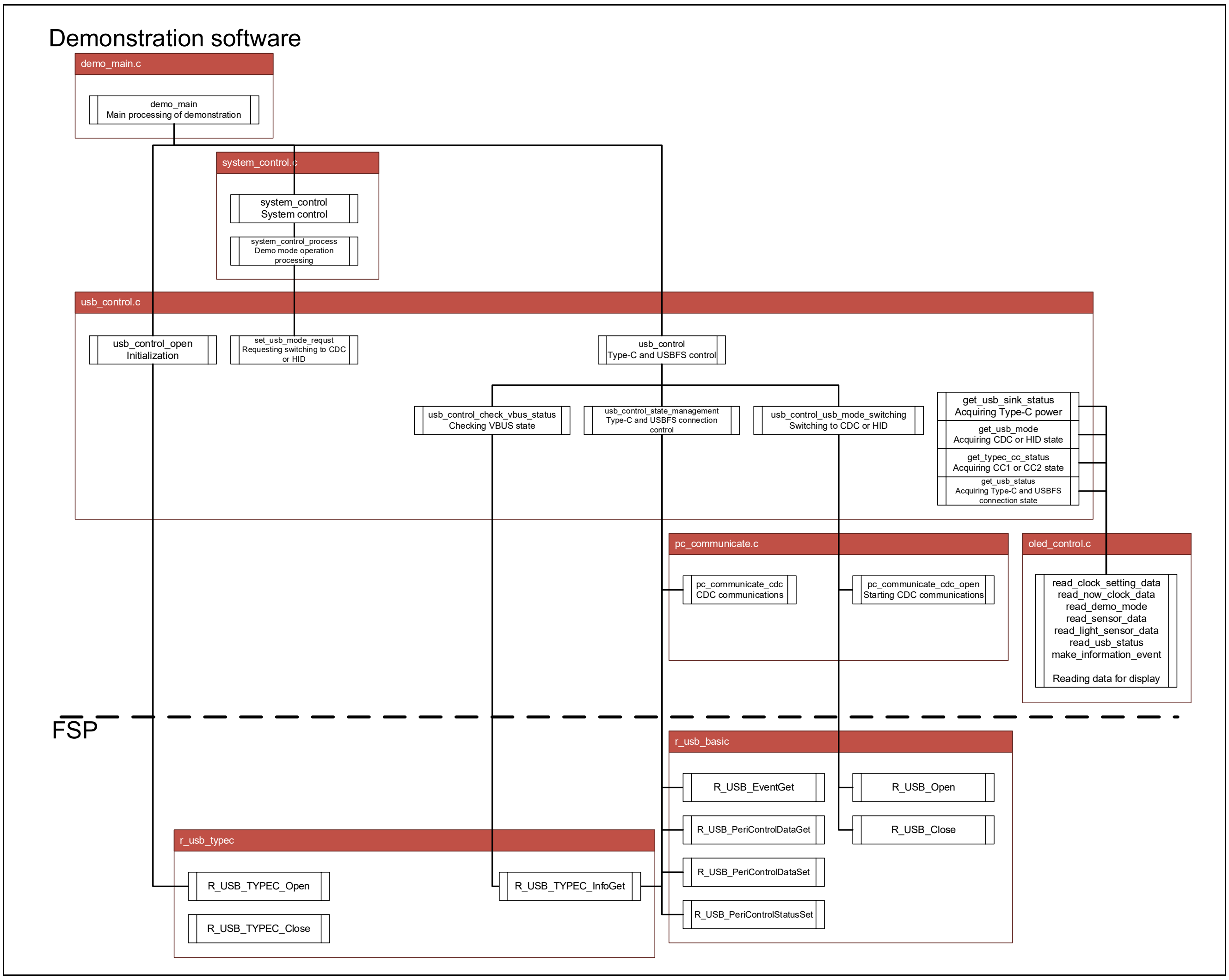


Figure 4-29 Structure of the Processes for Controlling USB Type-C and USB FS Connections

4.12.2 Connection State Control

Figure 4-30 is a state transition diagram of the control of the USB Type-C and USB FS connections.

The USB Type-C state is controlled by using the USB Type-C connection state and CDC connection events. The result of switching executed before the USB Type-C connection is made is reflected after the USB Type-C connection.

The USB-TYPEC (r_usb_typec) module of the FSP is used to detect a USB Type-C CC connection. For details of the USB-TYPEC (r_usb_typec) module, refer to the description of USB TYPEC (r_usb_typec) in the FSP Documentation V6.3.0.

In addition, the USB (r_usb_basic) module of the FSP is used to handle the USB FS connection operation (enumeration). For details of the USB (r_usb_basic) module, refer to the description of USB (r_usb_basic) in the FSP Documentation V6.3.0.

- FSP Documentation V6.3.0
  Extract the data from the downloaded zip file and open the following files.
  — Top page
  ¥fsp_documentation_v6.3.0¥fsp_documentation¥v6.3.0¥fsp_user_manual_v6.3.0¥**index.html**
  — USB-TYPEC (r_usb_typec) module
  ¥fsp_documentation_v6.3.0¥fsp_documentation¥v6.3.0¥fsp_user_manual_v6.3.0¥**group___u_s_b___t_y_p_e_c.html**
  — USB(r_usb_basic) module
  ¥fsp_documentation_v6.3.0¥fsp_documentation¥v6.3.0¥fsp_user_manual_v6.3.0¥**group___u_s_b.html**

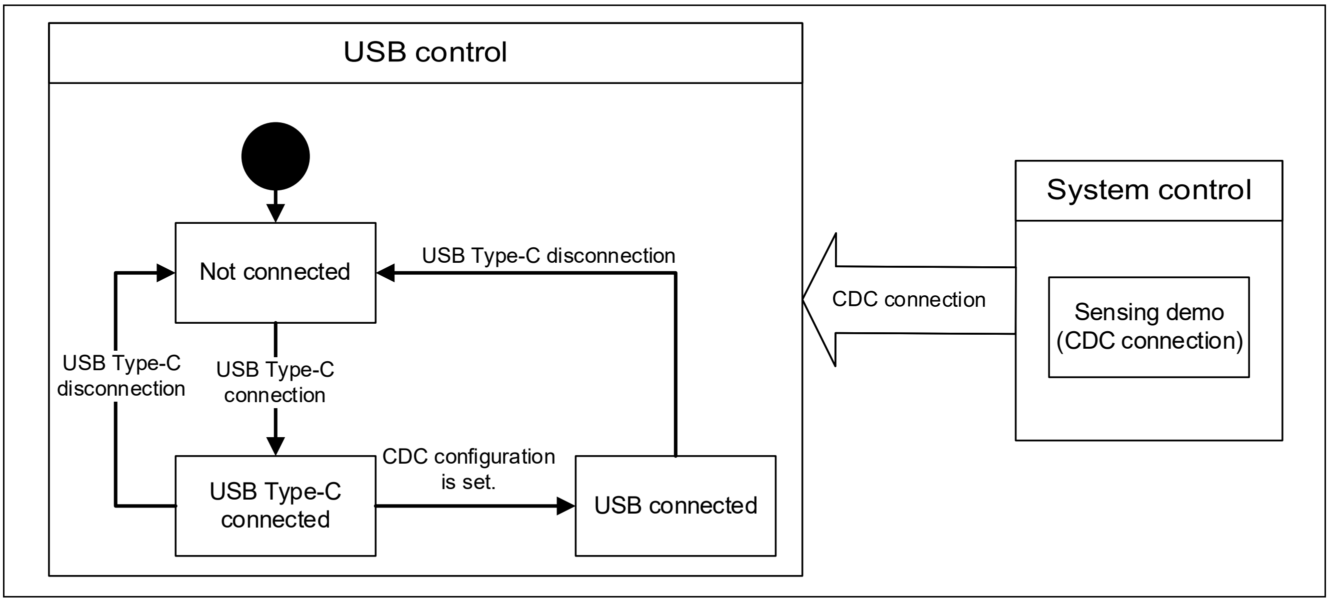


Figure 4-30 State Transitions for Controlling USB Type-C and USB FS Connections

4.13 Communications with the PC Application

The demonstration software uses CDC in communicating with the demonstration PC application in sensing demo mode. Communications with the PC do not proceed during date and time setting.

4.13.1 Processing Structure

Figure 4-31 shows the processing structure for communications with the PC application.

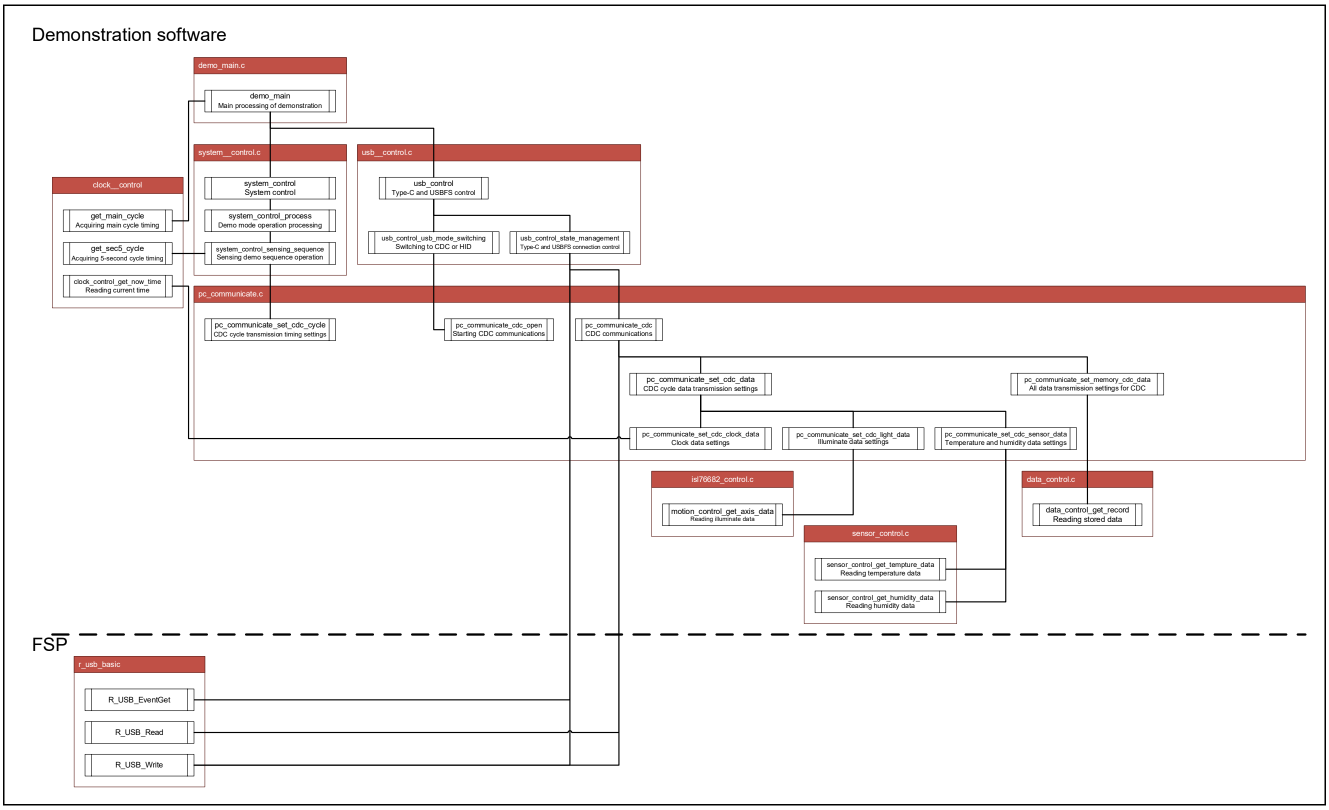


Figure 4-31 Structure of the Processes for Communications with the PC Application

4.13.2 CDC Communications

After reception of a communications start command, data are transmitted at 5-second intervals until reception of a communications stop command. If an all data read command is received, data are sent in the order of reading until there are no data to be read according to the data control process. Figure 4-32 shows the state transitions for CDC communications.

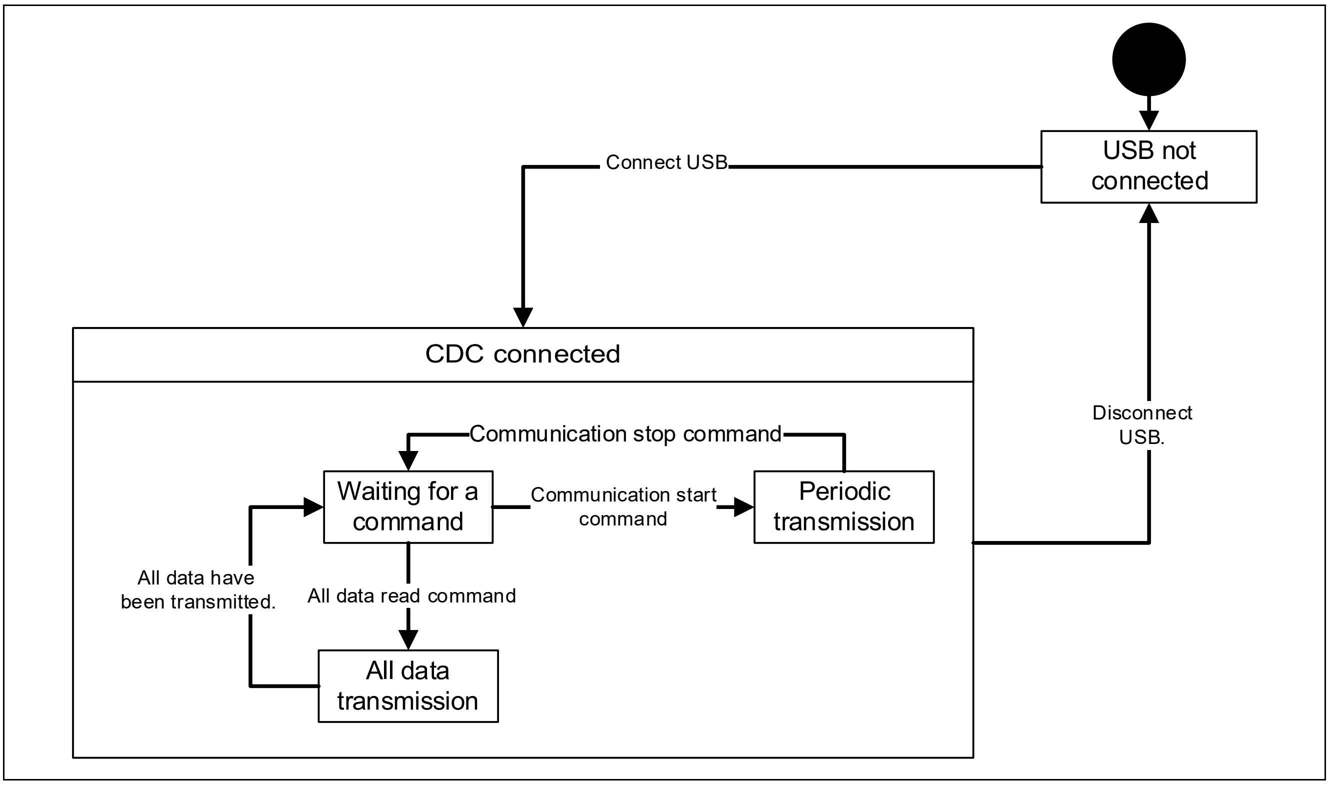


Figure 4-32 State Transitions for CDC Communications

4.13.3 Periodic Transmission

After reception of a communications start command, data are transmitted to the PC at 5-second intervals until a communications stop command is received. (a) The date and time acquired from the RTC, (b) the results of measurement acquired from the temperature and humidity sensor control process, and (c) the results of measurement acquired from the light sensor control process are transmitted to the PC. Figure 4-33 shows the state transitions for periodic transmission.

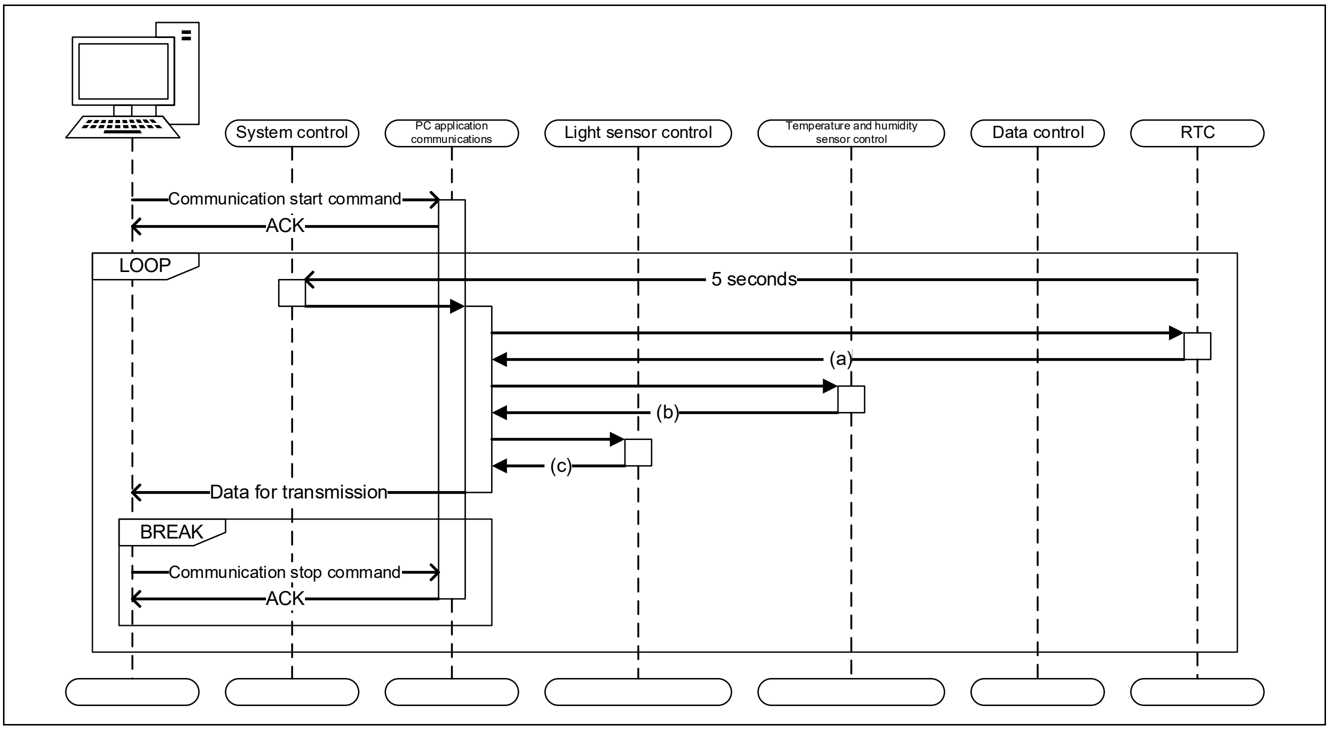


Figure 4-33 State Transitions for Periodic Transmission

4.13.4 All Data Transmission

After reception of an all data read command, data are transmitted to the PC at intervals of the main cycle. Records are read from the data control process and transmitted to the PC. Data transmission ends when there are no data to be read from the data control process. To indicate the end of data, data containing bytes filled with 0xFF except for the STX, ETX, and command bytes are sent. Figure 4-34 shows the state transitions for all data transmission.

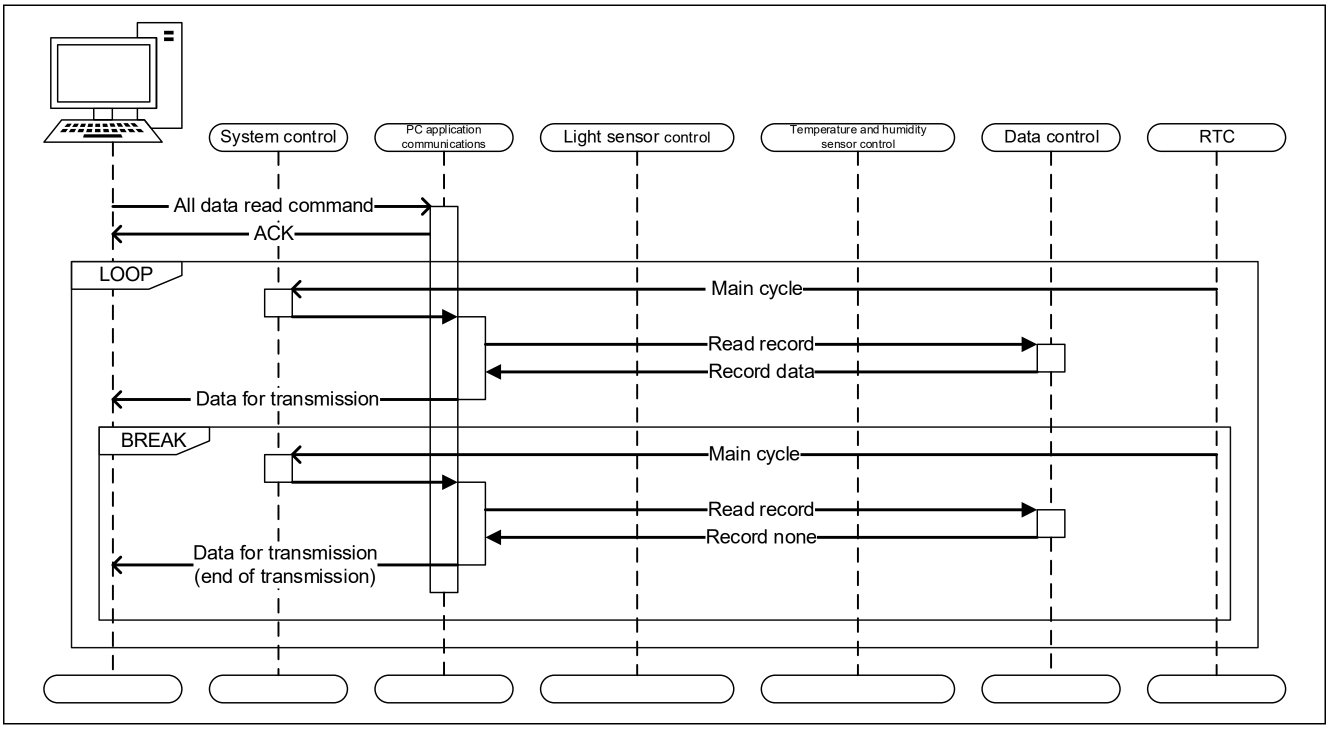


Figure 4-34 State Transitions for All Data Transmission

4.13.5 Format of Receive Commands

Table 4-9 shows the format of receive commands.

Table 4-9 Format of Receive Commands

Data Offset (Bytes)	Contents	Command	Remark
0	STX	0x02	
1	Command	0x30 to 0x32	0x30: Communications start command 0x31: Communications stop command 0x32: Read command
2	ETX	0x03	

4.13.6 Format of Transmission Data

Table 4-10 shows the format of transmission data.

Table 4-10 Format of Transmission Data

Data Offset (Bytes)	Contents	Transmission Data	Remark
0	STX	0x02	
1	Command	0x5A	
2	Year	0x00 to 0x99	
3	Month	0x01 to 0x12	BCD
4	Day	0x01 to 0x31	BCD
5	Hour	0x00 to 0x24	BCD
6	Minute	0x00 to 0x59	BCD
7	Second	0x00 to 0x59	BCD
8	Temperature	-40 to 125	Integer part
9		-99 to 99	Fractional part
10	Humidity	0 to 100	Integer part
11		0 to 99	Fractional part
12 and 13	Maximum illuminance	0 to 64000	
14 and 15	Minimum illuminance	0 to 64000	
16 and 17	Average illuminance	0 to 64000	
18 and 19	Dummy data	0	Dummy data
20 and 21		0	Dummy data
22 and 23		0	Dummy data
24	ETX	0x03	

4.14 VBUS Monitoring

This section describes the operation of the VBUS monitoring function. This function uses QE for USB, a USB development assistance tool, to enable monitoring of the VBUS voltage and current. For details on how to use the VBUS monitoring function through QE for USB, refer to Chapter 7, Procedure for Using QE for USB to Confirm the USB VBUS Voltage and Current.

4.14.1 Processing Structure

Figure 4-35 shows the structure of the VBUS monitoring processes.

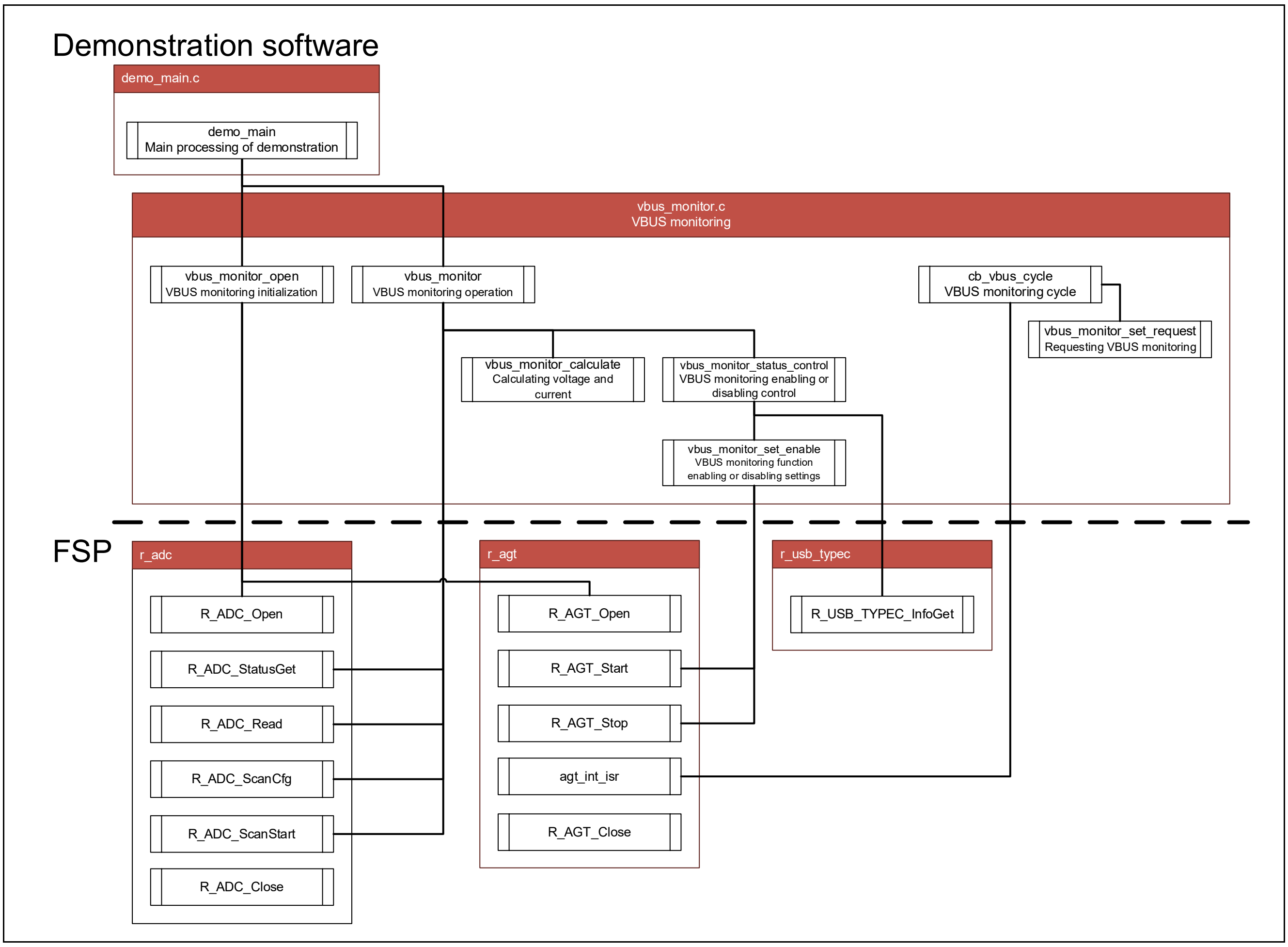


Figure 4-35 Structure of the VBUS Monitoring Processes

4.14.2 VBUS Monitoring Operation

The VBUS monitoring function operates while VBUS ON is detected by the USB control process. The results of A/D conversion of the values from the ADC pins that are assigned to VSENSE and ISENSE are measured at 40-ms intervals set up by using the AGT module. The results of A/D conversion for VSENSE and ISENSE are only read once at this time and the obtained VSENSE and ISENSE values are converted to voltage and current values and stored as global data. Note that the voltage and current values are set to 0 while VBUS monitoring is stopped. Figure 4-36 shows the state transitions for VBUS monitoring.

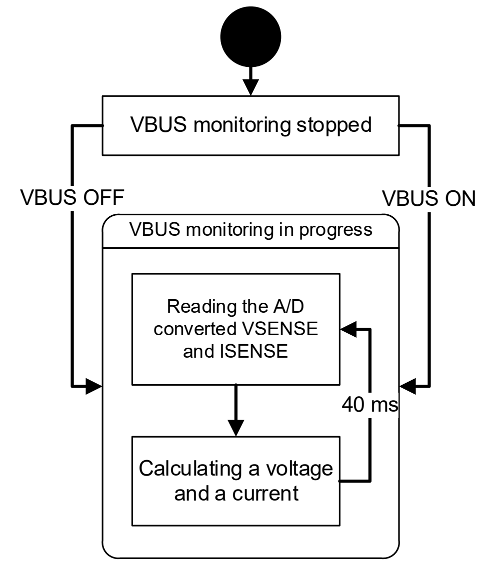


Figure 4-36 State Transitions for VBUS Monitoring

4.14.3 Calculation of VBUS Voltage and Current

The following equations are used to calculate the VBUS voltage and current values. Table 4-12 shows the specifications of the data (variables) for storing the voltage and current values.

$$Voltage = \frac{A/D - converted\ VSENSE \times reference\ voltage \times 2}{Maximum\ A/D\ count}$$

$$Current = \frac{A/D - converted\ ISENSE \times reference\ voltage}{Maximum\ A/D\ count \times 20 \times 0.05}$$

Table 4-11 Values Used in the Equations

Item	Value	Remark
Reference voltage	3.3 V	AVCC0
Maximum A/D count	4095	12-bit ADC

Table 4-12 Specifications of Data

Data	Data Name	Data Type	Remark
Voltage	g_VbusMonitor_VsenseData	uint16_t	Unit: mV
Current	g_VbusMonitor_IsenseData	uint16_t	Unit: mA

4.15 USB Vendor ID and Product ID Setting

The sample code prepares the definitions of the USB vendor ID and product ID in r_usb_pcdc_description.c (see the orange rectangle in Figure 4-37). The values in the figure are the default settings of the vendor ID and product ID, so change them to the correct IDs when using the sample code on an actual product.

```
/***********************************************************************************
 * File Name    : r_usb_pcdc_descriptor.c
 * Description  : Contains function definitions.
 ***********************************************************************************
/***********************************************************************************
* Copyright (c) 2025 Renesas Electronics Corporation and/or its affiliates
*
* SPDX-License-Identifier: BSD-3-Clause
***********************************************************************************
/******************************************************************************
 Includes   <System Includes> , "Project Includes"
 ******************************************************************************/
#include "r_usb_basic.h"
#include "r_usb_basic_api.h"
#include "r_usb_basic_cfg.h"

/******************************************************************************
 Macro definitions
 ******************************************************************************/
/* bcdUSB */
#define USB_BCDNUM                      (0x0200U)
/* Release Number */
#define USB_RELEASE                     (0x0200U)
/* DCP max packet size */
#define USB_DCPMAXP                     (64U)
/* Configuration number */
#define USB_CONFIGNUM                   (1U)
/* Vendor ID */
#define USB_VENDORID                    (0x0000U)
/* Product ID */
#define USB_PRODUCTID                   (0x0002U)
```

Figure 4-37 Definitions of the USB Vendor ID and Product ID in the Sample Code

4.16 Amounts of ROM and RAM Usage

Table 4-13 shows the amounts of ROM and RAM used by the sample code.

- Compiler used: GCC Arm Embedded 13.2.1.arm-13-7
- Optimization level of the compiler: Optimize more (-O2)

Table 4-13 Amounts of Memory Usage

Function	ROM Usage (Bytes)	RAM Usage (Bytes)
Main processing, system control, key input, etc.	11330	2008
USB control and CDC communications	23347	2573
Sensor control (temperature and humidity sensor control and light sensor control)	5034	80
Data control (storing and reading)	3593	34
OLED display	7914	594
Total	57785	5719

5. Procedure for Starting to Use the Sample Code

This chapter describes the steps from importing the project files for the sample code to building a project in the e^2 studio. The series of steps is as follows:

1. Download and install the latest versions of the e^2 studio and FSP
2. Download the sample code
3. Start the e^2 studio and import the project files for the sample code
4. Build the project

5.1 Downloading and Installing the Latest Versions of the e^2 studio and FSP

First, download the latest version of the FSP platform installer from the following Web page for the RA Flexible Software Package (FSP).

Flexible Software Package (FSP) | Renesas

Execute the downloaded file and proceed to install each item by following the procedure described by the installer. The installation procedure will install the latest versions of the e^2 studio and FSP.

The following versions of the e^2 studio and FSP were used in developing this application note.

- e^2 studio: e^2 studio 2025-12
- FSP: v6.3.0

5.2 Downloading the Sample Code

Next, download the sample code from the following Web page for the EK-RA2L2.

EK-RA2L2 - Evaluation Kit for RA2L2 MCU Group | Renesas

5.3 Starting the e² studio and Importing the Project Files for the Sample Code

Start the e² studio and select [Import projects] (see Figure 5-1).

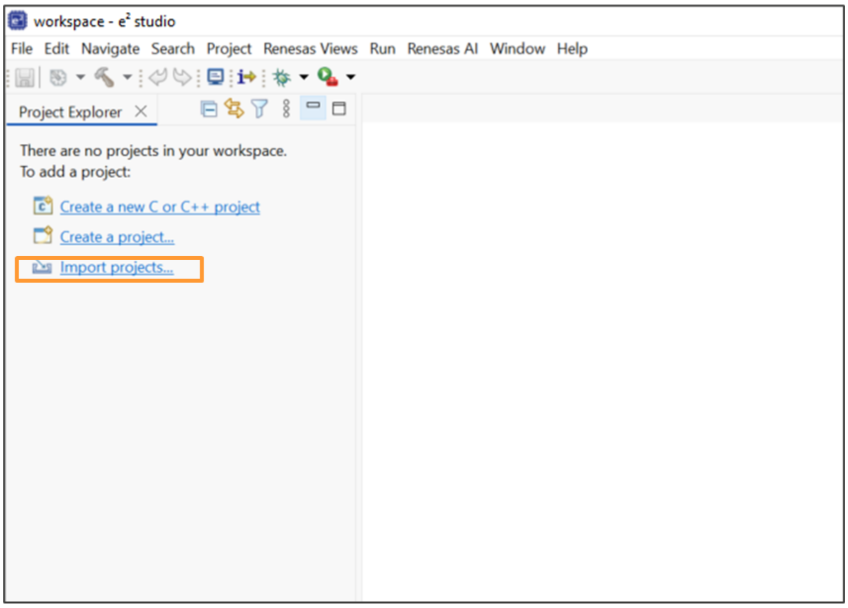


Figure 5-1 Selecting the Importing of Projects

Select the folder containing the downloaded set of sample code and import the project files for the sample code.

If the project files have been imported normally, the folders of the sample code are displayed as shown in Figure 5-2, and each of the source files can be confirmed.

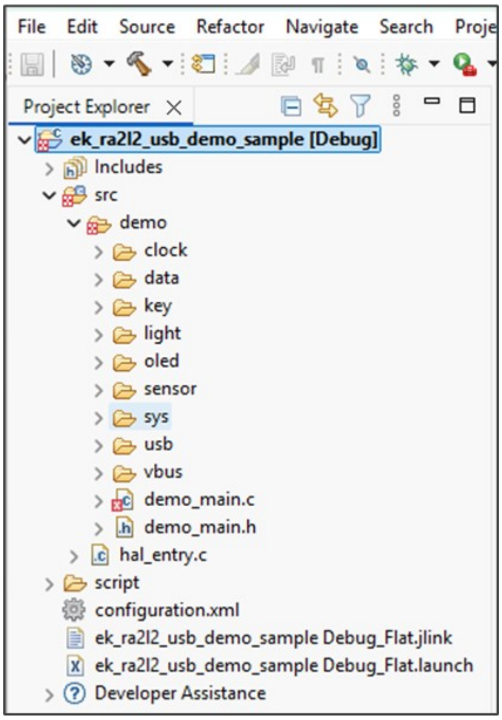


Figure 5-2 e² studio Window after the Completion of Importing

5.4 Generating Code in FSP Pin Configuration

Open FSP Configuration from [configuration.xml] and click on [Generate Project Content] to generate code, as shown in Figure 5-3, Generating Code in FSP Pin Configuration.

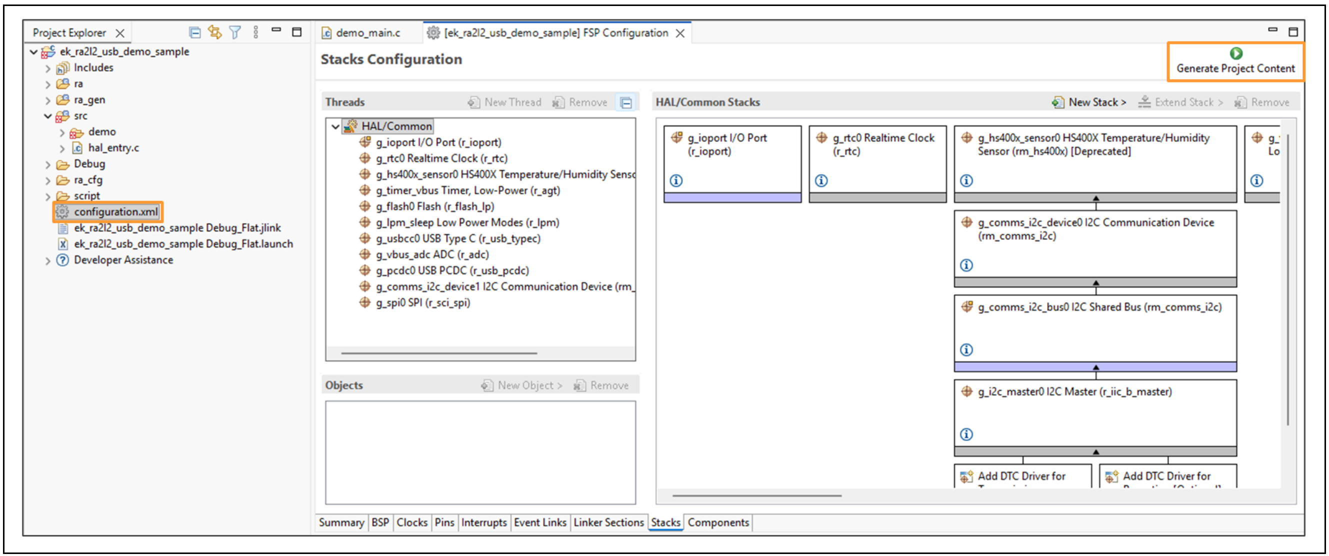


Figure 5-3 Generating Code in FSP Pin Configuration

5.5 Building a Project

Right-click on the imported project file then click on [Build Project] to execute the building process, as shown in Figure 5-4.

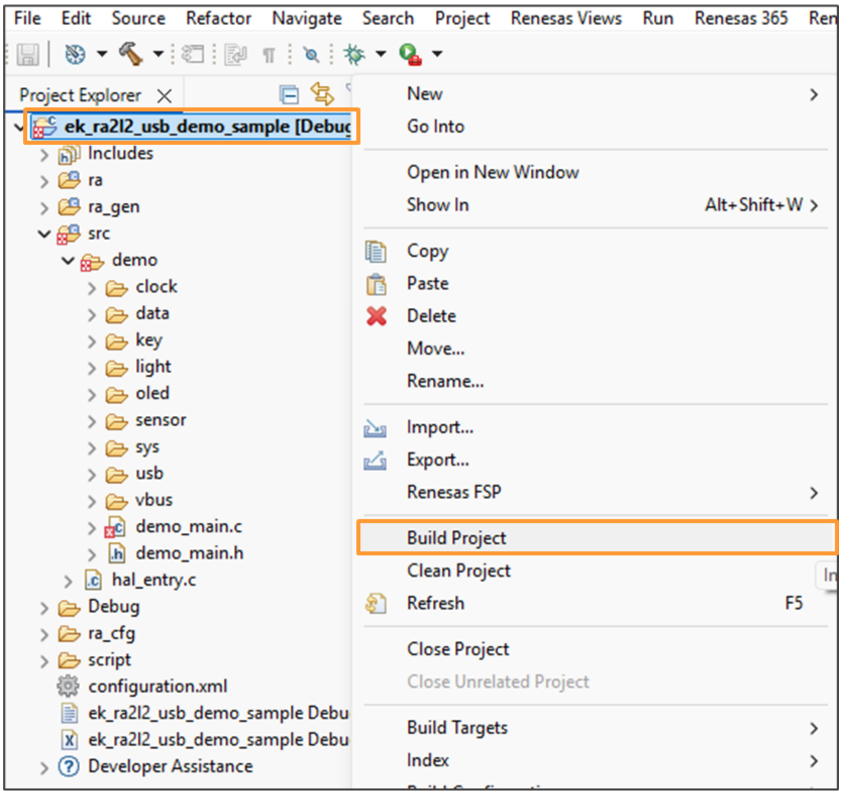


Figure 5-4 Building a Project

If the result of building is displayed as shown in Figure 5-5 (divided into two parts here because there are so many lines), building was successful. Note that the figure below shows the displayed results of building the sample code for the first time. The building time and number of results displayed will be reduced from the second time on.

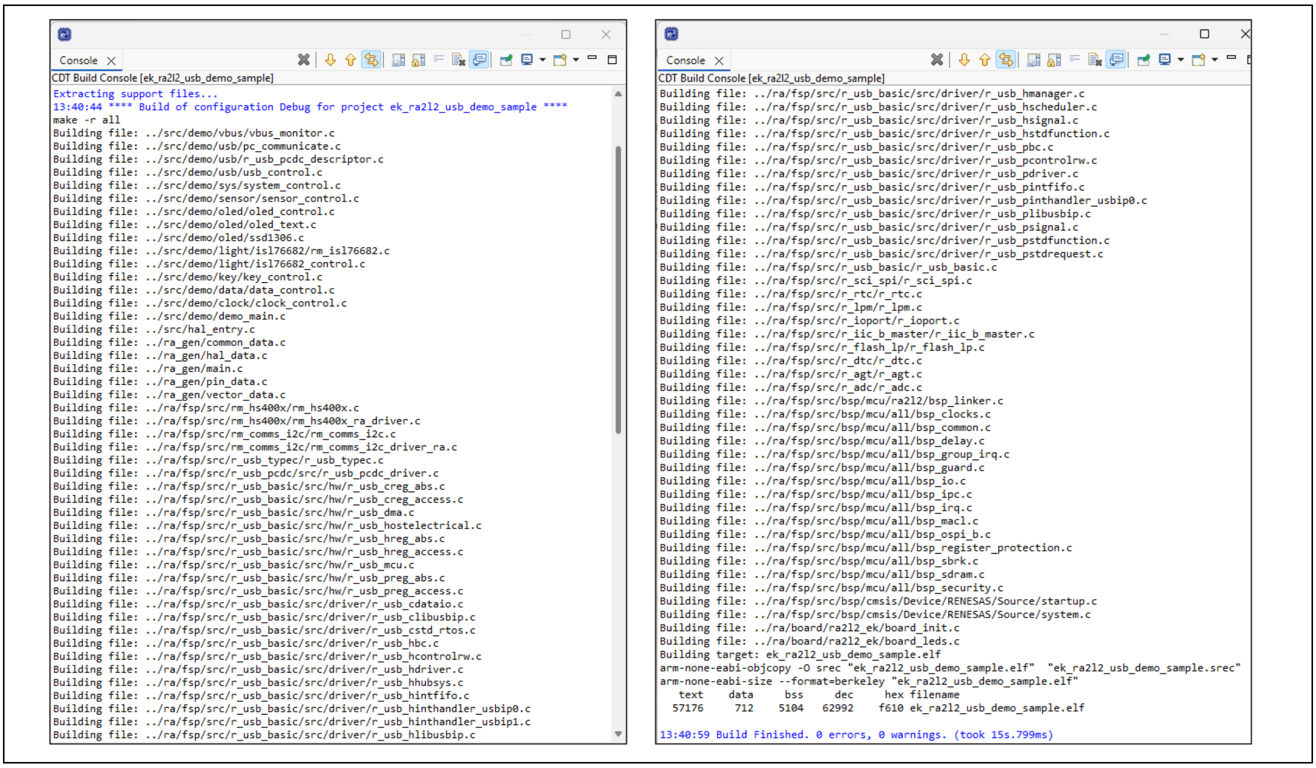


Figure 5-5 Results of Building

This ends the explanation of the procedure for starting the sample code for this system.

6. Sensor Data Monitoring Using the PC Demo Application

This chapter describes the sensor data monitoring operation using the PC demonstration application.
After power-on, when the board is connected to a PC, USB communication is enabled as a CDC device. By using the PC demonstration application after the board is connected to the PC, sensor data can be transmitted from the board to the PC, and the acquired data can be visualized in graphs and tables.

6.1 Launching the PC Demo Application

After connecting the board to a PC, you can use the PC demo application to send sensor data from the board to the PC and visualize the received data in graphs and tables. When you unzip the PC demo app (zip file), you will see the file structure shown in Figure 6-1.

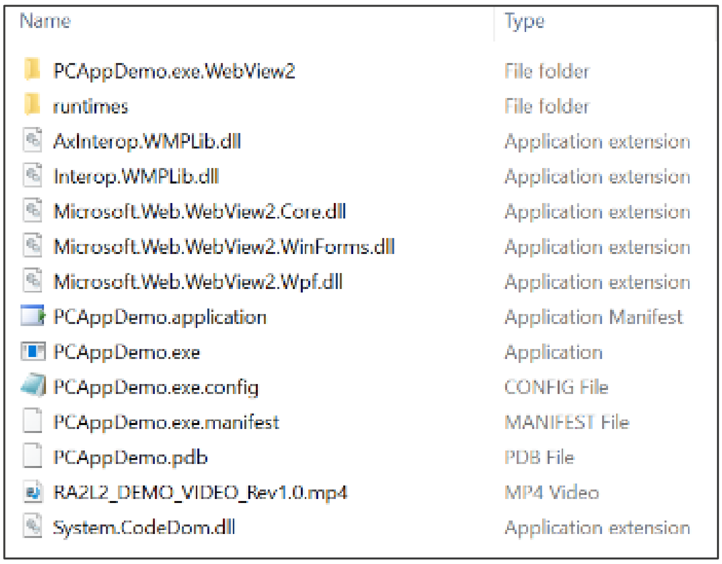


Figure 6-1 PC Demo App file structure

When you run the PC demo application executable file (PCAppDemo.exe) from within the folder, the PC demo application will start. After starting, the initial screen shown in Figure 6-2 will be displayed. The PC demo application can be started even before connecting to the board.

Figure 6-2 PC Demo App initial screen

6.2 Real-time display of sensor data

With the board USB connected, PC Demo App checks whether the board corresponding to Connect described in Config file. ID of the board is connected to the device ID. After confirming the relevant board, PC Demo App and board are connected by CDC and the "Connect" button is switched to the "Disconnect" button. In this state, the display of sensor data in graphs and tables has not started yet. If the "Connect" button is pressed when the board is not connected, the message "Check the board connection." is displayed as shown in Figure 6-3.

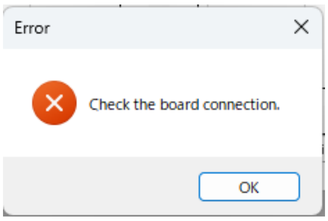
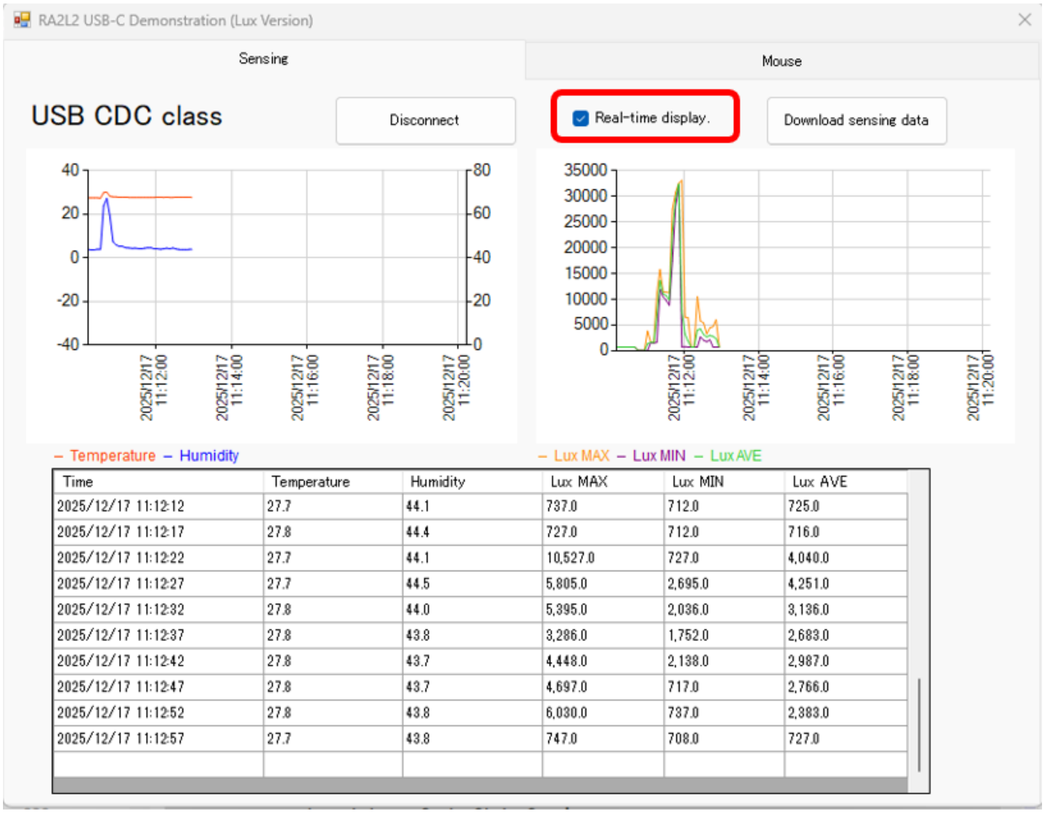


Figure 6-3 Error message of board connection

Next, when the "Real-time display" checkbox is selected, the temperature and humidity data and illuminance data acquired on the demonstration board are read in 5-second intervals and displayed in real time in a table and graph. As long as the check box is selected, reading continues and the table and graph are updated every 5 seconds. Clearing the check box stops the acquisition of temperature and humidity data and illuminance data, and also stops updating tables and graphs. If you select the "Real-time display" checkbox again while the table and graph are displayed, the table and graph are cleared and the newly acquired data is displayed.



Time	Temperature	Humidity	Lux MAX	Lux MIN	Lux AVE
2025/12/17 11:12:12	27.7	44.1	737.0	712.0	725.0
2025/12/17 11:12:17	27.8	44.4	727.0	712.0	716.0
2025/12/17 11:12:22	27.7	44.1	10,527.0	727.0	4,040.0
2025/12/17 11:12:27	27.7	44.5	5,805.0	2,695.0	4,251.0
2025/12/17 11:12:32	27.8	44.0	5,395.0	2,036.0	3,136.0
2025/12/17 11:12:37	27.8	43.8	3,286.0	1,752.0	2,683.0
2025/12/17 11:12:42	27.8	43.7	4,448.0	2,138.0	2,987.0
2025/12/17 11:12:47	27.8	43.7	4,697.0	717.0	2,766.0
2025/12/17 11:12:52	27.8	43.8	6,030.0	737.0	2,383.0
2025/12/17 11:12:57	27.7	43.8	747.0	708.0	727.0

Figure 6-4 Screen during Real-time display

6.3 Display of sensor data download

When "Download sensing data" is pressed, temperature/humidity data and illuminance data stored on board are read and displayed in tables and graphs. When the reading is completed, the temperature/humidity data and illuminance data stored on the board are cleared, and the same data cannot be read. In addition, if "Download sensing data" is pressed while the table and graph are displayed, the table and graph are cleared.

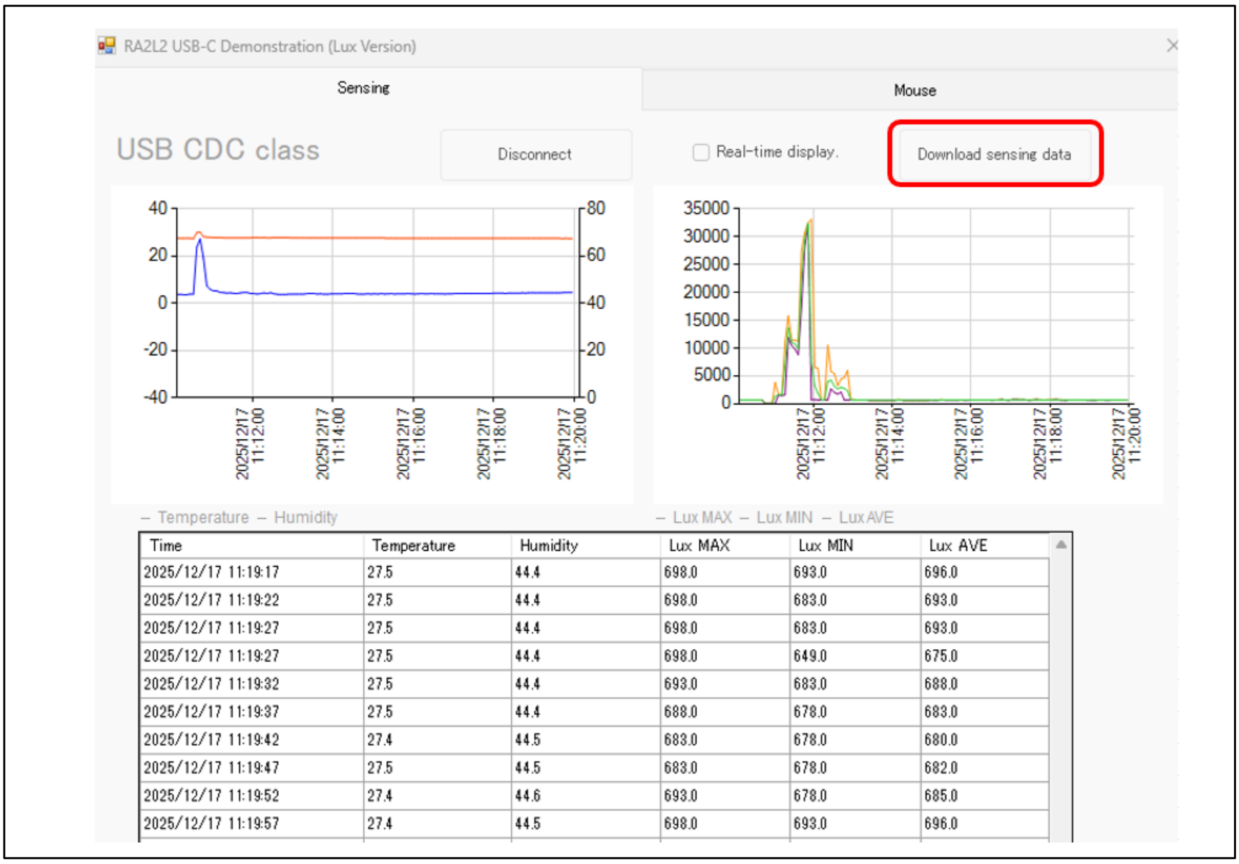


Figure 6-5 Screen Durgin download sensing data

Even when PC Demo App is in use, the demonstration board continues to operate in the sensing demo mode, so OLED screen changes as usual.

6.4 Exiting PC demo app

To close PC Demo App, press Close in the upper-right corner of the App window. When Real-time display is running, clear the checkbox and close the application window.

7. Procedure for Using QE for USB to Confirm the USB VBUS Voltage and Current

This chapter describes the procedure for checking the results of measuring the USB VBUS voltage and current of the EK-RA2L2 by installing QE for USB, a USB development assistance tool, and using the USB VBUS monitor.

QE for USB provides the following debugging functions to facilitate debugging of a USB system. For the details and methods of usage of each of the functions, refer to the QE for USB Usage Guide (R20AN0413) and release notes for QE for USB.

- [USB State Chart]
  Displays the state transitions of USB connection (enumeration) processing in real time.
- [USB Setting Registers]
  Displays the values and descriptions of registers related to the settings for USB connection.
- [USB Descriptors]
  Displays a list of descriptors, which are settings to be made during USB connection (enumeration).
- [USB Type-C Check]
  Displays information related to the USB Type-C connection, based on information from the MCU registers.
- [USB VBUS Monitor]
  Displays the results of measuring the USB VBUS voltage and current.

7.1 Installation of the Latest QE for USB

QE for USB can be installed by either of the following methods. For details, refer to the release notes for QE for USB.

- Install QE for USB by using the Renesas Software Installer of the e^2 studio.
- Download QE for USB from the following Web page for QE for USB and install it.
  https://www.renesas.com/en/software-tool/qe-usb-dedicated-tool-usb

7.2 Procedure for Checking the USB VBUS Voltage and Current in the USB VBUS Monitor View

In the e^2 studio, click on the following items in sequence to open the [USB VBUS Monitor (QE)] view.

[Renesas Views] menu → [Renesas QE] → [USB VBUS Monitor (QE)]

After starting the system, connect the USB Type-C cable and stop the program. The results of measuring the USB VBUS voltage and current at the time of stopping the program will be graphically displayed. Note that on the USB VBUS monitor of QE for USB, values of the following variables are shown on a graph.

Voltage: g_VbusMonitor_VsenseData

Current: g_VbusMonitor_IsenseData

Figure 7-1 shows an example of the results of measuring the USB VBUS voltage and current in this system, by using the USB VBUS monitor of QE for USB.

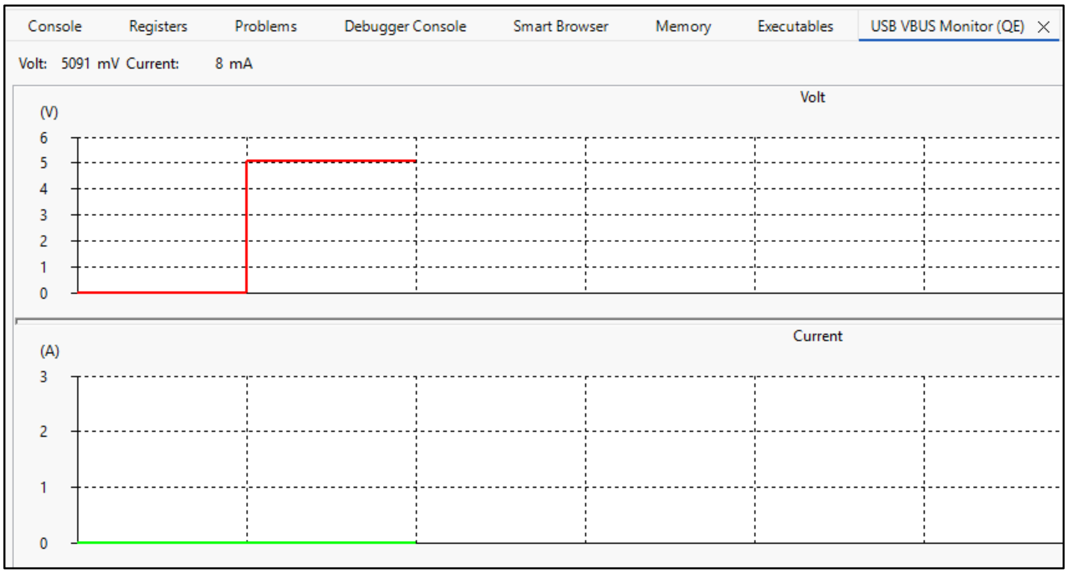


Figure 7-1 Example of Results of Measuring the USB VBUS Voltage and Current

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Apr.08.26	—	First edition issued.

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.

Notice

1. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation or any other use of the circuits, software, and information in the design of your product or system. Renesas Electronics disclaims any and all liability for any losses and damages incurred by you or third parties arising from the use of these circuits, software, or information.
2. Renesas Electronics hereby expressly disclaims any warranties against and liability for infringement or any other claims involving patents, copyrights, or other intellectual property rights of third parties, by or arising from the use of Renesas Electronics products or technical information described in this document, including but not limited to, the product data, drawings, charts, programs, algorithms, and application examples.
3. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.
4. You shall be responsible for determining what licenses are required from any third parties, and obtaining such licenses for the lawful import, export, manufacture, sales, utilization, distribution or other disposal of any products incorporating Renesas Electronics products, if required.
5. You shall not alter, modify, copy, or reverse engineer any Renesas Electronics product, whether in whole or in part. Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copying or reverse engineering.
6. Renesas Electronics products are classified according to the following two quality grades: “Standard” and “High Quality”. The intended applications for each Renesas Electronics product depends on the product’s quality grade, as indicated below.
   "Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; industrial robots; etc.
   "High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment; etc.
   Unless expressly designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not intended or authorized for use in products or systems that may pose a direct threat to human life or bodily injury (artificial life support devices or systems; surgical implantations; etc.), or may cause serious property damage (space system; undersea repeaters; nuclear power control systems; aircraft control systems; key plant systems; military equipment; etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or any third parties arising from the use of any Renesas Electronics product that is inconsistent with any Renesas Electronics data sheet, user’s manual or other Renesas Electronics document.
7. No semiconductor product is absolutely secure. Notwithstanding any security measures or features that may be implemented in Renesas Electronics hardware or software products, Renesas Electronics shall have absolutely no liability arising out of any vulnerability or security breach, including but not limited to any unauthorized access to or use of a Renesas Electronics product or a system that uses a Renesas Electronics product. RENESAS ELECTRONICS DOES NOT WARRANT OR GUARANTEE THAT RENESAS ELECTRONICS PRODUCTS, OR ANY SYSTEMS CREATED USING RENESAS ELECTRONICS PRODUCTS WILL BE INVULNERABLE OR FREE FROM CORRUPTION, ATTACK, VIRUSES, INTERFERENCE, HACKING, DATA LOSS OR THEFT, OR OTHER SECURITY INTRUSION (“Vulnerability Issues”). RENESAS ELECTRONICS DISCLAIMS ANY AND ALL RESPONSIBILITY OR LIABILITY ARISING FROM OR RELATED TO ANY VULNERABILITY ISSUES. FURTHERMORE, TO THE EXTENT PERMITTED BY APPLICABLE LAW, RENESAS ELECTRONICS DISCLAIMS ANY AND ALL WARRANTIES, EXPRESS OR IMPLIED, WITH RESPECT TO THIS DOCUMENT AND ANY RELATED OR ACCOMPANYING SOFTWARE OR HARDWARE, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY, OR FITNESS FOR A PARTICULAR PURPOSE.
8. When using Renesas Electronics products, refer to the latest product information (data sheets, user’s manuals, application notes, “General Notes for Handling and Using Semiconductor Devices” in the reliability handbook, etc.), and ensure that usage conditions are within the ranges specified by Renesas Electronics with respect to maximum ratings, operating power supply voltage range, heat dissipation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any malfunctions, failure or accident arising out of the use of Renesas Electronics products outside of such specified ranges.
9. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics, such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Unless designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not subject to radiation resistance design. You are responsible for implementing safety measures to guard against the possibility of bodily injury, injury or damage caused by fire, and/or danger to the public in the event of a failure or malfunction of Renesas Electronics products, such as safety design for hardware and software, including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult and impractical, you are responsible for evaluating the safety of the final products or systems manufactured by you.
10. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. You are responsible for carefully and sufficiently investigating applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive, and using Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
11. Renesas Electronics products and technologies shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations. You shall comply with any applicable export control laws and regulations promulgated and administered by the governments of any countries asserting jurisdiction over the parties or transactions.
12. It is the responsibility of the buyer or distributor of Renesas Electronics products, or any other party who distributes, disposes of, or otherwise sells or transfers the product to a third party, to notify such third party in advance of the contents and conditions set forth in this document.
13. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.
14. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products.

(Note1) “Renesas Electronics” as used in this document means Renesas Electronics Corporation and also includes its directly or indirectly controlled subsidiaries.

(Note2) “Renesas Electronics product(s)” means any product developed or manufactured by or for Renesas Electronics.

(Rev.5.0-1 October 2020)

Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,
Koto-ku, Tokyo 135-0061, Japan
www.renesas.com

Contact information

For further information on a product, technology, the most up-to-date version of a document, or your nearest sales office, please visit: www.renesas.com/contact/.

Trademarks

Renesas and the Renesas logo are trademarks of Renesas Electronics Corporation. All trademarks and registered trademarks are the property of their respective owners.