RA2L2 Group
USB Type-C Reference Design for RA2L2 MCUs

Introduction

This user's manual describes the overview and specifications of the USB Type-C Reference Design for RA2L2 MCUs.

Contents

1. Overview of the USB Type-C Reference Design for RA2L2 MCUs

1.1 What is the 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 (TWS) 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 USB 2.0 Full-Speed (FS) communications, various types of serial communications, and low-power modes, together with the USB Type-C CC detection operation.

1.2 Features of the USB Type-C Reference Design for RA2L2 MCUs

- Uses the RA2L2, which is the industry's first 32-bit MCU to support Release 2.4 of the USB Type-C standard and USB 2.0 Full-Speed (FS) communications.
- System configuration containing the USB Type-C interface on the assumption of small-size battery-powered applications
  - Appropriate for USB data loggers, True Wireless Stereo (TWS) charging cases, PC peripheral devices, etc.
  - A small-size battery-driven single board equipped with a charger IC, sensor device, and LCD
- USB Type-C CC detection operation by using the RA2L2's built-in USB Type-C interface
- Supports three types of demo use cases utilizing the main features of the RA2L2.
  - Three types of demo use cases: Stand-alone (running from a battery), connected to a charger, and connected to a PC
  - USB Type-C CC detection, USB 2.0 Full-Speed (FS) communications, various other types of connectivity, and low-power modes
- PCB design files and a variety of technical information including sample code are provided.

1.3 Configuration of the USB Type-C Reference Design for RA2L2 MCUs

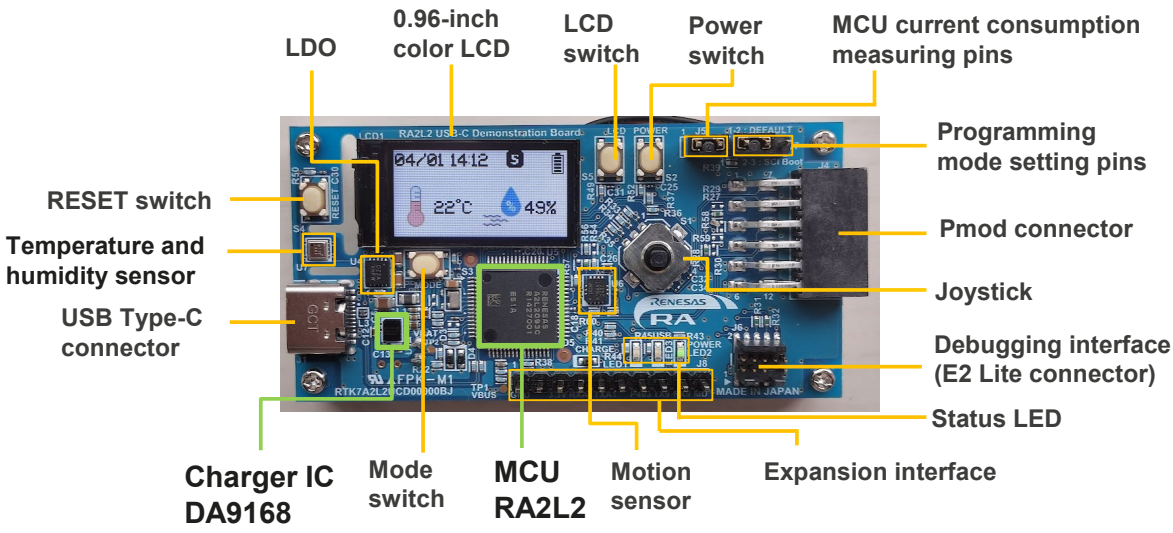
This reference design consists of the items listed in Table 1-1.

Table 1-1 Configuration of the Reference Design

No.	Item	Description
1	RA2L2 USB-C Demonstration Board (hereafter referred to as the demo board)	Single demo board with a mounted RA2L2. This board is not for sale. If you would like to use it, contact our sales team or click on the following link to the point for contact. Contact Us | Renesas
2	PCB design files	PCB design data of the demo board, including circuit diagrams, BOM, Gerber data, and artwork files. They are available on the Web page for the reference design.
3	Sample code	Sample code for the reference design. It is available on the Web page for the reference design.
4	Application note	USB Type-C Reference Design for RA2L2 MCUs Application Note (this document)

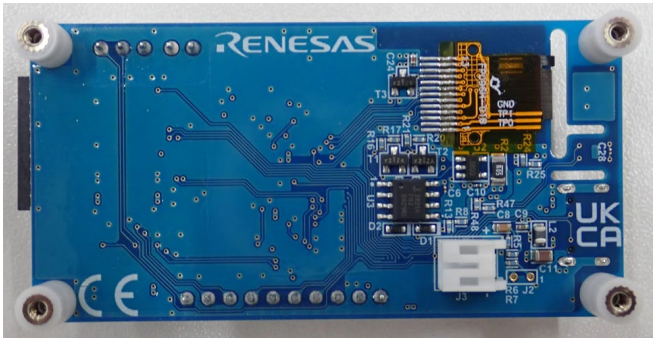
1.4 Outward Appearance and Components of the Demo Board

Figure 1-1 shows the outward appearance of the demo board and describes its components.



Power LED (green) ON: MCU is operating normally,
OFF: MCU is in software standby mode or operation is stopped
USB LED (yellow) ON: USB power is being supplied,
OFF: USB power is not being supplied
Charging LED (red) ON: Charging is in progress, OFF: Charging is stopped

Back of the board (after the battery is installed)



Back of the board (before the battery is installed)

Figure 1-1 Outward Appearance of the Demo Board

2. Hardware Specifications

This chapter describes the hardware specifications of the demo board.

2.1 Outline of Hardware Specifications

Table 2-1 lists the hardware specifications of this demo board in outline.

Table 2-1 Outline of Hardware Specifications

Item	Specifications
Board part number	RTK7A2L2UCD00000BJ
MCU	RA2L2: R7FA2L2093CFM (Code flash memory: 128 Kbytes, RAM: 16 Kbytes, Data flash memory: 4 Kbytes, PKG: 64-pin QFP)
Clocks	High-speed on-chip oscillator (48-MHz operation): System clock and peripheral module clocks 32.768-kHz crystal resonator: RTC clock
Sensors	Temperature and humidity sensor (Renesas: HS4001) × 1*1 Motion sensor (TDK: ICM-42688-P) × 1
Switches	Joystick (4-way + center press) × 1 Power switch, mode switch, LCD switch, and reset switch
Status LEDs	Power LED, charging LED, and USB LED
Display	0.96-inch color LCD
Interfaces	USB Type-C™ × 1 Pmod™ interface × 1 Debugging interface (E2 emulator Lite (E2 Lite) connector) × 1 Expansion interface × 1
Charger IC	DA9168 (1-cell battery charger IC)
Power supply	1-cell lithium-ion battery (Data Power Technology Ltd.: DTP502535 (400 mAh)) USB bus power
External dimensions	35 × 70 mm

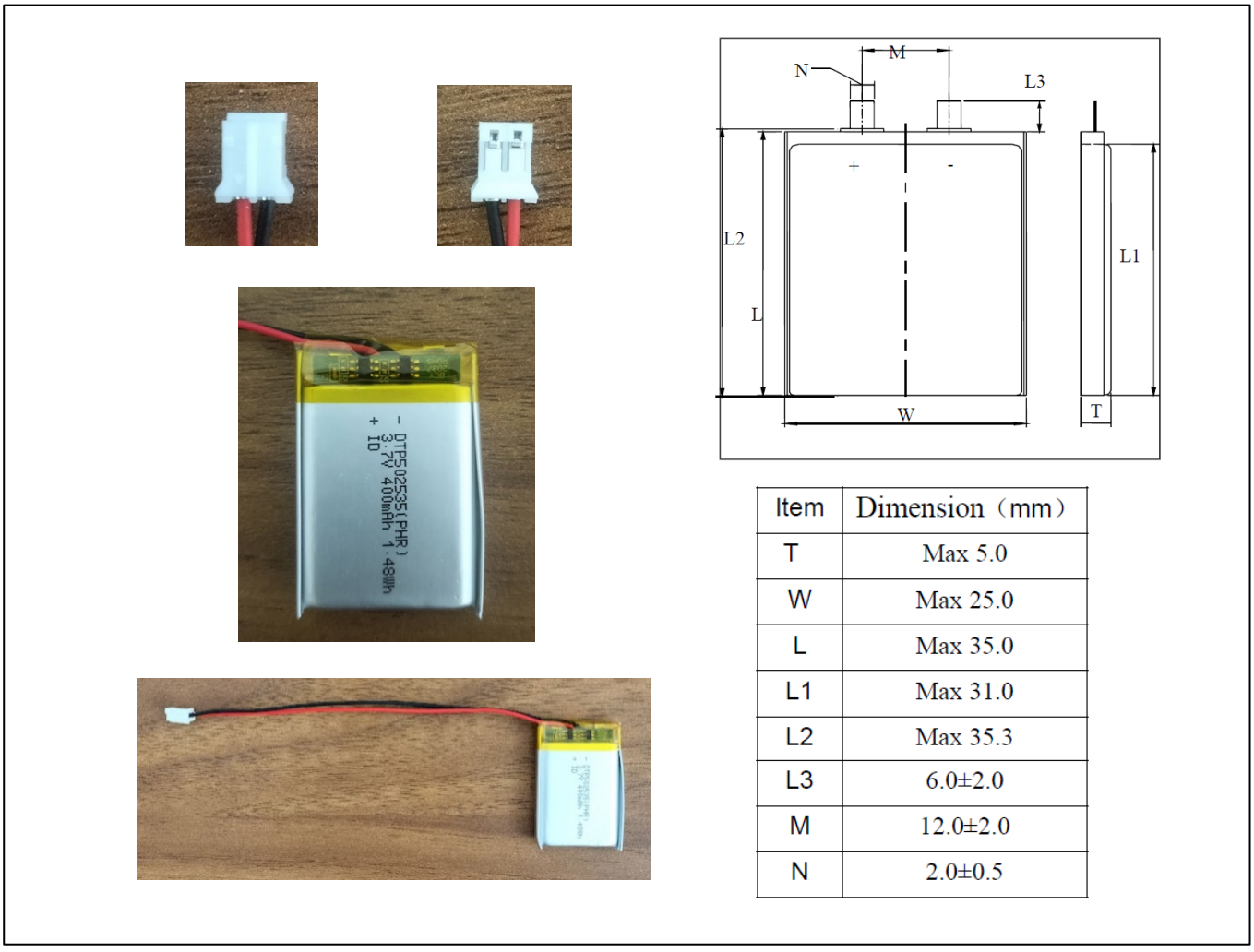
Note 1. Renesas has announced the discontinuation of the HS4001. “MEMS Vision #MVH4001D” is scheduled to be the replacement.

2.2 Outline of Battery Specifications

A 1-cell lithium-ion battery (part number: DTP502535) made by Data Power Technology Ltd. is used on this demo board. Table 2-2 lists the specifications of the battery in outline. Figure 2-1 shows the outward appearance of the battery.

Table 2-2 Outline of Battery Specifications

Item	Specifications
Battery type	Rechargeable lithium-ion polymer battery
Rated capacity	400 mAh
Normal voltage	3.70 V
Charge Limited voltage	4.20 V
Discharge cut-off voltage	2.80 V
Maximum continuous charge current	1C (400 mA)
Maximum continuous discharge current	1C (400 mA)
Operating temperature range	Charge: 0 to 45°C, Discharge: –20 to 60°C
Storage temperature range	–20 to 60°C
Operating and storage humidity range	65 ± 20% RH



Item	Dimension (mm)
T	Max 5.0
W	Max 25.0
L	Max 35.0
L1	Max 31.0
L2	Max 35.3
L3	6.0±2.0
M	12.0±2.0
N	2.0±0.5

Figure 2-1 Outward Appearance of the Battery

2.3 Outline of RA2L2 Specifications

Table 2-3 lists the specifications of the MCU (RA2L2) used on this demo board in outline. The part number of the MCU used on this demo board is the R7FA2L2093CFM (operating temperature: –40°C to +105°C) variant of the R7FA2L209xCFM products.

Table 2-3 Outline of RA2L2 Specifications

Parts number		R7FA2L209xCFM	R7FA2L207xCFM	R7FA2L209xCFL R7FA2L209xCNE	R7FA2L207xCFL R7FA2L207xCNE	R7FA2L209xCFJ R7FA2L209xCNH	R7FA2L207xCFJ R7FA2L207xCNH
Pin count		64		48		32	
Package		LQFP		LQFP/HWQFN		LQFP/HWQFN	
Code flash memory		128 KB	64 KB	128 KB	64 KB	128 KB	64 KB
Data flash memory		4 KB		4 KB		4 KB	
SRAM(Parity)		16 KB		16 KB		16 KB	
System	CPU clock	48 MHz		48 MHz		48 MHz	
	Sub clock oscillator	Yes		Yes		Yes	
	ICU	Yes		Yes		Yes	
	KINT	8		5		4	
Event control	ELC	Yes		Yes		Yes	
DMA	DTC	Yes		Yes		Yes	
Timers	GPT32	1 (PWM outputs: 2)		1 (PWM outputs: 2)		1 (PWM outputs: 2)	
	GPT16	6 (PWM outputs: 12)		6 (PWM outputs: 12)		6 (PWM outputs: 7)	
	AGTW	2		2		2	
	RTC	Yes		Yes		Yes	
	WDT/IWDT	Yes		Yes		Yes	
Communication	SCI	4		4		3	
	I3C	1		1		1	
	SPI	1		1		1	
	CAN	1		1		1	
	SSIE	1		1		1	
	UARTA	2		2		2	
	USBFS	1		1		1	
	USBCC	1		1		1	
Analog	ADC12	17		13		10	
	TSN	Yes		Yes		Yes	
Data processing	CRC	Yes		Yes		Yes	
	DOC	Yes		Yes		Yes	
Security		TRNG		TRNG		TRNG	
I/O ports	I/O pins	51		35		21	
	Input pins	3		3		3	
	Pull-up resistors	51		35		21	
	N-ch open-drain outputs	38		24		13	
	5-V tolerance	7		7		5	

2.4 System Block Diagram

Figure 2-2 shows a system block diagram of this demo board.

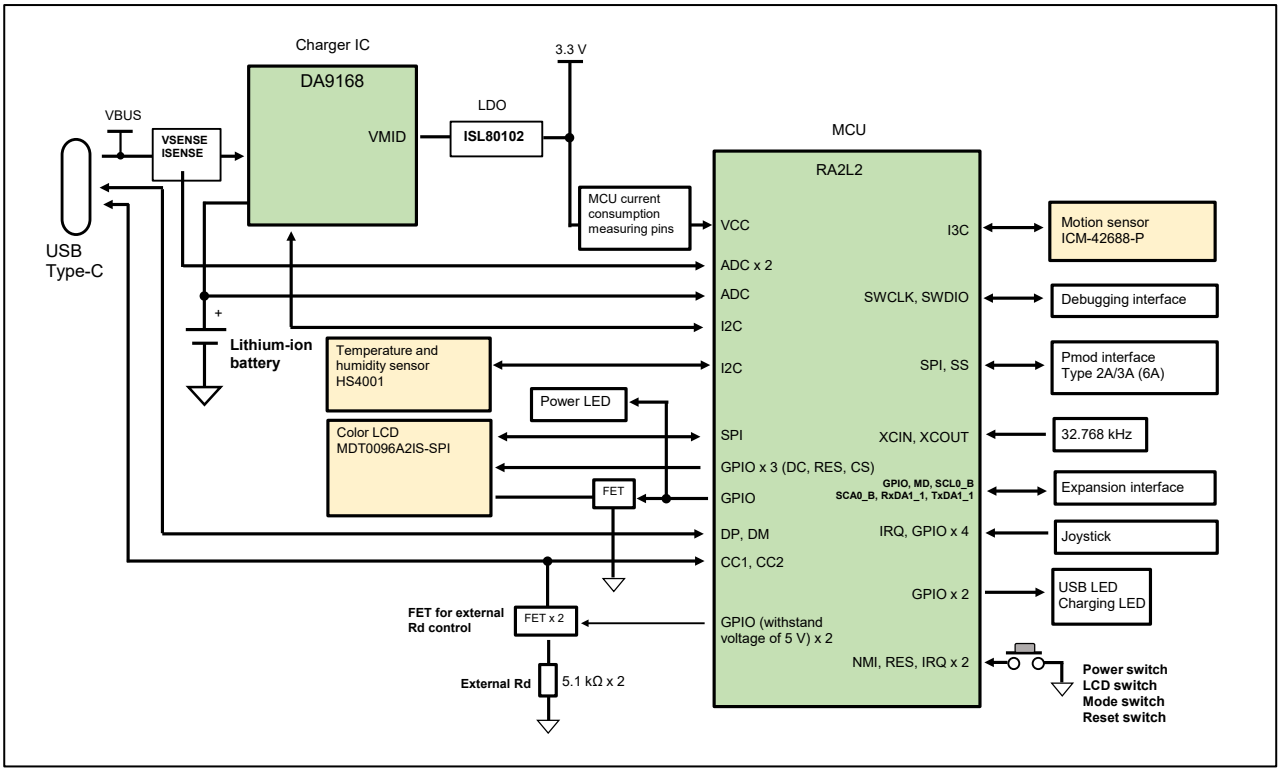


Figure 2-2 System Block Diagram

3. Software Specifications

This chapter describes the software specifications of the USB Type-C Reference Design for RA2L2 MCUs.

3.1 Software

- Integrated development environment: e^2 studio 2025-04.1
- C compiler: GCC Arm Embedded 13.2.1.arm-13-7
- FSP (Flexible Software Package): v6.0.0

3.2 Flowchart of the Main Processing

Figure 3-1 is a flowchart of the main processing of the sample code. The LCD drawing processing 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.

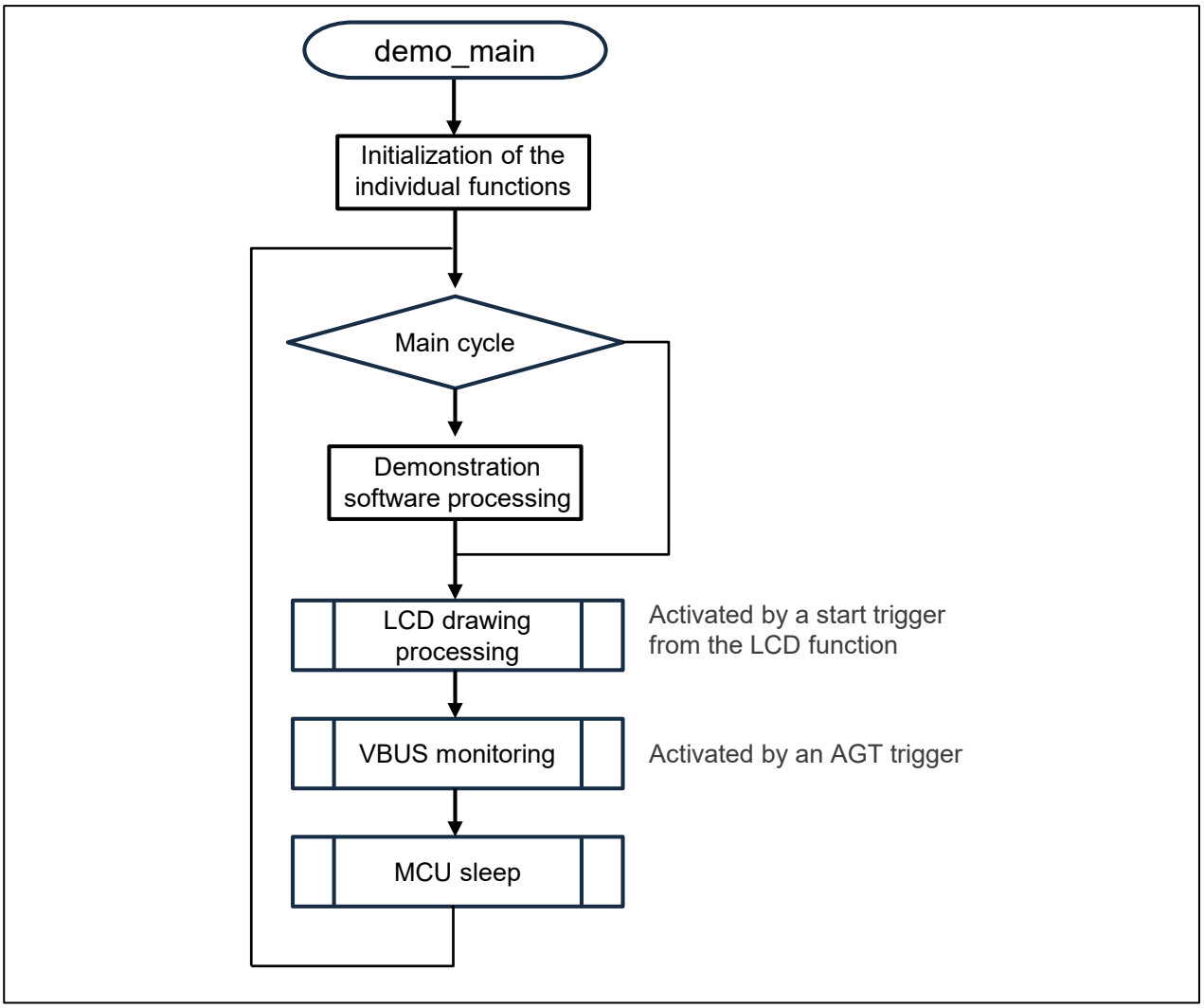


Figure 3-1 Flowchart of the Main Processing

3.3 Overview of Demonstration Operations and State Transitions

Table 3-1 shows an overview of the demonstration operations of the sample code.

Table 3-1 Overview of the Demonstration Operations

Demonstration Operation	Overview
Date and time setting mode	Mode for setting the date and time by using the joystick.
Sensing demo mode	Mode for displaying the temperature and humidity values and the results of detection by the motion sensor on the color LCD. In addition, the data from the sensor can be sent to a PC by connecting the board as a USB CDC device to the PC.
Mouse demo mode	Mode for operating the board as a USB mouse by connecting it as a USB HID device to a PC. The mouse cursor can be moved by operating the joystick.
USB notification	Mode for displaying the results of USB Type-C CC detection and the state of USB connection on the LCD 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.
Power-saving mode	Mode for reducing the power consumption by stopping the display on the LCD and measurement by the sensors.
Standby mode	Mode for the maximum reduction of power consumption by stopping the USB Type-C interface in addition to the steps taken for the power-saving mode.

Figure 3-2 shows the state transitions of the entire sample code.

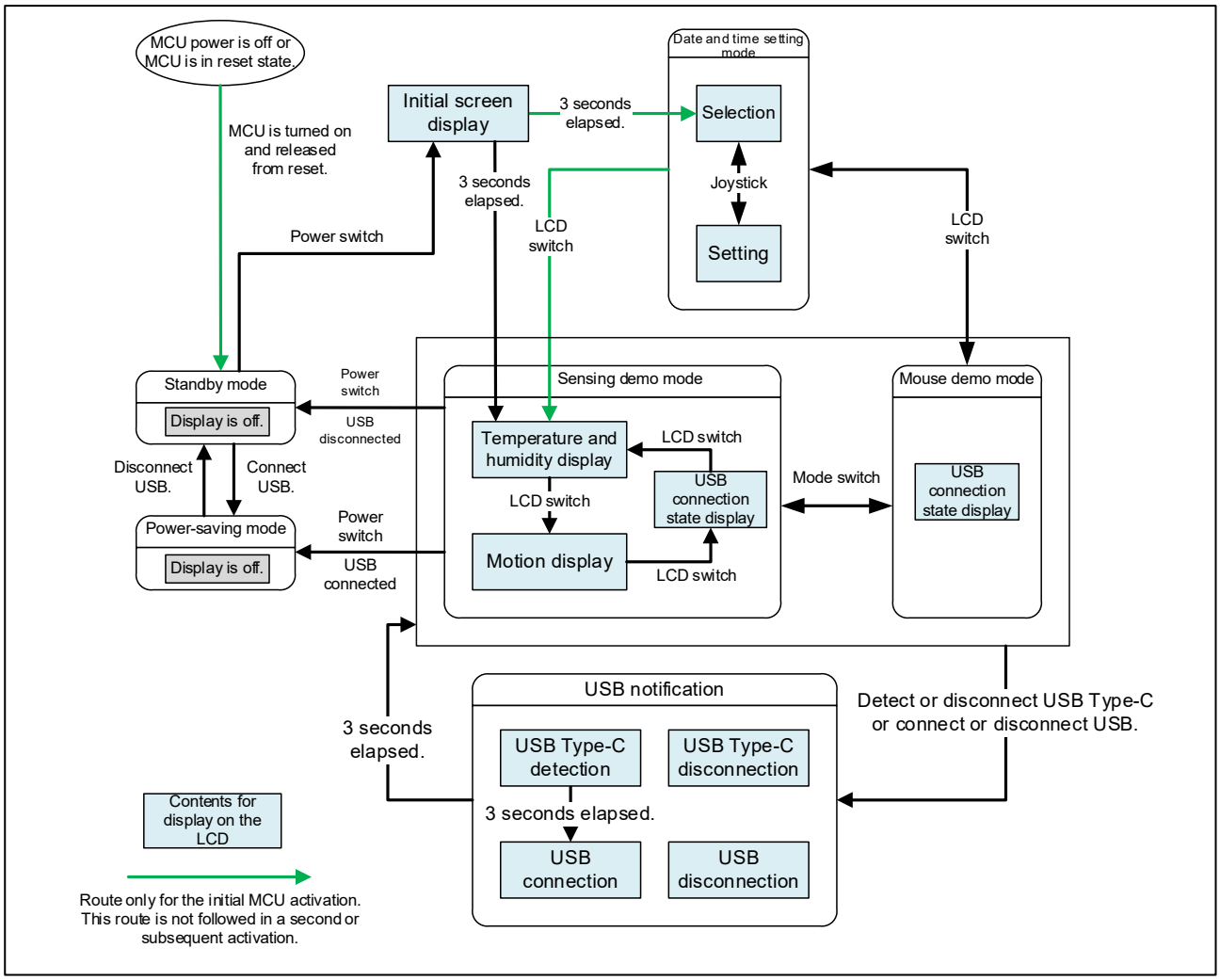


Figure 3-2 State Transitions of the Entire Sample Code

Table 3-2 lists the states of the major functions in the individual demo modes.

Table 3-2 States of the Major Functions in the Individual Demo Modes

Operation Mode	Sensing	LCD Display	Charging	USB Type-C Interface*1	USBFS
Sensing demo mode	Operating	On	Operating	Operating	Operating
Mouse demo mode	Operating	On	Operating	Operating	Operating
Date and time setting mode	Stopped	On	Operating	Operating	Operating
Power-saving mode	Stopped	Off	Operating	Operating	Operating
Standby mode	Stopped	Off	Stopped	Stopped	Stopped

Note 1. On-chip USB Type-C interface in the RA2L2.

3.4 Software Structure

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

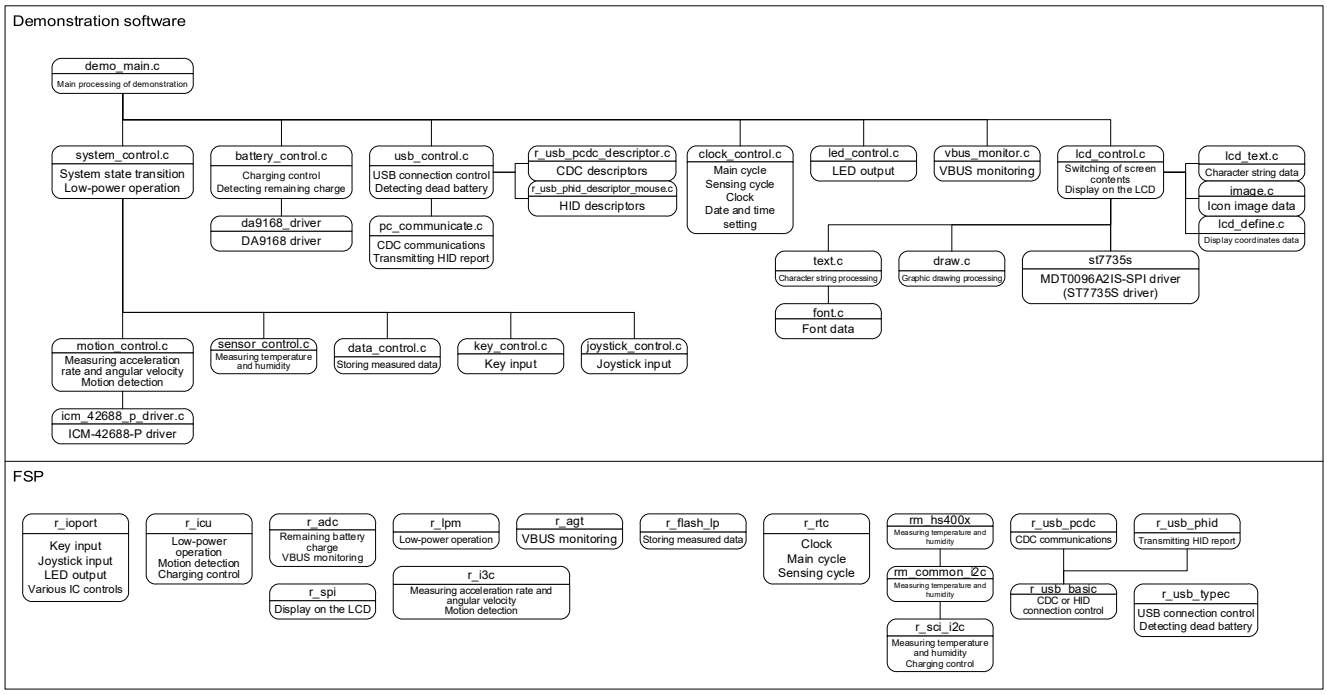


Figure 3-3 Overall Structure of the Sample Code Software

3.5 List of MCU Pin Assignments and Pin Settings

Table 3-3 lists the MCU pin assignments and pin settings of this reference design.

Table 3-3 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	GPIO	Output mode (initial high output)	None	Low	External Rd control for CC1 (OD output)
2	P401	GPIO	Output mode (initial high output)	None	Low	External Rd control for CC2 (OD output)
3	P402	GPIO	Input mode	None	Low	LCD display switching button
4	P403	GPIO	Input mode	Input pull-up	—	Free (connected to the expansion interface connector)
5	VCL	—	—	—	—	4.7-uF capacitor
6	P215	XCIN	Peripheral mode	—	—	Sub-clock
7	P214	XCOUT	Peripheral mode	—	—	Sub-clock
8	VSS	—	—	—	—	VSS
9	P213	SDA1_A	Peripheral mode	None	—	Charger IC - SDA
10	P212	SCL1_A	Peripheral mode	None	—	Charger IC - SCL
11	VCC	—	—	—	—	VCC
12	P411	GPIO	Output mode (initial high output)	None	Low	Charger IC - CHG_EN
13	P410	IRQ5	IRQ mode	None	Low	Charger IC - INT
14	P409	GPIO	Output mode (initial high output)	None	High	Charger IC – EN (spare)
15	P408	IRQ7	IRQ mode	None	Low	Motion sensor INT2 (or INT1)
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	GPIO	Input mode	Input pull-up	—	Pmod (#1) - CS/CTS/-
22	P206	MISO0_D RXD0_D SCL0_D	Input mode	Input pull-up	—	Pmod (#3) - MISO/RXD/SCL
23	P205	MOSI0_D TXD0_D SDA0_D	Input mode	Input pull-up	—	Pmod (#2) - MOSI/TXD/- Pmod (#4) - SDA
24	P204	SCK0_D	Input mode	Input pull-up	—	Pmod (#4) - SCK/RTS
25	RES	—	—	—	—	Debugger (#10) - SWD/JTAG Reset switch Charger IC - RIN_N
26	P201	MD	Peripheral mode	None	—	Debugger (#4) - SWD/JTAG (connected to the expansion interface connector [for SCI boot])
27	P200	GPIO	Input mode	None	—	—
28	P304	GPIO	Output mode (initial low output)	None	High	USB LED
29	P303	GPIO	Output mode (initial low output)	None	High	Charge status LED
30	P302	SDA2_A	Peripheral mode	None	—	Temperature and humidity sensor – SDA
31	P301	SCL2_A	Peripheral mode	None	—	Temperature and humidity sensor – SCL
32	P300	SWCLK	Peripheral mode	None	—	Debugger (#4) - SWD/JTAG
33	P108	SWDIO	Peripheral mode	None	—	Debugger (#2) - SWD/JTAG
34	P109	SCL0_B	Peripheral mode	None	—	Motion sensor - SCL (connected to the expansion interface connector [for SCI boot/TXD9_B])

Pin No.	Pin Name	Signal	Pin Setting Mode	Internal Pull-Up/Pull-Down Setting	Active Level	Function
35	P110	SDA0_B	Peripheral mode	Input pull-up	—	Motion sensor - SDA (connected to the expansion interface connector [for SCI boot/RXD9_B])
36	P111	IRQ4	IRQ mode	None	Low	Motion sensor INT1 (or INT2)
37	P112	GPIO	Input mode	Input pull-up	—	Pmod (#10) - GPIO
38	P113	GPIO	Input mode	Input pull-up	—	Pmod (#9) - GPIO
39	VCC	—	—	—	—	VCC
40	VSS	—	—	—	—	VSS
41	P107	GPIO	Input mode	Input pull-up	—	Pmod (#8) - GPIO
42	P106	GPIO	Input mode	Input pull-up	—	Pmod (#7) - GPIO
43	P105	GPIO	Output mode (initial high output)	None	Low	Color LCD - RESET
44	P104	GPIO	Output mode (initial high output)	None	—	Color LCD - D/C
45	P103	SSLA0_A	Peripheral mode	None	—	Color LCD - CS
46	P102	RSPCKA_A	Peripheral mode	None	—	Color LCD – SCL (CLOCK)
47	P101	MOSIA_A	Peripheral mode	None	—	Color LCD – SDA (DI)
48	P100	MISOA_A	Peripheral mode	None	—	Color LCD – SDA (DO)
49	P500	GPIO	Output mode (initial low output)	None	High	Power LED Color LCD - Backlight
50	P501	GPIO	Output mode (initial low output)	None	—	Motion sensor - AD0
51	P502	GPIO	Input mode	None	Low	Joystick - Center
52	P015	RXDA1_A	Input mode	Input pull-up	—	Expansion interface
53	P014	TXDA1_A	Input mode	Input pull-up	—	Expansion interface
54	P013	GPIO	Input mode	None	Low	Joystick - A
55	P012	GPIO	Input mode	None	Low	Joystick - B
56	AVCC0	—	—	—	—	VCC
57	AVSS0	—	—	—	—	VSS
58	P011	GPIO	Input mode	None	Low	Joystick - C
59	P010	GPIO	Input mode	None	Low	Joystick - D
60	P004	GPIO	Input mode	None	Low	Mode switch
61	P003	AN003	Analog mode	None	—	Battery voltage
62	P002	AN002	Analog mode	None	—	VBUS monitoring - ISENSE
63	P001	AN001	Analog mode	None	—	VBUS monitoring - VSENSE
64	P000	IRQ6	IRQ mode	None	Low	Power switch

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Sep. 16, 2025	—	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.

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