RENESAS

VOICE-RA2L1 Engineering Manual
Renesas VUI Reference Solution

Renesas Advanced (RA) Family
RA2 Series

Renesas Electronics
www.renesas.com

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Renesas VUI Reference Solution

VOICE-RA2L1 Engineering Manual

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1.   Overview

VOICE-RA2L1 is an edge voice recognition evaluation kit designed to be used by Ecosystem Partners, Application Engineers, Field Application Engineers, and for Business Development opportunities. The primary purpose is to evaluate the functionality of projects developed by Ecosystem Partners, and to facilitate the development of additional partner projects. The kit design to use the RA2L1 MCU with LQFP 48pin package as the core logic device, with OPAMP and power devices chosen from the Renesas product portfolio.

2.   Kit Contents

The following components are included in the kit:
1. VOICE-RA2L1 board
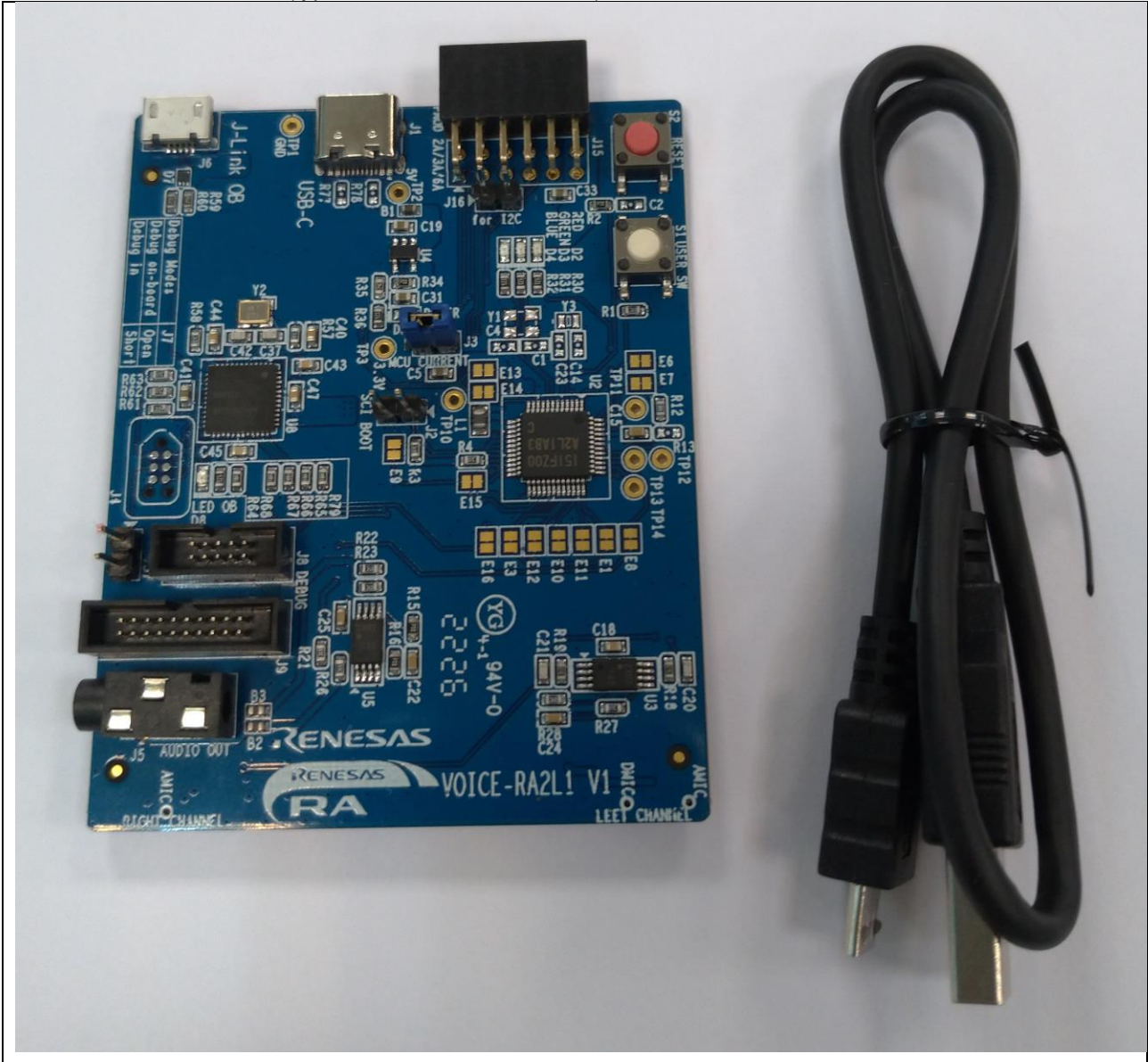2. Micro USB device cable (type-A male to micro-B male)

Figure 1. VOICE-RA2L1 Kit Contents

3.   Kit Ordering Information

VOICE-RA2L1 kit orderable part number: **TW001-VUIA2L1POCZ**

4. Kit Peripheral Features

Following is a list of the specific features that have been implemented:

- PMOD: 1 Digilent PMOD connectors, supporting UART, SPI and I2C configurations.

- Microphones: 1 I2S MEMS digital microphones and 2 MEMS analog microphones, distance between each pair of microphones is 50mm which is suitable for beamforming applications.

- Audio out: One stereo audio headphone jack supporting mono output on both channels.

- LEDs: Five LEDs, D2 (Red), D3 (Green) and D4 (Blue) configurable by user, D5 (Blue) as a 3.3V power indicator, D8(Green) as a JLOB (J-LINK on board) indicator.

- Buttons: One RESET button (S2), and one USER button (S1).

- Debug: J-Link On-Board debug interface, supporting JTAG or SWD debug port.

- USB: Micro USB-B (J6) for power input and J-Link On-Board function, USB-C (J1) for power input only.

- Form Factor: 7.5 x 6 cm

5. MCU Feature Support

The RA2L1 MCU supports a full array of peripheral functions. The published features of the MCU are listed below. Features highlighted in **BOLD** text are directly supported by this kit hardware for voice applications.

- **Arm Cortex-M23 Core**
  - Armv8-M architecture with DSP instruction set
  - Maximum operating frequency: 48 MHz
  - Support for 4-GB address space
  - On-chip debugging system: **SWD**
  - Boundary scan and Arm Memory Protection Unit (Arm MPU) with 8 regions

- **Memory**
  - Up to 256KB code flash memory
  - 8-KB data flash memory (100,000 program/erase cycles minimum)
  - 32KB SRAM
  - Memory Protection Units (MPU)
  - 128-bit unique ID

- Connectivity
  - Serial Communications Interface (SCI) × 5
  - Serial Peripheral Interface (SPI) × 2
  - I2C bus interface (IIC) × 2

- Analog
  - **19 channel 12-bit A/D Converter (ADC12) with sample-and-hold circuits**
  - **12-bit D/A Converter (DAC12) × 1**

- **Timers**
  - **General PWM Timer 32-bit (GPT32) × 4**
  - **General PWM Timer 16-bit (GPT16) × 6**
  - **Port Output Enable for GPT (POEG)**
  - Asynchronous General-Purpose Timer (AGT) × 2

- Safety
  - ECC in SRAM

- SRAM parity error check

- Flash area protection

- ADC self-diagnosis function

- Clock Frequency Accuracy Measurement Circuit (CAC)

- Cyclic Redundancy Check (CRC) calculator

- Data Operation Circuit (DOC)

- Port Output Enable for GPT (POEG)

- Independent Watchdog Timer (IWDT)

- GPIO readback level detection

- Register write protection

- Main oscillator stop detection

■ Security and Encryption

- AES128/256

- True Random Number Generator (TRNG)

■ System and Power Management

- Low power modes

- Switching regulator

- Realtime Clock (RTC)

- Event Link Controller (ELC)

- Data Transfer Controller (DTC)

- Key Interrupt Function (KINT)

- Power-on reset

- Low Voltage Detection (LVD) with voltage settings

■ Multiple Clock Sources

- Main clock oscillator (MOSC) (1 to 20 MHz)

- **Sub-clock oscillator (SOSC) (32.768 kHz)**

- **High-speed on-chip oscillator (HOCO)** (24/32/**48**/64 **MHz**)

- Middle-speed on-chip oscillator (MOCO) (8 MHz)

- Low-speed on-chip oscillator (LOCO) (32.768 kHz)

- IWDT-dedicated on-chip oscillator (15 kHz)

- Clock out support

General-Purpose I/O Ports

- 5V tolerance, open drain, input pull-up, switchable driving ability

Operating Voltage

- VCC: 1.6 to 5.5 V

6. Kit Architecture
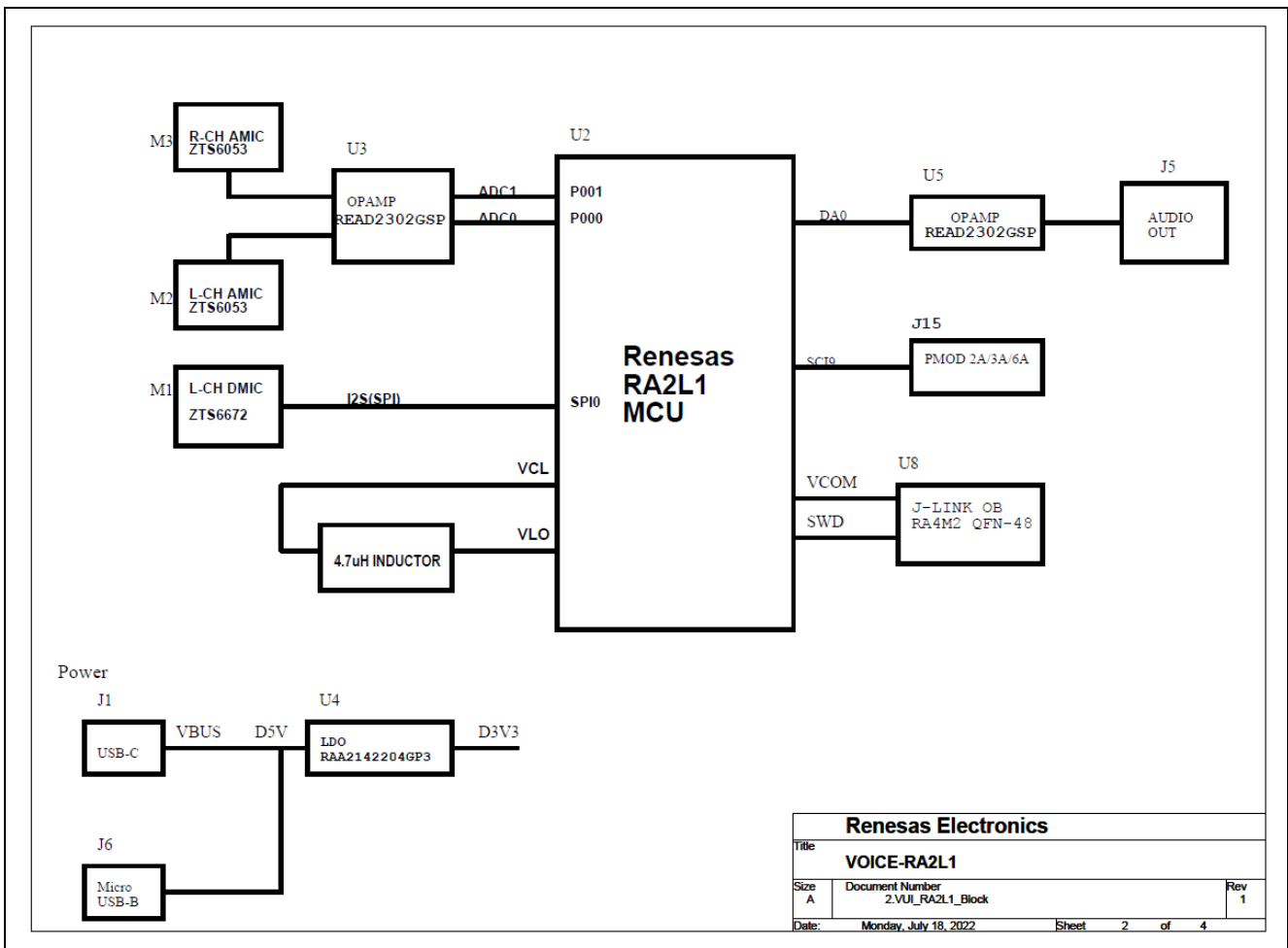
6.1 System Block Diagram

Figure 2. System Block Diagram

6.2   Jumper Settings

Two types of jumpers are provided on the VOICE-RA2L1 board.
1. Traditional pin header jumpers copper jumpers
2. Copper jumpers (trace-cut type and solder bridge type)

6.2.1   Traditional Pin Header Jumpers

These jumpers are traditional small pitch jumpers that require an external shunt to open/close them. The traditional pin jumpers on the VOICE-RA2L1 board are 2.54mm pitch headers and require compatible 2.54mm shunt jumpers.

Default Jumper Configuration
The following table describes the default settings for each jumper on the VOICE-RA2L1 board. This includes copper jumpers (Ex designation) and traditional pin jumpers (Jx designation.)

Functional details for many of the listed jumpers may be found in sections associated with each functional area of the kits.

Table 1. Default Jumper Settings

Location	Default Open/Closed	Function
J2	Open	SCI Boot mode : Close to configures the RA2L1 MCU enter SCI boot mode, code can be download through J15 PMOD connector.
J3	Short	J3 labeled with "measure current", it is for measure RA2L1 MCU current, remove this jumper wire and serial with a current meter to measure RA2L1 MCU current. The RA2L1 current is around 8.33mA.
J7	Open	Short with a jumper wire to set the on board debug RA4M2 MCU(U8) in RESET for disable on board debug function.
J16	open	Short with jumper wire to route I2C SDA signal to J15 PMOD connector pin 4.

6.2.2   Copper Jumpers

Copper jumpers are of two types, designated trace-cut and solder-bridge.
A trace-cut jumper is provided with a narrow copper trace connecting its pads. The silk screen overlay printing around a trace-cut jumper is a solid box. To isolate the pads, cut the trace between pads adjacent to each pad, then remove the connecting copper foil either mechanically or with the assistance of heat. Once the etched copper trace is removed, the trace-cut jumper is turned into a solder-bridge jumper for any later changes.
A solder-bridge jumper is provided with two isolated pads that may be joined together by one of three methods:
● Solder may be applied to both pads to develop a bulge on each and the bulges joined by touching a soldering iron across the two pads.
● A small wire may be placed across the two pads and soldered in place.
● A SMT resistor, size 0805, 0603, or 0402, may be placed across the two pads and soldered in place. A zero-ohm resistor shorts the pads together.

For any copper jumper, the connection is considered closed if there is an electrical connection between the pads (default for trace-cut jumpers.) The connection is considered open if there is no electrical connection between the pads (default for the solder-bridge jumpers.)

Figure 3. Copper Jumpers

Table 2. Default Copper Jumper Settings

Location	Default Open/Closed	Function
E1	Closed	SCK output to I2S digital microphone
E3	Closed	SCK input to RA2L1 GPT_POEG1
E6	Closed	ADC0, Analog microphone left channel
E7	Closed	ADC1, Analog microphone right channel
E8	Closed	DAC out to OPAMP, audio out
E9	Closed	P201/MD signal, cut it then the J8, J9 can be debug out function
E10	Closed	SCK input for SPI0
E11	Closed	MOSI for I2S digital microphone left channel
E12	Closed	SSL input for SPI0
E13	Closed	JLINK VCOM_RXD signal
E14	Closed	JLINK VCOM_TXD signal
E15	Closed	JLINK SWCLK signal
E16	Closed	JLINK SWDIO signal

7. MCU Port Mapping

Here are the port and pin assignments for the kit.

Table 3. MCU Port Assignments

Port	Assigned Function(s)
P000	Analog microphone, left channel
P001	Analog microphone, right channel
P002	Test point 11 (TP11)
P012	Test point 12 (TP12)
P013	Test point 13 (TP13)
P014	Audio out DAC
P015	Test point 14 (TP14)
P100	GPT5 output for SCK to I2S D-MIC left channel
P101	SPI0 MOSIA input form I2S D-MIC left channel
P102	SPI0 RSPCKA input
P103	SPI0 SSLA0 input
P104	SCK input to RA2L1 GPT_POEG1
P108	Debug, SWDIO for SWD
P109	Connect to PMOD(J15), it can be configured as MOSI/TXD/SDA
P110	Connect to PMOD(J15), it can be configured as MISO/RXD/SCL
P111	Connect to PMOD(J15), it can be configured as SPICLK
P112	Delayed SPI SS output signal to P103
P200	NMI, pull-high with 10K
P201/MD	Boot Mode, The RA2L1 enter SCI boot mode if the MD pin is held low on release the reset signal, it is for download code to RA2L1 flash memory.
P206	PMOD GPIO1
P207	PMOD GPIO2
P208	PMOD GPIO3
P212/EXTAL	LED3, user LED, blue color
P213/XTAL	LED2, user LED, green color
P214/XCOUT	No connection, reserve for 32768Hz crystal
P215/XCIN	No connection, reserve for 32768Hz crystal
P300	Debug, SWCLK for SWD
P301	Connect to PMOD(J15), it can be configured as SPI SS(Slave Select)
P302	PMOD, can be GPIO or IRQ5
P400	User switch(S1), also IRQ0
P401	GPT6 output for WS to I2S D-MIC left channel
P407	Test point 10 (TP10)
P408	JLOB VCOM TXD

P409	JLOB VCOM RXD
P500	LED1, user LED, red color

8. Implementation Details

One PMOD type 2A/3A/6A connectors (2x6 pin, dual row, right angle socket) is included. If the RA2L1 SCI9 been configured as Simple I2C, please insert a jumper on header J16 to route SDA signal to PMOD connector pin 4 for meet PMOD 6A pin definition.

Table 4. PMOD Port Assignments (J15)

MCU Port	PMOD Type 2A Signal (SPI)	PMOD Type 3A Signal (UART)	PMOD Type 6A Signal (I2C)	PMOD connector Pin
P301	SPI_SS			1
P109	MOSI	TXD		2
P110	MISO	RXD	SCL	3
P111	SPI_SLK		SDA(P109)	4
	GND	GND	GND	5
	+3.3V	+3.3V	+3.3V	6
P302	INT	INT	INT	7
P206	GPIO	GPIO	GPIO	8
P207	GPIO	GPIO	GPIO	9
P208	GPIO	GPIO	GPIO	10
	GND	GND	GND	11
	+3.3V	+3.3V	+3.3V	12
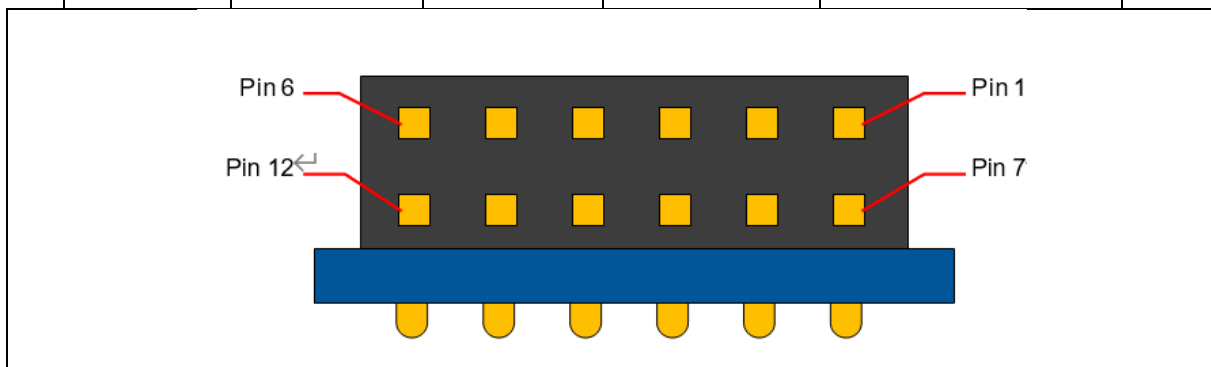
Figure 4. PMOD connector

8.1 Microphones

This board includes a pair of analog MEMS microphones (M2 & M3, ZillTek ZTS6053). These 2 analog microphone signals are amplified by Renesas READ2302GSP OPAMP, then fed to RA2L1 ADC channels 0 & 1. One digital I2S MEMS microphone (M1, ZillTek ZTS6672) is also provided, which is connected to RA2L1 SPI0 channels. The physical distance between the 2 analog microphones is 50mm for support beamforming applications.

Table 5. Analog MEMS Microphone left channel (M2) Port Assignments

MCU Port	MEMS microphone Pin
P000	1 – OUT
	2 – GND
	3 – GND
	4 – GND
	5 – VDD

Table 6. Analog MEMS Microphone right channel (M3) Port Assignments

MCU Port	MEMS microphone Pin
P001	1 – OUT
	2 – GND
	3 – GND
	4 – GND
	5 – VDD

Table 7. Digital I2S MEMS Microphone left channel (M1) Port Assignments

MCU Port	SPI0 Signal	MEMS microphone Pin
P401	SSLA0	1 – LRC (Word Select)
	GND – for Select as left channel	2 – SELECT
	GND	3 – GND
P102	RSPCKA	4 – BCLK
	3.3V	5 – VDD
P101	MOSIA	6 – DATA
		7 – CONFIG

8.2   Audio out

A stereo headphone jack is connected to the MCU DAC. The DAC signals are connected through an OPAMP for drive earphone, which is Renesas READ2302GSP, in ultra-small 8 pins TSSOP packages.

Table 8. Headphone Jack Pin Assignments

MCU Port	Audio out Signal	Headphone Jack Pin
P014 (DA0)	VOUT1	1 (Sleeve)
	VOUT2	2 (Mono signal)
	VOUT2	3 (Mono signal)

8.3   LEDs

3 LED are included on the board and are connected to the MCU I/O. These are Red, Green, and Blue, and can be used for any user defined functions.

Table 9. User LED Port Assignments

MCU Port	Connected User LED
P500	Red (D2)
P213	Green (D3)
P212	Blue (D4)

D5 (blue) is power LED to indicate 3.3V power, and D8 (Green) is debug status LED to indicate the status of the JLOB connection.

8.4   Buttons

There are two mechanical push-button switches on the board. One button is for system/MCU reset (S2). The second button is a user programmable button (S1).

Table 10. User Button Port Assignment (S1)

MCU Port	User Button Interrupt
P400	IRQ0

8.5 Debug

The VOICE-RA2L1 board supports following three debug modes.

Debug Modes	Debug MCU (one that connects to the IDE on PC)	Target MCU (one that is being debugged)	Debugging Interface/Protocol	Connector Used
Debug on-board	RA4M2 (on-board)	RA2L1 (on-board)	SWD	Micro USB (J6)
Debug in	External debugging tools	RA2L1 (on-board)	SWD	20-pin connector (J9) or 10-pin connector (J8)
Debug out	RA4M2 (on-board)	Any external RA MCU	SWD, JTAG	20-pin connector (J9) or 10-pin connector (J8)

Notes:
• Please cut E9 for Debug out function
• See Table 14 for the Debug USB connector pin definition.
• See Table 15 for the 10-pin JTAG connector pin definition.
• See Table 16 for the 20-pin JTAG connector pin definition.

Table 11. Jumper Connection Summary for Different Debug

Debug Modes	J7
Debug on-board	Open
Debug in	Closed
Debug out	Open

The J-Link On-Board (JLOB) debug interface supporting JTAG, SWD debug interface and also supports the VCOM (Virtual COM port) function. The debug MCU is a Renesas RA4M2, programmed with J-Link firmware licensed by Segger. This interface includes one USB micro-B connector (J6) for host debug through the J-Link MCU, one 10-pin and one 20-pin debug header (supporting JTAG and SWD).

Table 12. Debug USB Connector

Debug USB Connector(J6)		VOICE-RA2L1
Pin	Description	Signal / Bus
J6-1	+5VDC	VBUS2 / TP2
J6-2	Data-	D_N
J6-3	Data+	D_P
J6-4	USB ID, jack internal switch, cable inserted	N.C.
J6-5	Ground	GND

Table 13. 10-pin JTAG/SWD Connector (J8)

Pin	JTAG Pin Name	SWD Pin Name	RA4M2 Signal/Bus
J8-1	Vtref	Vtref	+3V3
J8-2	TMS	SWDIO	P108/SWDIO
J8-3	GND	GND	GND
J8-4	TCK	SWCLK	P300/SWCLK
J8-5	GND	GND	GND
J8-6	TDO		P109
J8-7	Key	Key	N.C.
J8-8	TDI		P110
J8-9	GND Detect	GND Detect	GND
J8-10	nSRST	nSRST	RESET#

Table 14. 20-pin JTAG/SWD Connector (J9)

Pin	JTAG Pin Name	SWD Pin Name	RA4M2 Signal/Bus
J9-1	Vtref	Vtref	+3V3
J9-2	TMS	SWDIO	P108/SWDIO
J9-3	GND	GND	GND
J9-4	TCK	SWCLK	P300/SWCLK
J9-5	GND	GND	GND
J9-6	TDO		P109
J9-7	Key	Key	N.C.
J9-8	TDI		P110
J9-9	GND Detect	GND Detect	GND
J9-10	nSRST	nSRST	RESET#
J9-11	GND	GND	GND
J9-12	N/A	N/A	N.C.
J9-13	GND	GND	GND
J9-14	N/A	N/A	N.C.
J9-15	GND	GND	GND
J9-16	N/A	N/A	N.C.
J9-17	GND	GND	GND
J9-18	N/A	N/A	N.C.
J9-19	N/A	N/A	GND
J9-20	N/A	N/A	N.C.

Table 15. Debug Port Signal Assignments

RA2L1 MCU Port	Debug signal usage
P108	SWDIO
P300	SWCLK

8.6 Power

5V may be supplied from an external USB host to the USB Debug connector (J6) labelled with **J-Link OB** on the board or from USB type-C connector(J1) labelled with **USB-C**.
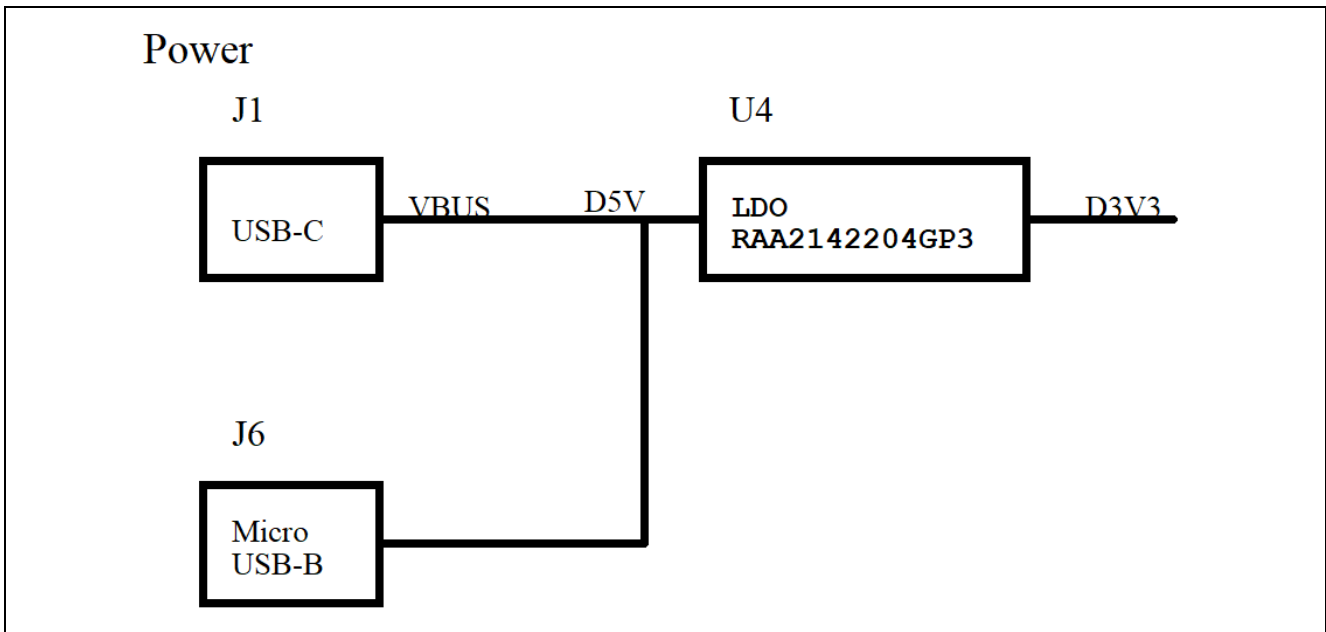

Figure 5. VOICE-RA2L1 Power Block Diagram

8.7 USB Type-C

The board includes one USB TYPE-C connector (J1) only for supply 5V purpose.

Table 16. USB Type-C Signal Assignments (J1)

USB FS Signal	USB-C Signal Name	USB-C Connection
GND	GND	A1
N.C.	TXp1	A2
N.C.	TXn1	A3
VBUS1	VBUS	A4
N.C.	CC1	A5
USB1_P	DP1	A6
USB1_N	DN1	A7
N.C.	SBU1	A8
VBUS1	VBUS	A9
N.C.	RXN2	A10
N.C.	RXP2	A11
GND	GND	A12
GND	GND	B1
N.C.	TXP2	B2
N.C.	TXN2	B3
VBUS1	VBUS	B4
N.C.	CC2	B5
USB1_P	DP2	B6
USB1_N	DN2	B7
N.C.	SBU2	B8
VBUS1	VBUS	B9
N.C.	RXN1	B10
N.C.	RXP1	B11
GND	GND	B12

9. Certifications

To support international distribution, the following certification requirements are met, both by design and test.

Americas: FCC Class B

Europe: CE Class B

Revision History

Rev.	Date	Description	
		Page	Summary
1.0	September 2022		Initial release

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Renesas Electronics Corporation