

RZ/V Verified Linux Package

Software Manual for RZ/V2MA

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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.

How to Use This Manual

1. Purpose and Target Readers

This document is designed to provide the user with an understanding of the software development environment for RZ/V2MA Group processors. It is intended for users developing software incorporating the processors. Basic knowledge of software development and Linux systems is necessary to use this document.

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

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

2. List of Abbreviations and Acronyms

Abbreviation	Full form
BSP	Board support package
CSI	Clock serial interface
DMA	Direct memory access
eMMC	Embedded multi-media card
GPIO	General purpose input/output interface
GPL	GNU General Public License
I2C	Inter-integrated circuit
LGPL	GNU Lesser General Public License
PCI	Peripheral component interconnect
PCIe	PCI Express
PFC	Pin function controller
PWM	Pulse width modulation
SDHC	SD high capacity
SDHI	SD card host interface H/W module
SDIO	SD input/output
SDXC	SD extended capacity
TSU	Thermal sensor unit
UART	Universal Asynchronous Receiver/Transmitter
USB	Universal Serial Bus

3. Conventions

Command line runs on Linux host PC will be shown as below:

```
$ echo "This is command line run on x86-64 Linux PC"
```

Command line run on target board will be shown as below:

```
# echo "This is command line run on ARM board"
```

File content will be shown as below:

```
<$WORK/a script>  
#!/bin/bash  
echo "This is content in a file"
```

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1. Overview

Renesas provides the RZ/V Verified Linux Package (hereafter as “RZ/V VLP (RZ/V2MA)”) software as the integrated Linux package.

The Linux system in this package consists of a Linux kernel, Linux Standard Library, and Linux shell.

This Linux package has checked the operation and managed this version by Renesas.

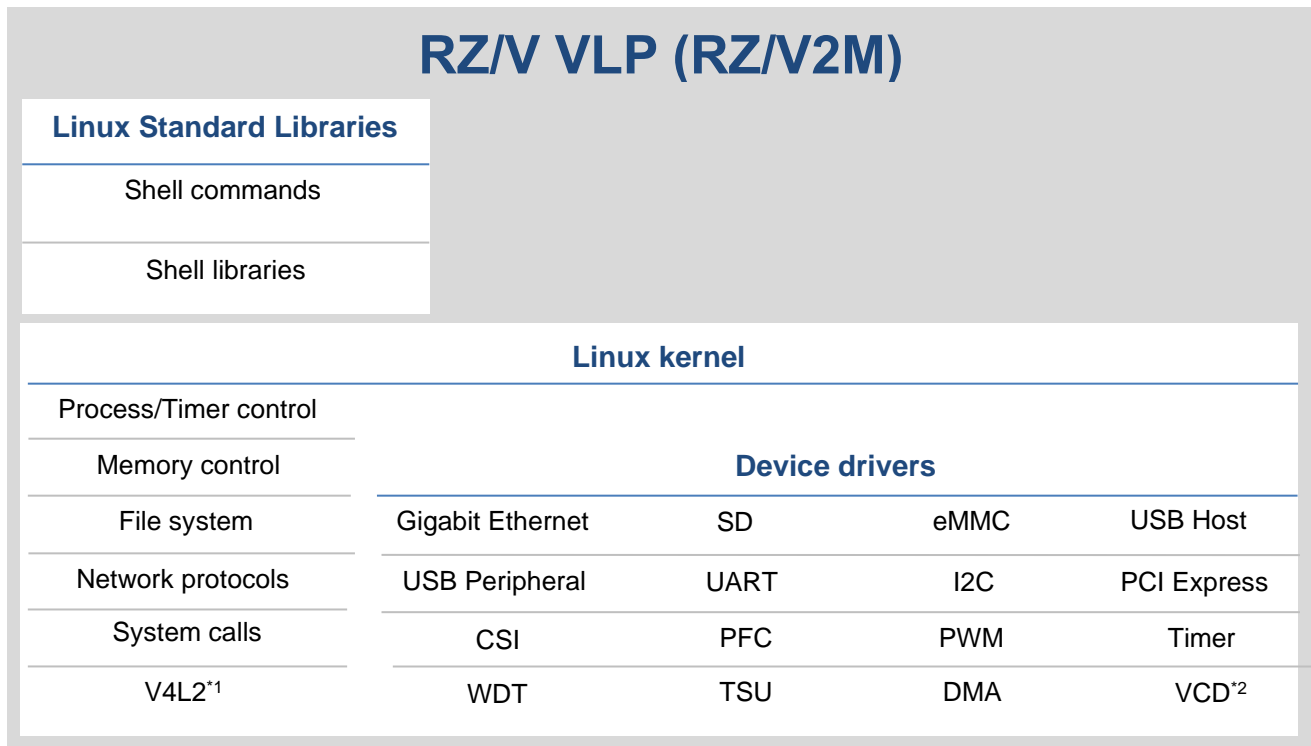


Figure 1-1. RZ/V VLP (RZ/V2M)

Note1: V4L2 in this package provides functions required for using a USB/MIPI camera.

Note2: Provided in the RZ/V2MA Video Codec Package.

1.1 Overview of RZ/V VLP (RZ/V2M)

The main software in this package is as follows.

Refer to "RZ/V Verified Linux Package Release Note" (hereafter as "release note") for each version of the software.

Table 1-1. RZ/V VLP (RZ/V2M) software components

Component	Software name	Summary	Section
Linux Kernel	CIP SLTS Linux kernel	Linux kernel proposed by CIP project.	2.1
Linux Standard Libraries	busybox	A Program that combines UNIX utilities into a small execute file.	2.2
	binutils	Binary tool sets.	2.2
	glibc	GNU standard C library.	2.2
	openssl	Cryptographic library with the TLS/SSL protocol.	2.2
	(Various software other than above)	Building system provided by Yocto Project.	2.6
Video	V4L2	The name of a popular API used in the handling of moving image data under the Linux OS.	2.5

The following table shows the device drivers in this package.

Table 1-2. Device drivers in RZ/V VLP (RZ/V2M)

Driver	Summary	Section
Gigabit Ethernet	Transmit/Receive Ethernet frames.	2.4.1
SD	Read/Write SD cards.	2.4.2
eMMC	Read/Write eMMC.	2.4.3
USB Host	Transmit/Receive data between USB devices as USB Host function.	2.4.4
USB Peripheral	Transmit/Receive data between USB devices as USB Peripheral function.	2.4.5
UART	Serial communication by UART.	2.4.6
I2C	Transmit/Receive data between connected devices on the I2C bus.	2.4.7
PCI Express	Communicate by PCI express.	2.4.8
CSI	Clock synchronism serial transmission.	2.4.9
PFC	Switch the dual function of LSI external pins and configure the setting of GPIO pins.	2.4.10
PWM	Output PWM signal.	2.4.11
Timer	Configure the setting of the interval timer.	2.4.12
Watchdog Timer	Configure the setting of the watchdog timer.	2.4.13
TSU	Get the LSI temperature output from the temperature sensor.	2.4.14
DMA	Control the DMA controller on the RZ/V2MA.	2.4.15

2. RZ/V VLP (RZ/V2M) Main Functions

This chapter explains the major functions of the software included in this package.

2.1 Linux Kernel

The Linux kernel is the core of the UNIX-like Linux OS. The Linux kernel is in its own kernel space, instead of in the user space which holds applications.

The RZ/V VLP (RZ/V2M) provides CIP SLTS Linux kernel which is managed by Civil Infrastructure Platform (CIP) Project.

The Linux kernel consists of the several components described below.

2.1.1 Linux System Call

A Linux system call is the interface between the user space and the Linux kernel. It allows applications to handle the components described below.

2.1.2 Process/Timer Control

A process is a running program. In Linux, processes have a one-to-one relation with threads, so there is no distinction between the two.

The Linux kernel controls multiple threads by running respectively for a specified time and then running the next. The time over which a thread run is controlled by interrupts generated by a hardware timer.

2.1.3 Memory Control

The Linux kernel allocates memory for each process. At this time, the kernel allocates memory from a virtual area called the virtual memory space.

2.1.4 File System

OSs generally handles data as files. A File system is a system for abstracting and controlling files.

Linux handles not only data but also certain devices (such as mouse and keyboard devices) as files. This file system is referred to as the virtual file system (VFS). The VFS enables Linux to handle data and devices through a common interface for access to files.

2.1.5 Device Driver

Device drivers are software modules to operate the hardware devices. Device drivers are divided into two types according to whether they are independent of or dependent on the machine's architecture. The former is called the board support package (BSP). Besides, the source code for those which are independent of the architecture is under `./linux/drivers`, and that for the others (depending) under `./linux/arch`.

Refer to section 2.4 for details on the device drivers in this Linux package.

2.1.6 Network Protocols

The Linux kernel supports multiple protocols, including the Internet Protocol (IP), Transmission Control Protocol (TCP), and User Datagram Protocol (UDP) as network functions.

2.2 Linux Standard Libraries

A library is a collection of often-used functions that can be used by other computer programs. The two types of library Linux supports are static and shared libraries.

Static libraries, with “.a” as the filename extension, are included in executable files when programs are created. Static libraries have merits in their higher speed of execution and that operation will not change once a program has been compiled. On the other hand, their drawback is that including static libraries in all programs leads to the programs being bigger.

Shared libraries, with “.so” followed by a period and the version number as the filename extension, are only loaded when a program is executed. Shared libraries have the merit that access by multiple programs to a shared library leads to the programs being smaller. On the other hand, one drawback is that updating a library can affect all functions for which the library is in use.

- Relationship between links and libraries

The means for a program to call the functions of libraries is referred to as linking. There are two types of linking, static and dynamic.

In static linking, the functions of a library are built into the main body of the program in advance when a program is created. Static libraries are those for which building is with the use of static linking.

In dynamic linking, the functions of a library are called during the execution of a program. Shared libraries are those in which linking takes the form of setting up such calls.

Linux standard libraries in this package is based on CIP Core. Software components not included in CIP Core are used that is provided by Yocto Project.

CIP Core provides the following software. Please refer to the release note or component list about each software version.

- glibc
- binutils *Unincluded in the root file system.
- Busybox
- openssl

2.3 Linux Shell

Linux shell is a program bridging the interfaces for operating the actual Linux operation.

In running processes under Linux, users enter character strings through a shell, which provides a character user interface (CUI), or use a graphical user interface (GUI). These handles processing by the Linux kernel, which serves as the core of the Linux OS.

However, how processing by CUI or GUI relates to the Linux kernel itself cannot be directly understood. In addition, most results of processing by the Linux kernel are output informs that users cannot understand without intermediary interpretation.

For these reasons, an appropriate program is required to mediate between users and the Linux kernel and to convert data to suit the respective forms in which they can understand the data. The Linux shell is that program.

There are various types of Linux shell. The RZ/V VLP (RZ/V2M) uses the Bourne Again Shell (bash).

2.4 Device Drivers

This package provides device drivers for controlling the hardware functions on RZ/V2MA and various devices on the board. This subsection describes the main device drivers in this package.

2.4.1 Gigabit Ethernet

This module controls the Ethernet MAC interface on RZ/V2MA to handle the transfer/receive of Ethernet frame data on Linux.

2.4.1.1 Hardware Configuration

Table 2-1. Hardware configuration (Gigabit Ethernet)

RZ/V2MA
1ch (ETH0)

2.4.1.2 Function

This module provides the following functions.

- Comply with IEEE802.3
- Transmission and reception of Ethernet frame
- Transfer rate: 100 Mbps, 1000 Mbps
- Transmission mode: Full-duplex mode

2.4.1.3 Software Interface

The function of this module is provided as a standard Linux network interface. It can be used various network functions of Linux by specifying the following network interface.

Table 2-2. Network interface (Gigabit Ethernet)

Network interface	Summary
eth0	The default configuration sets to eth0.

2.4.1.4 Device Driver Specification

Refer to the following documentation for details.

- Linux Interface Specification Device Driver Gigabit Ethernet User's Manual: Software

2.4.2 SD

This module controls the SD/MMC Host Controller on the RZ/V2MA to perform reading/writing and DMA transfer to an SD card.

2.4.2.1 Hardware Configuration

Table 2-3. Hardware configuration (SD)

RZ/V2MA
2ch* (SDI0, SDI1)

Note: RZ/V2MA Evaluation Board Kit has only one connector for SDI0.

2.4.2.2 Description of Functionality

This module supports the following functions.

Table 2-4. Supported functions (SD)

Function	Support status
SD memory Card	SD, SDHC, SDXC ^{*1}
SDIO Card	Supported ^{*3}
Transfer Modes	1bit, 4bit
Bus Speed Mode ^{*2}	Default Speed (DS), High Speed (HS), UHS-I
DMA Transfer	Supported the internal DMA
Card Power Control	Supported
Card Detection (CD)	Supported
Card Detection (DAT3)	Unsupported
Write Protection	Supported ^{*3}
SPI Mode	Unsupported
SD Mechanical Write Protect Switch	Supported ^{*3}
SD Clock Control	Supported
CPRM Security	Unsupported
CMD52 During Data Transfer(C52PUB)	Unsupported
Data Transfer Abort (IOABT)	Unsupported
Read Wait (RWREQ)	Unsupported
SDIO Wake Up	Unsupported
SDIO Suspend/Resume	Unsupported

Notes: *1. SDXC memory cards that are formatted with the exFAT cannot be mounted because BSP standard file system does not support the exFAT.

*2. DDR50 is unsupported.

*3. RZ/V2MA Evaluation Board Kit does not support this function.

The following table shows the list of SD standard documents related to this module.

Table 2-5. SD standard document

Document No.	Publication	Document title	Revision	Date
-	SD Card Association	SD Specifications Part 1 Physical Layer Specification Simplified Specification	4.01	Jan. 22, 2013
-	SD Card Association	SD Specifications Part E1 SDIO Simplified Specification	3.00	Feb. 25, 2011

2.4.2.3 Software Interface

The function of this module is provided as a standard Linux device interface. It can be used the SD function on Linux by specifying the following device file.

Table 2-6. Device file (SD)

Device file	Summary
/dev/mmcblkN*	The default configuration sets as bellow: SDI0: /dev/mmcblkN* SDI1: /dev/mmcblkN*

Note: The numerical value N might be different according to the system. (ex: /dev/mmcblk0)

2.4.2.4 Device Driver Specification

Refer to the following documentation for details.

- Linux Interface Specification Device Driver SD/eMMC User's Manual: Software

2.4.3 eMMC

This module controls the SD/MMC Host Controller on RZ/V2MA to read from or write into an eMMC memory and to proceed with DMA transfer.

2.4.3.1 Hardware Configuration

Table 2-7. Hardware configuration (eMMC)

RZ/V2MA
1ch (eMMC)

2.4.3.2 Description of Functionality

This module supports the following functions.

Table 2-8. Supported functions (eMMC)

Function	Support status
eMMC device access	Supported
Transfer modes	1,4,8bit
Bus speed modes*	High-Speed, HS200, Backward compatible
DMA transfer	Supported internal DMA
Stream transfer	Unsupported
Open-ended / Multi block transfer	Unsupported

Note: High Speed DDR and HS400 are unsupported.

The following table shows the list of eMMC standard documents related to this module.

Table 2-9. eMMC standard document

Document No.	Publication	Document Title	Revision	Date
JESD84-B51	JEDEC STANDARD	EMBEDDED MULTI-MEDIA CARD (e•MMC), ELECTRICAL STANDARD (5.1)	5.1	2013.09

2.4.3.3 Software Interface

The function of this module is provided as a standard Linux device interface. It can be used the eMMC function on Linux by specifying the following device file.

Table 2-10. Device file (eMMC)

Device file	Summary
/dev/mmcblkN*	The default configuration sets as bellow: eMMC: /dev/mmcblkN*

Note: The numerical value N might be different according to the system. (ex: /dev/mmcblk0)

2.4.3.4 Device Driver Specification

Refer to the following documentation for details.

- Linux Interface Specification Device Driver SD/eMMC User's Manual: Software

2.4.4 USB Host

This module controls the USB host controller on RZ/V2MA to transfer data to/from USB devices. This module complies with the USB3.1 Gen1 standard.

2.4.4.1 Hardware Configuration

Table 2-11. Hardware configuration (USB Host)

RZ/V2MA
1ch* (USB)

Note: USB Host is used exclusivity with USB Peripheral.

2.4.4.2 Description of Functionality

This module provides the following functions.

- Transfer: Super-Speed(5Gbps)/High-Speed (480Mbps)/Full-Speed*1 (12Mbps)/Low-Speed*1 (1.5Mbps)
- Transfer types: Isochronous/Interrupt*1/Control/Bulk
- High bandwidth transfer: Isochronous/Interrupt
- Comply with eXtensible Host Controller Interface (xHCI) Specification for USB

The module supports the USB On-The-Go.

The following list shows the USB standard documents related to this module.

- Universal Serial Bus 3.1 Specification Revision 1.0 and ECNs approved through June 27, 2017
- Universal Serial Bus Specification Revision 2.0

2.4.4.3 Software Interface

The function of this module is provided as a standard Linux device interface. After connecting to a USB device, USB devices can be controlled on Linux by specifying the following device file.

USB devices can be enabled through kernel configuration.

Table 2-12. Device file (USB Host)

Device file	Summary
/dev/input/eventX*	Device files compatible with keyboard.
/dev/input/mouseY*	Device files compatible with mouse.
/dev/sdZ*	Device files compatible with USB storage.

Note: The numerical value X, Y, and Z might be different according to the system. (ex: /dev/input/event0)

2.4.4.4 Device Driver Specification

Refer to the following documentation for details.

- Linux Interface Specification Device Driver USB Host User's Manual: Software

2.4.5 USB Peripheral

This module controls the USB peripheral controller on RZ/V2MA to transfer data to/from USB devices. This module complies with USB3.1 Gen1 standard.

2.4.5.1 Hardware Configuration

Table 2-13. Hardware configuration (USB Peripheral)

RZ/V2MA
1ch* (USB)

Note: USB Peripheral is used exclusivity with USB Host.

2.4.5.2 Description of Functionality

This module provides the following functions.

- Transfer: Super-Speed (5Gbps)/High-Speed (480Mbps)/Full-Speed (12Mbps)
- Transfer type: Interrupt/Control/Bulk
- Each PIPE can be set below.
 - [USB 3.1]
 - Number of endpoints: 0 to 8
 - Transfer type: Control (PIPE0 only), Bulk, Interrupt
 - Transfer direction: IN/OUT
 - IN: ep1(PIPE1), ep3(PIPE3), ep5(PIPE5), ep7(PIPE7)
 - OUT: ep2(PIPE2), ep4(PIPE4), ep6(PIPE6), ep8(PIPE8)
 - Maximum packet size: 512byte (PIPE0), 1024byte (others) *Unsupported for high bandwidth
 - [USB 2.0]
 - Number of endpoints: 0 to 8
 - Transfer type: Control (PIPE0 only), Bulk, Interrupt
 - Transfer direction: IN/OUT
 - IN: ep1(PIPE1), ep3(PIPE3), ep5(PIPE5), ep7(PIPE7)
 - OUT: ep2(PIPE2), ep4(PIPE4), ep6(PIPE6), ep8(PIPE8)
 - Maximum packet size: 64byte (PIPE0), 1024byte (others) *Unsupported for high bandwidth

This module supports the USB On-The-Go.

The following list shows the USB standard documents related to this module.

- Universal Serial Bus 3.1 Specification Revision 1.0 and ECNs approved through June 27, 2017
- Universal Serial Bus Specification Revision 2.0

2.4.5.3 Software Interface

This module provides a standard Linux interface for implementing the function as USB peripheral.

The following table shows an example of a device file. The supported USB devices can be enabled through kernel configuration.

Table 2-14. Device file (USB Peripheral)

Device file	Summary
/dev/ttyGS0	Device files for serial communication on a USB port.

2.4.5.4 Device Driver Specification

Refer to the following documentation for details.

- Linux Interface Specification Device Driver USB Peripheral User's Manual: Software

2.4.6 UART

This module controls UART on RZ/V2MA to transfer data over RS232C links and control the settings for communications.

2.4.6.1 Hardware Configuration

Table 2-15. Hardware configuration (UART)

RZ/V2MA
2ch (UART0, UART1)

2.4.6.2 Description of Functionality

This module provides the following functions. *

- Data transfer over RS232C links
- Control of the settings for communications
 - The following baud rate are supported: 9600, 19200, 38400, 57600, and 115200 bps
 - Parity bit: no parity/odd/even
 - Stop bits: 1 or 2 bit
 - Bit width for transfer: 7 or 8 bit
- Hardware Flow control

Note: This Linux system uses ch0 standardly as the UART for console connection.

The following settings are executed after starting up Linux immediately:

Baud rate: 115200bps, Parity bit: None, Stop bit: 1bit, Bid width for transfer: 8bit

2.4.6.3 Software Interface

The function of this module is provided as a standard Linux device interface. It can be used for UART communication on Linux by specifying the following device file.

Table 2-16. Device file (UART)

Device file	Summary
/dev/ttyS*	The default configuration sets as bellow: UART0: /dev/ttyS0 UART1: /dev/ttyS1

2.4.6.4 Device Driver Specification

Refer to the following documentation for details.

- Linux Interface Specification Device Driver UART User's Manual: Software

2.4.7 I2C

This module controls the I2C interface on RZ/V2MA to transmit data between the slave devices on the I2C bus.

2.4.7.1 Hardware Configuration

Table 2-17. Hardware configuration (I2C)

RZ/V2MA
4ch (I2C0~I2C3)

2.4.7.2 Description of Functionality

This module provides the following functions.

Table 2-18. Supported functions (I2C)

Function	Support status
Master mode	Supported
Slave mode	Unsupported
Serial clock (SCL)	Settable for "High" level width and "Low" level width

This module supports I2C transfer speed as follows.

Table 2-19. Transfer speed (I2C)

Interface mode	Real transfer speed	Support status
Standard mode (100KHz)	Max 100Kbit/s	Supported.
Fast mode (400KHz)	Max 400Kbit/s	Supported.
High speed mode (3.4MHz)	Max 3400Kbit/s	Unsupported.

This module complies with the following standard.

Table 2-20. I2C standard document

Document No.	Publication	Document title	Revision	Date
-	Philips Semiconductors	THE I2C-BUS SPECIFICATION	2.1	2000.01

2.4.7.3 Software Interface

The function of this module is provided as a standard Linux interface. I2C communication can be executed on Linux by specifying the following device file.

Table 2-21. Device file (I2C)

Device file	Summary
/dev/i2c-*	The default configuration sets as bellow: I2C0: /dev/i2c-0 I2C1: /dev/i2c-1 I2C2: /dev/i2c-2 I2C3: /dev/i2c-3

2.4.7.4 Device Driver Specification

Refer to the following documentation for details.

- Linux Interface Specification Device Driver I2C User's Manual: Software

2.4.8 PCI Express

This module controls PCI Express (PCIe) interface on RZ/V2MA and performs data communication. This module complies with PCIe Gen2.

2.4.8.1 Hardware Configuration

Table 2-22. Hardware configuration (PCIe)

RZ/V2MA
2 lane (PCI)

Note: PCI Express cannot be used on the RZ/V2MA Evaluation Board Kit.

2.4.8.2 Description of Functionality

This module provides the following function.

- Supported configuration: Root complex, Endpoints
- Transfer rate: 5GT/s
- Host initiated IO (legacy) reads and writes
- Host initiated memory reads and writes
- Slave initiated memory reads and writes
- Interrupt: INTx, MSI

This module complies with the following standard.

- PCI Express Base Specification 4.0

2.4.8.3 Software Interface

PCI Express communication is executed on Linux by specifying the following device file.

Table 2-23. Device file (PCIe)

Device file	Summary
/sys/class/pci_bus	The default configuration sets as bellow: PCI: /sys/class/pci_bus

2.4.8.4 Device Driver Specification

Refer to the following documentation for details.

- Linux Interface Specification Device Driver PCI Express User's Manual: Software

2.4.9 CSI

This module controls CSI interface on RZ/V2MA and performs serial data transmission.

2.4.9.1 Hardware Configuration

Table 2-24. Hardware configuration (CSI)

RZ/V2MA
6ch (CSI0~CSI5)

2.4.9.2 Description of Functionality

This module provides the following function.

Table 2-25. Supported functions (CSI)

Function	Support status
Data transfer mode	Master reception only mode, Master transmission/reception mode, Slave reception only mode, Slave transmission/reception mode
Serial data length	8, 16bit
Initial bit	MSB/LSB * Default setting is MSB.
Data transfer method	Interrupt
Serial clock	(Master mode) Max 48 MHz, divided from 2 to 32,766 (Slave mode) Max 24 MHz
Transmit/Receive FIFO	16bit (8bit + 8bit) * 16 stage
Waiting time between serial data	Settable in master mode

2.4.9.3 Software Interface

CSI communication is executed on Linux by specifying the following device file.

Table 2-26. Device file (CSI)

Device file	Summary
/dev/spidev*.0	The default configuration sets as bellow: CSIN: /dev/spidevN.0* * N is changed depending on the number of using CSI channels. (N=0~5)

2.4.9.4 Device Driver Specification

Refer to the following documentation for details.

- Linux Interface Specification Device Driver CSI User's Manual: Software

2.4.10 PFC

This module controls the pin function controller (PFC) on RZ/V2MA to switch the shared function of LSI external pins and set general purpose input/output interface (GPIO).

2.4.10.1 Hardware Configuration

(1) Supported pin

Available GPIO pins on RZ/V2MA are shown in the table below. The shared pins setting initially in this BSP are described in bold. Refer to the “RZ/V2MA Hardware Manual” for the detail of each shared pin.

Table 2-27. IO Group PORT00

External pin	Dual-purpose pin0	Dual-purpose pin 1	Dual-purpose pin 2
	GPIO	-	eMMC
P0008	P00_08	-	-
P0009	P00_09	-	-
P0012	P00_12	-	-
P0013	P00_13	-	-

Table 2-28. IO Group PORT01

External pin	Dual-purpose pin0	Dual-purpose pin1	Dual-purpose pin2
	GPIO	PWM	External interruption
PM0	P01_00	PM0	INEXINT8
PM1	P01_01	PM1	INEXINT9
PM2	P01_02	PM2	INEXINT10
PM3	P01_03	PM3	INEXINT11
PM4	P01_04	PM4	INEXINT12
PM5	P01_05	PM5	INEXINT13
PM6	P01_06	PM6	INEXINT14
PM7	P01_07	PM7	INEXINT15
PM8	P01_08	PM8	INEXINT16
PM9	P01_09	PM9	INEXINT17
PM10	P01_10	PM10	INEXINT18
PM11	P01_11	PM11	INEXINT19
PM12	P01_12	PM12	INEXINT20
PM13	P01_13	PM13	INEXINT21
PM14	P01_14	PM14	INEXINT22
PM15	P01_15	PM15	INEXINT23

Table 2-29. IO Group PORT02

External pin	Dual-purpose pin0	Dual-purpose pin1	Dual-purpose pin2
	GPIO	-	External interruption
INEXINT0	P02_00	-	INEXINT0
INEXINT1	P02_01	-	INEXINT1
INEXINT2	P02_02	-	INEXINT2
INEXINT3	P02_03	-	INEXINT3
INEXINT4	P02_04	-	INEXINT4
INEXINT5	P02_05	-	INEXINT5
INEXINT6	P02_06	-	INEXINT6
INEXINT7	P02_07	-	INEXINT7

Table 2-30. IO Group PORT03

External pin	Dual-purpose pin0	Dual-purpose pin1	Dual-purpose pin2	Dual-purpose pin3
	GPIO	CSI0, CSI1, CSI2, CSI3	UART0, UART1, IIC2, IIC3, CSI3	CSI0, CSI1, CSI2, CSI3
CSTXD0	P03_00	CSTXD0	UATX0	CSRXD0
CSRXD0	P03_01	CSRXD0	UARX0	-
CSSCLK0	P03_02	CSSCLK0	UACTS0N	-
CSCS0	P03_03	CSCS0	UARTS0N	-
CSTXD1	P03_04	CSTXD1	UATX1	CSRXD1
CSRXD1	P03_05	CSRXD1	UARX1	-
CSSCLK1	P03_06	CSSCLK1	UACTS1N	-
CSCS1	P03_07	CSCS1	UARTS1N	-
CSTXD2	P03_08	CSTXD2	I2SDA2	CSRXD2
CSRXD2	P03_09	CSRXD2	I2SCL2	-
CSSCLK2	P03_10	CSSCLK2	I2SDA3	-
CSCS2	P03_11	CSCS2	I2SCL3	-
CSTXD3	P03_12	CSTXD3	CSRXD3	-
CSRXD3	P03_13	CSRXD3	-	-
CSSCLK3	P03_14	CSSCLK3	-	-
CSCS3	P03_15	CSCS3	-	-

Table 2-31. IO Group PORT04

External pin	Dual-purpose pin0	Dual-purpose pin1	Dual-purpose pin2
	GPIO	CSI4, CSI5	CSI4, CSI5
CSTXD4	P04_00	CSTXD4	CSRXD4
CSRXD4	P04_01	CSRXD4	-
CSSCLK4	P04_02	CSSCLK4	-
CSCS4	P04_03	CSCS4	-
CSTXD5	P04_04	CSTXD5	CSRXD5
CSRXD5	P04_05	CSRXD5	-
CSSCLK5	P04_06	CSSCLK5	-
CSCS5	P04_07	CSCS5	-

Table 2-32. IO Group PORT05

External pin	Dual-purpose pin0	Dual-purpose pin1	Dual-purpose pin2
	GPIO	-	IIC0, IIC1
I2SDA0	P05_00	-	I2SDA0
I2SCL0	P05_01	-	I2SCL0
I2SDA1	P05_02	-	I2SDA1
I2SCL1	P05_03	-	I2SCL1

Table 2-33. IO Group PORT06

External pin	Dual-purpose pin0	Dual-purpose pin1	Dual-purpose pin2
	GPIO	-	-
P0600	P06_00	-	-
P0601	P06_01	-	-
P0602	P06_02	-	-
P0603	P06_03	-	-
P0604	P06_04	-	-
P0605	P06_05	-	-
P0606	P06_06	-	-
P0607	P06_07	-	-
P0608	P06_08	-	-
P0609	P06_09	-	-
P0610	P06_10	-	-
P0611	P06_11	-	-

Table 2-34. IO Group PORT07

External pin	Dual-purpose pin0	Dual-purpose pin1	Dual-purpose pin2
	GPIO	-	-
P0700	P07_00	-	-
P0701	P07_01	-	-
P0702	P07_02	-	-
P0703	P07_03	-	-
P0704	P07_04	-	-
P0705	P07_05	-	-

Table 2-35. IO Group PORT08

External pin	Dual-purpose pin0	Dual-purpose pin1	Dual-purpose pin2
	GPIO	SDIO	-
SD0CMD	P08_00	SD0CMD	-
SD0CLK	P08_01	SD0CLK	-
SD0DAT0	P08_02	SD0DAT0	-
SD0DAT0	P08_03	SD0DAT0	-
SD0DAT2	P08_04	SD0DAT2	-
SD0DAT3	P08_05	SD0DAT3	-
SD0WP	P08_06	SD0WP	-
SD0CD	P08_07	SD0CD	-

Table 2-36. IO Group PORT09

External pin	Dual-purpose pin0	Dual-purpose pin1	Dual-purpose pin2
	GPIO	SDI1	External interruption
SD1FCMD	P09_00	SD1FCMD	-
SD1FCLK	P09_01	SD1FCLK	-
SD1FDAT0	P09_02	SD1FDAT0	-
SD1FDAT1	P09_03	SD1FDAT1	-
SD1FDAT2	P09_04	SD1FDAT2	-
SD1FDAT3	P09_05	SD1FDAT3	-
SD1FWP	P09_06	SD1FWP	INEXINT24
SD1FCD	P09_07	SD1FCD	INEXINT25

Table 2-37. IO Group PORT10

External pin	Dual-purpose pin0	Dual-purpose pin1	Dual-purpose pin2
	GPIO	SDI1	External interruption
P1000	P10_00	-	—
P1001	P10_01	-	—
P1002	P10_02	-	—
P1003	P10_03	-	—
P1004	P10_04	-	—
P1005	P10_05	-	—
P1006	P10_06	-	INEXINT26
P1007	P10_07	-	INEXINT27
P1008	P10_08	-	—

Table 2-38. IO Group PORT11

External pin	Dual-purpose pin0	Dual-purpose pin1	Dual-purpose pin2
	GPIO	-	External interruption
P1100	P11_00	-	-
P1101	P11_01	-	-
P1102	P11_02	-	-
P1103	P11_03	-	-
P1104	P11_04	-	-
P1105	P11_05	-	-
P1106	P11_06	-	INEXINT28
P1107	P11_07	-	INEXINT29
P1108	P11_08	-	-

Table 2-39. IO Group PORT12

External pin	Dual-purpose pin0	Dual-purpose pin1	Dual-purpose pin2
	GPIO	-	External interruption
P1200	P12_00	-	INEXINT30
P1201	P12_01	-	INEXINT31
P1202	P12_02	-	INEXINT32
P1203	P12_03	-	INEXINT33

Table 2-40. IO Group PORT13

External pin	Dual-purpose pin0	Dual-purpose pin1	Dual-purpose pin2
	GPIO	-	External interruption
P1300	P13_00	-	-
P1301	P13_01	-	-
P1302	P13_02	-	-
P1303	P13_03	-	-
P1304	P13_04	-	-
P1305	P13_05	-	-
P1306	P13_06	-	-
P1307	P13_07	-	-
P1308	P13_08	-	-
P1309	P13_09	-	INEXINT34
P1310	P13_10	-	INEXINT35
P1311	P13_11	-	INEXINT36

Table 2-41. IO Group PORT14

External pin	Dual-purpose pin0	Dual-purpose pin1	Dual-purpose pin2
	GPIO	-	External interruption
P1400	P14_00	-	-
P1401	P14_01	-	-
P1402	P14_02	-	INEXINT37
P1403	P14_03	-	-
P1404	P14_04	-	-
P1405	P14_05	-	-
P1406	P14_06	-	INEXINT38
P1407	P14_07	-	-

Table 2-42. IO Group PORT17

External pin	Dual-purpose pin0	Dual-purpose pin1	Dual-purpose pin2
	GPIO	-	-
P1700	P17_00	-	-

Table 2-43. IO Group PORT20

External pin	Dual-purpose pin0	Dual-purpose pin1	Dual-purpose pin2
	GPIO	-	-
P2000	P20_00	-	-
P2001	P20_01	-	-
P2002	P20_02	-	-

2.4.10.2 Description of Functionality

This module provides the following function.

- Control GPIO.
 - Select input/output of GPIO pin.
 - Read a state of high/low in an input pin.
 - Set high/low in an output pin.
- Switch between dual-purpose pins.
- Control Pull-up/down of a dual-purpose pin.
- Switch drive capability of LSI pin.
- Switch slew-rate of a dual-purpose pin.
- Mask control for an external interruption signal.
- Inverse the polarity of an external interruption signal.
 - Specify the inverse of polarity when the external interruption signal is low-active.

2.4.10.3 Software Interface

This module function is executed on Linux by specifying the following device file.

Table 2-44. Device file (PFC)

Device file	Summary
/sys/class/gpio/gpioN*	The default configuration sets as bellow: gpioN: /sys/class/gpio/gpioN*

Note: N indicates each pin number.

2.4.10.4 Device Driver Specification

Refer to the following documentation for details.

- Linux Interface Specification Device Driver PFC User's Manual: Software

2.4.11 PWM

This module sets pulse width modulation timer (PWM) on RZ/V2MA and outputs a PWM signal.

2.4.11.1 Hardware Configuration

Table 2-45. Hardware configuration (PWM)

RZ/V2MA
16ch (PWM0-PWM15)

2.4.11.2 Description of Functionality

This module provides the following function.

- Output continuous high-level width of signal*
- When PWM_CLK = 48MHz, PWM signal is settable as follows:
 - Period: 2.083 μ s - 0.416s (2.4 Hz -> 480 kHz)
 - Minimum resolution: 21ns
 - Duty rate: 0% - 100%
- Invert the PWM signal level (Low/High)

2.4.11.3 Software Interface

This module sets and outputs a PWM signal on Linux by specifying the following PWM sysfs interfaces.

Table 2-46. Device file (PWM)

Device file	Summary
/sys/class/pwm/pwmchip*/pwm0	The default configuration sets as below: PWMN: /sys/class/pwm/pwmchipN/pwm0 (N=0~15) (e.g.) PWM0: /sys/class/pwm/pwmchip0/pwm0 PWM1: /sys/class/pwm/pwmchip1/pwm0 PWM15: /sys/class/pwm/pwmchip15/pwm0

2.4.11.4 Device Driver Specification

Refer to the following documentation for details.

- Linux Interface Specification Device Driver PWM User's Manual: Software

2.4.12 Timer

This module configures the setting of interval timer by the timer (TIM) on RZ/V2MA.

2.4.12.1 Hardware Configuration

Table 2-47. Hardware configuration (TIM)

RZ/V2MA
32ch (TIM0-TIM31)

2.4.12.2 Description of Functionality

This module provides the following function.

- Run a timer with the 32-bit counter by specifying the timer mode (interval or free-running).

2.4.12.3 Software Interface

This module sets and outputs a timer signal on Linux by specifying the following interfaces.

Table 2-48. Device file (TIM)

Device file	Summary
/dev/hw_tim*	The default configuration sets as bellow: TIMN: /dev/hw_timN (N=0~31) (e.g) TIM0: /dev/hw_tim0 TIM1: /dev/hw_tim1 ... TIM31: /dev/hw_tim31

2.4.12.4 Device Driver Specification

Refer to the following documentation for details.

- Linux Interface Specification Device Driver Timer User's Manual: Software

2.4.13 Watchdog Timer

This module configures the setting of watchdog timer (WDT) on RZ/V2MA.

2.4.13.1 Hardware Configuration

Table 2-49. Hardware configuration (WDT)

RZ/V2MA
2ch* (WDT0, WDT1)

Note: WDT0 and WDT1 are respectively for CA53 core 0 and core 1.

2.4.13.2 Description of Functionality

This module provides the following function.

- Set the watchdog timer with a 32-bit counter driven by WDT_CLK (48 MHz).
- The value of the periodic counter is settable from 1s to 89s.
- The interrupt occurs with the specified period. WDT is cleared before the WDT counter overflows.

2.4.13.3 Software Interface

This module sets and outputs a timer signal on Linux by specifying the following interfaces.

Table 2-50. Device file (WDT)

Device file	Summary
/dev/watchdog*	The default configuration sets as bellow: WDT0: /dev/watchdog0 WDT1: /dev/watchdog1

2.4.13.4 Device Driver Specification

Refer to the following documentation for details.

- Linux Interface Specification Device Driver WDT User's Manual: Software

2.4.14 TSU

This module configures the setting of the temperature sensor unit (TSU) on RZ/V2MA and gets the temperature of LSI output from this sensor.

2.4.14.1 Hardware Configuration

Table 2-51. Hardware configuration (TSU)

RZ/V2MA
1ch* (TSU0, TSU1) *

2.4.14.2 Description of Functionality

This module provides the following functions.

- Get the LSI temperature. *
Note: Comparing the temperature from TSU0 and TSU1, the higher value is the LSI temperature.
- Shut down the system when the LSI temperature exceeds the prespecified threshold.

2.4.14.3 Software Interface

The function of this module is provided as a standard Linux thermal sysfs interface.

Table 2-52. Device file (TSU)

Device file	Summary
/sys/class/thermal/thermal_zone0	The default configuration sets as bellow:

2.4.14.4 Device Driver Specification

Refer to the following documentation for details.

- Linux Interface Specification Device Driver TSU User's Manual: Software

2.4.15 DMA

This module controls the DMA controller on the RZ/V2MA.

2.4.15.1 Hardware Configuration

Table 2-53. Hardware configuration (DMA)

RZ/V2MA
16ch

2.4.15.2 Description of Functionality

This module provides the following functions.

- DMA device driver module management with DMA Engine framework.
- Control each channel of support DMAC.
- Call the registered callback function when completing the DMA transfer.
- Control the data transfer between memory to memory.
- Control the descriptor transfer.

2.4.15.3 Device Driver Specification

Refer to the following documentation for details.

- Linux Interface Specification Device Driver DMA User's Manual: Software

2.5 V4L2

Video for Linux 2 (V4L2) is a name of popular API. V4L2 handles moving image data on Linux OS, such as importing video from the camera. In this package, V4L2 provides only the required functions to import moving images from a USB camera or MIPI camera.

To capture video data from a camera, V4L2 controls the camera by specifying device files (e.g. /dev/video0) that corresponds to the camera device. The captured frame data can be used by application programs after mapping the data into user land.

2.5.1 API

The following table shows V4L2 APIs that are checked the operation in the RZ/V VLP (RZ/V2M).

Table 2-54. System calls using in V4L2

System call	Summary
open	Open a V4L2 device file.
close	Close a V4L2 device file.
ioctl	Issue V4L2 API for the opened device file.
select	Check if DQBUF can be executed.
mmap	Map a buffer in user space.
munmap	Unmap a buffer in user space.
ioctl(VIDIOC_S_FMT)	Specify the data format.
ioctl(VIDIOC_REQBUFS)	Request a buffer area.
ioctl(VIDIOC_QUERYBUF)	Query the status of a buffer.
ioctl(VIDIOC_QBUF)	Register a buffer.
ioctl(VIDIOC_DQBUF)	Release a buffer.
ioctl(VIDIOC_STREAMON)	Start streaming.
ioctl(VIDIOC_STREAMOFF)	Stop streaming.
ioctl(VIDIOC_QUERYCAP)	Inquire about the device capabilities.

Note: The string in parentheses after system call "ioctl" is the constant name to specify as the second argument when "ioctl" is issued.

2.5.2 Software Interface

Specify the following interface when using V4L2.

Table 2-55. Device file (V4L2)

Device file	Summary
/dev/videoN	This device file corresponds to the camera module. * N depends on the number of connecting devices. * For a MIPI camera, the device file is fixed as /dev/video0 and not changed dynamically.

2.6 Yocto environment, root File System and SDK

The RZ/V VLP (RZ/V2M) is developed based on Yocto Project. By building the Yocto environment (hereafter called “bitbake”) in this Linux package on Linux PC, it can be generated the Linux Kernel binaries to boot Linux for RZ/V2MA board and the file system image that mounts at Linux booting (hereafter called “root file system”). Using the prescribed method of bitbake also enables to generate the files to install the cross-compiler environment (hereafter called “SDK”) that can be installed on the Linux PC. Refer to the release note about the Yocto Project version that this Linux package is based on.

Notes: *1. Refer to the release note for the version of the Yocto Project this package is based on.

*2. Refer to the start-up guide on how to bitbake and make SDK.

The above root file system and SDK are composed by AArch64 binaries and libraries. Furthermore, by enabling the AArch32 libraries at bitbake, in addition to AArch64, it can support not only AArch32 binaries and libraries but also multilib. (Any AArch32 binaries and libraries would not be included in the root file system and SDK without additional user’s setting.)

The root file system in this package does not include GPLv3+ software components, it may be provided as an option.

This Linux package supports the configurations listed in the table below.

Table 2-56. RZ/V VLP (RZ/V2M) configuration

Configuration name	Summary
core-image-bsp	An image supporting for the RZ/V2MA device drivers.
core-image-minimal	Based on core-image-minimal provided by Yocto Project.

3. U-Boot

This chapter describes about the U-Boot included in the RZ/V VLP (RZ/V2M).

3.1 Supported Functions

U-boot for RZ/V2MA provides the following functions.

- Chip and board-specific hardware configuration.
- Load and boot the Linux kernel from a boot device (SD).
- Store the U-Boot environmental variables into eMMC.
- Executing boot commands using the serial console.
- Write into eMMC.

Note: Refer to the start-up guide for the method of how to write into eMMC and supported U-Boot environmental variables.

Revision History	RZ/V Verified Linux Package Software Manual for RZ/V2MA
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Rev.	Date	Description	
		Page	Summary
1.00	Sep.16.2022	—	First edition issued.
1.10	Jan.13.2023	—	Updated the revision number.
1.20	Jul.31.2023	—	Changed the document title.
		1, 17	Removed notes indicating that the PCIe Express endpoint is not supported.

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