

Linux Interface Specification Video Capture

User's Manual: Software

RZ/G2L Group, RZ/V2L Group,
RZ/V2N Group and RZ/G3E Group

All information contained in these materials, including products and product specifications, represents information on the product at the time of publication and is subject to change by Renesas Electronics Corp. without notice. Please review the latest information published by Renesas Electronics Corp. through various means, including the Renesas Electronics Corp. website (<http://www.renesas.com>).

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.1.12 Jul 2025)

Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,
Koto-ku, Tokyo 135-0061, Japan

www.renesas.com

Trademarks

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

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/.

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 manual is designed to provide the user with an understanding of the hardware functions and electrical characteristics of the MPU. It is intended for users designing application systems incorporating the MPU.. It is intended for users developing software incorporating the processors. A basic knowledge of software development and Linux systems is necessary in order 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.

The following documents apply to the RZ/G2L Group, RZ/V2L Group, RZ/V2N Group and RZ/G3E Group. Make sure to refer to the latest versions of these documents. The newest versions of the documents listed may be obtained from the Renesas Electronics Web site.

Document Type	Description	Document Title	Document No.
User's manual for Hardware	Hardware specifications (pin assignments, memory maps, peripheral function specifications, electrical characteristics, timing charts) and operation description Note: Refer to the application notes for details on using peripheral functions.	RZ/G2L Group User's Manual: Hardware	---
		RZ/V2L Group User's Manual: Hardware	---
		RZ/V2N Group User's Manual: Hardware	---
		RZ/G3E Group User's Manual: Hardware	---
User's manual for Software	Description of Video Capture Linux interface Specification	Linux interface Specification Device Driver Video Capture	This user's manual
Application Note	Information on using peripheral functions and application examples Sample programs Information on writing programs in assembly language and C	Available from Renesas Electronics Web site.	
Renesas Technical Update	Product specifications, updates on documents, etc.		

2. Notation of Numbers and Symbols

3. Register Notation

4. List of Abbreviations and Acronyms

Abbreviation	Full Form
CRU	Camera data Receiving Unit
V4L2	Video For Linux Two
MIPI CSI-2	MIPI Camera Serial Interface 2
VC	Virtual Channel

Table of Contents

1. Overview	1
1.1 Overview	1
1.2 General Function	1
1.2.1 MIPI CSI-2	1
1.2.2 Image Processing Block	2
1.3 Reference	3
1.3.1 Standard	3
1.3.2 Related document	3
1.4 Restrictions	3
2. Terminology	4
3. Operating Environment	5
3.1 Hardware Environment	5
3.2 Module Configuration	6
3.3 State Transition Diagram	6
4. Function	7
4.1 Connected Device	7
4.2 Input / Output Format	7
4.3 Input Resolution	8
4.4 Hardware Parameters	8
4.5 Field order	10
5. External Interface	11
5.1 Media Controller API	12
5.1.1 Show current routing	12
5.1.2 Activate/Deactivate a link	14
5.1.3 Configuring the pipeline and propagate format	15
5.1.4 Deactivate all active links	16
6. Integration	17
6.1 Directory Configuration	17
6.2 Integration Procedure	18
6.2.1 Camera data Receiving Unit Driver	18
6.2.2 I2C Driver	18
6.3 Option Setting	18
6.3.1 Module Parameters	18
6.3.2 Kernel Parameters	18

1. Overview

1.1 Overview

This manual explains the Linux Video capture (CRU) device driver in the RZ/G2L Group, RZ/V2L Group, RZ/V2N Group and RZ/G3E Group.

Note: Currently, this device is supported in two kernel versions v5.10 and v6.1 with the information below:

- v5.10: RZ/G2L Group, RZ/V2L Group.
- v6.1: RZ/G2L, RZ/G2LC, RZ/V2N Group and RZ/G3E Group.

1.2 General Function

The CRU consists of a MIPI CSI-2 block and an Image Processing block.

1.2.1 MIPI CSI-2

The MIPI CSI-2 is a MIPI Camera Serial Interface 2 receiver module.

- RZ/G2L, RZ/G2LC Group, RZ/V2N Group and RZ/G3E Group.

This module supports MIPI CSI-2 v2.1 and MIPI D-PHY v2.1 (80Mbps ~ 1500Mbps):

- RZ/G2L, RZ/G2LC Group.

This module supports MIPI CSI-2 v2.1 and MIPI D-PHY v1.2 (80Mbps ~ 2100Mbps):

- RZ/V2N Group and RZ/G3E Group.

The image signal received by the MIPI-CSI2 is output to the Image Processing module with following features:

- Support 1/2/4 lanes.
- Support some available input data format:
 - YCbCr/YUV422 8-bit
 - YCbCr/YUV422 10-bit
 - RGB565
 - RGB666
 - RGB888
 - RAW8/10/12/14/16
- Support 4 Virtual Channels.

1.2.2 Image Processing Block

- This block can receive video data received from the external Digital Parallel Interface (including ITU-R BT.656) or MIPI CSI-2 block and perform appropriate image processing for each.

Table 1-1 Features support on RZ/G2L Group, RZ/V2L Group, RZ/V2N Group and RZ/G3E Group

Features	RZ/G2L Group and RZ/V2L Group	RZ/V2N Group and RZ/G3E Group
Available input formats	Bayer, RGB, YUV	Bayer, RGB, YUV
Digital Parallel Interface (*)	YCbCr, 16-bit binary.	Not Supported
Color space conversion	YCbCr422 ⇔ RGB888	YCbCr422 ⇔ RGB888
Demosaicing	Bilinear Method to demosaic RAW8/10/12/14/16 formats to RGB888 format.	Bilinear Method to demosaic RAW8/10/12/14/16 formats to RGB888 format.
Linear Matrix (*)	Supported	Not Supported
Statistics (Statistical processing operation) (*)	Horizontal detection area 320~2048 pixels and vertical detection area 240~4080. Accumulate from RAW8, 10, 12, 14 and 16 data in the area (16x16, 32x32, 64x64, 128x128) Absolute sum operation of G adjacent pixel value difference from RAW8,10,12,14,16 data)	Not Supported
Output data formats (Only little endian is supported)	YCbCr422 Y component extraction from YCbCr422 RGB-888 (24 bits/pixel) RGB-888 (32 bits/pixel) ARGB-8888 (32 bits/pixel) RAW8,10,12,14,16 16-bit binary (parallel input only) (**)	YCbCr422 Y component extraction from YCbCr422 RGB-888 (24 bits/pixel) RGB-888 (32 bits/pixel) ARGB-8888 (32 bits/pixel) RAW8,10,12,14,16
Pattern Generator (for debugging):	Output Y, U, V values.	Output Y, U, V values.

(*) Only supported in Linux kernel v5.10

1.3 Reference

1.3.1 Standard

The following table shows the standard that this module corresponds.

<https://linuxtv.org/downloads/v4l-dvb-apis/userspace-api/index.html>

Table 1-2 Standard of V4L2 API

Title	Edition	Link
Linux Media Infrastructure userspace API		https://linuxtv.org/downloads/v4l-dvb-apis/userspace-api/index.html

1.3.2 Related document

The following table shows the document related to this module.

Table 1-3 Related documents

Issue	Title	Edition	Date
Coral Camera Datasheet	Camera Datasheet	Rev.1.1	Oct. 2020
Camera Sensor OV5645	OmniVision_OV5645	Rev.1.0	Oct. 2012

1.4 Restrictions

There is no restriction in this module

2. Terminology

The following table shows the terminology related to this module.

Table 2-1 Terminology

Terms	Explanation
CRU	Camera data Receiving Unit
V4L2	Video For Linux Two
MIPI CSI-2	MIPI Camera Serial Interface 2
VC	Virtual Channel

3. Operating Environment

3.1 Hardware Environment

The following table lists the hardware needed to use this module.

Table 3-1 Hardware Environment

Name	Version	Manufacture
RZ/G2L Evaluation Board Kit	SMARC module: v01 Carrier board: v03	Renesas Electronics Europe GmbH
RZ/G2LC Evaluation Board Kit	SMARC module: v01 Carrier board: v03	Renesas Electronics Europe GmbH
RZ/G2UL Evaluation Board Kit	SMARC module: v01 Carrier board: v03	Renesas Electronics Europe GmbH
RZ/V2L Evaluation Board Kit	SMARC module: v01 Carrier board: v03	Renesas Electronics Europe GmbH

Table 3-2 Hardware Environment

Name	Product number
RZ/V2N Evaluation Board Kit	RTK0EF0186C03000BJ
RZ/G3E SMARC Evaluation Board Kit	RTK9947E57S01000BE

3.2 Module Configuration

The following figures show the configuration of this module on RZ/V2L, RZ/G2L Group, RZ/V2N and RZ/G3E

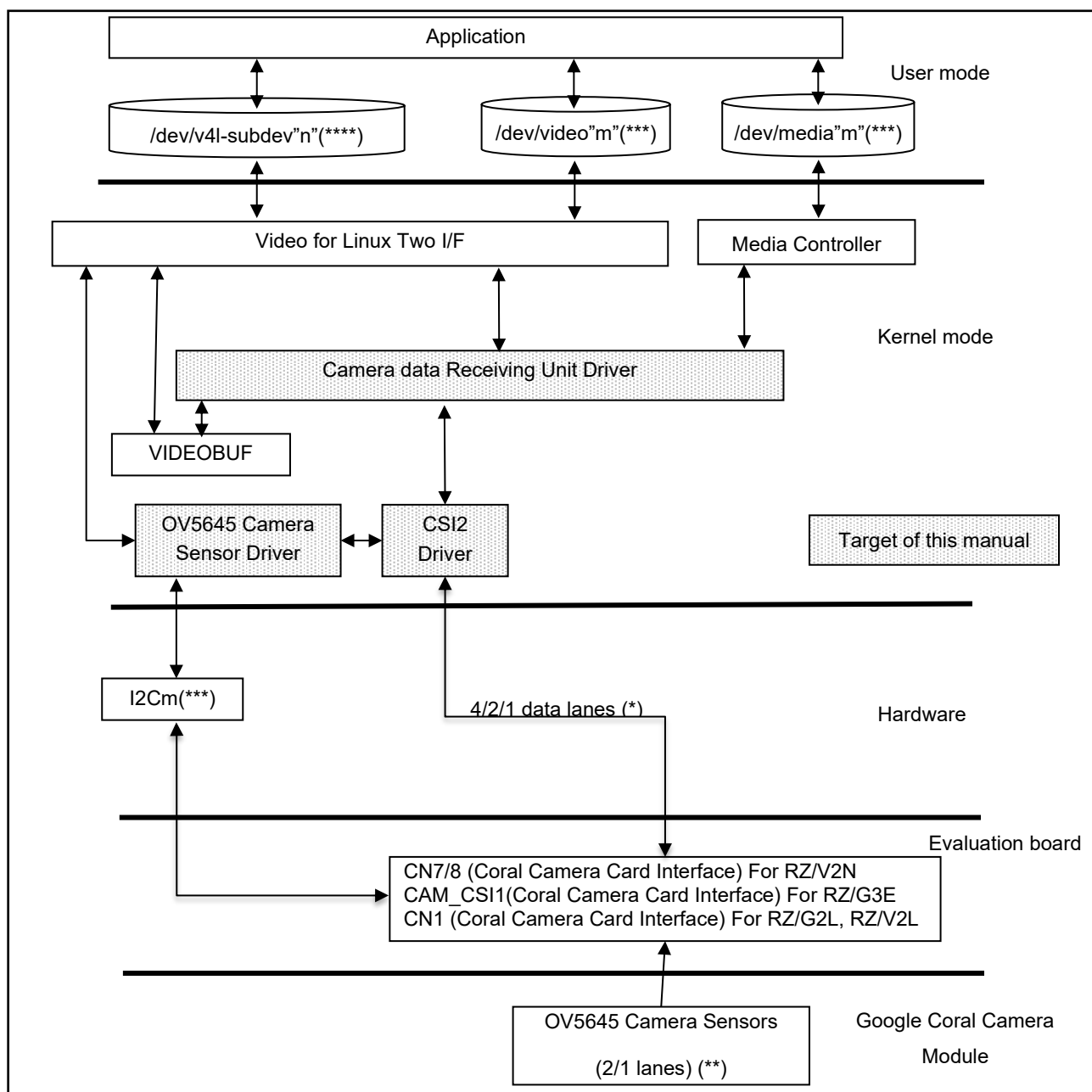


Figure 3-1 Module Configuration

Note:

- (*) MIPI CSI2 module can support 4/2/1 data lanes.
- (**) OV5645 camera sensor can support 2/1 data lanes.
- (***) $m = 0$ to 1 for RZ/V2N and $m = 0$ for RZ/G3E, RZ/G2L and RZ/V2L.
- (****) $n = 0$ to 5 for RZ/V2N and $n = 0$ to 2 for RZ/G3E, RZ/G2L Group and RZ/V2L since rz-5.10-cip54 and later, $n = 0$ to 1 for RZ/G2L Group and RZ/V2L from rz-5.10-cip41 and earlier.

3.3 State Transition Diagram

There is no state transition diagram for this module.

4. Function

This module controls the Image processing module and CSI2 on RZ/G2L, RZ/V2L, RZ/V2N and RZ/G3E supports the camera data receiving function. This module supports signal from the OV5645 camera sensor in RZ/G2L, RZ/V2L, RZ/V2N and RZ/G3E Evaluation Board Kit.

4.1 Connected Device

The following tables specify connectors connected to CRU on RZ/G2L Evaluation Board Kit, RZ/V2N Evaluation Board Kit and RZ/G3E SMARC Evaluation Board Kit.

Table 4-1 CRU connection (RZ/G2L Group, RZ/V2L, RZ/V2N and RZ/G3E)

Device	Interface	Camera Input Connector	Supporting Status
RZ/V2N	MIPI CSI2	CN7/8 (Coral Camera Card Interface)	Yes
RZ/G3E	MIPI CSI2	CAM_CSI1 (Coral Camera Card Interface)	Yes
RZ/G2L Group, RZ/V2L	MIPI CSI2	CN1 (Coral Camera Card Interface)	Yes

4.2 Input / Output Format

The following table shows the Input/output format for this module.

Table 4-2 Input/output format

Input format for CSI2/CRU		Output formats from OV5645	Media bus pixel code that this module supports
Width of bits	Data format		
8bit	YCbCr422	Yes	MEDIA_BUS_FMT_UYVY8_2X8

Table 4-3 Output format

Output formats from CRU	Output formats for this module	Pixel format definition macro in V4L2
YUYV	Yes	V4L2_PIX_FMT_YUYV
UYVY	Yes	V4L2_PIX_FMT_UYVY
GREY	Yes	V4L2_PIX_FMT_GREY
BGR24	Yes	V4L2_PIX_FMT_BGR24
XBGR32	Yes	V4L2_PIX_FMT_XBGR32
ABGR32	Yes	V4L2_PIX_FMT_ABGR32
ARGB32	Yes	V4L2_PIX_FMT_ARGB32
NV16	Yes	V4L2_PIX_FMT_NV16

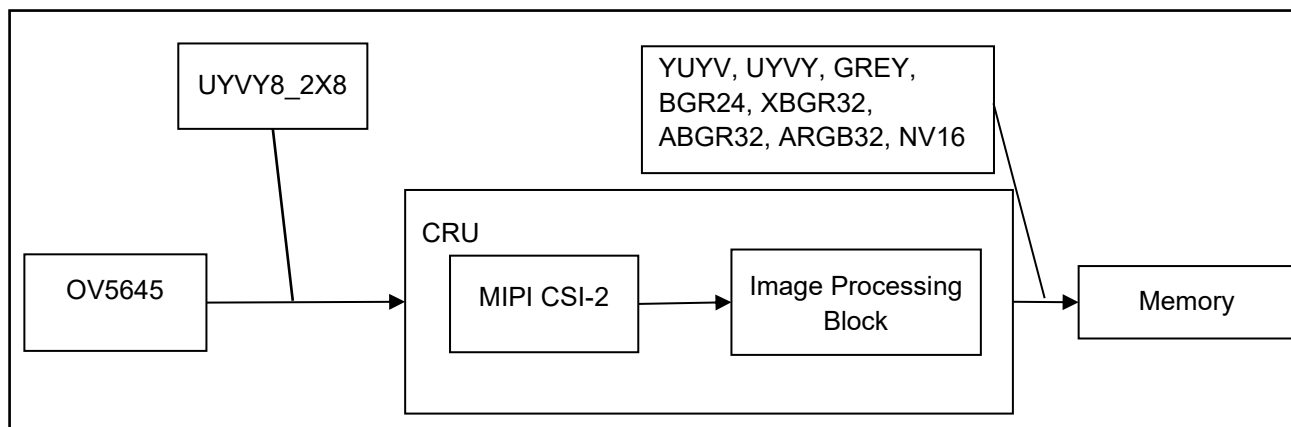


Figure 4-1 Flow of data

4.3 Input Resolution

The following table shows the input resolution for this module which outputs from all available resolution of OV5645 camera sensor.

Table 4-4 Input resolution

Input resolution for this module	RZ/G2L and RZ/V2L	RZ/V2N and RZ/G3E
2592x1944	Yes	No(*)
1920x1080	Yes	Yes
1280x960	Yes	Yes

(*) width must be aligned with 32.

4.4 Hardware Parameters

This module supports VIDIOC_S_CTRL for CRU and OV5645 camera sensor.

Hardware control parameters of camera sensor OV5645 can be set as following table.

Table 4-5 Hardware input control of camera sensor OV5645

Item	V4L2 Command ID	Default	Range
Exposure	V4L2_CID_EXPOSURE_AUTO	Auto	Auto / Manual
Gain	V4L2_CID_AUTOGAIN	Auto	Auto / Manual
Auto white balance	V4L2_CID_AUTO_WHITE_BALANCE	Auto	Auto / Manual
Saturation	V4L2_CID_SATURATION	64	0 - 255
Test pattern	V4L2_CID_TEST_PATTERN	None	<ul style="list-style-type: none"> - Vertical Color Bars - Pseudo-Random Data - Color Square - Black Image

Hardware control parameters of CRU can be set as following table.

Table 4-6 Hardware input control of CRU

Item	V4L2 Command ID	Default	Range
Minimum buffers for capture ⁽¹⁾	V4L2_CID_MIN_BUFFERS_FOR_CAPTURE	3	2 - 8
Skipping Frames Enable/Disable ⁽²⁾	V4L2_CID_CRU_FRAME_SKIP	0	0 - 1
Statistics Feature Enable/Disable ⁽³⁾	V4L2_CID_CRU_STATISTICS	0	0 - 1
Statistics Data Unit Blocksize ⁽³⁾	V4L2_CID_CRU_SD_BLKSIZE	0	0 – 3 with below values: (0: 16x16; 1: 32x32; 2: 64x64; 3: 128x128)
Statistics Horizontal Start Position ⁽³⁾	V4L2_CID_CRU_SD_STHPOS	0	0 – 376
Statistics Input Data Bit Position ⁽³⁾	V4L2_CID_CRU_SD_STSADPOS	0	0 - 8
Linear Matrix Processing Enable/Disable ⁽⁴⁾	V4L2_CID_CRU_LINEAR_MATRIX	0	0 - 1
Linear Matrix R/G/B offset ⁽⁴⁾	V4L2_CID_CRU_LINEAR_MATRIX_ROF, V4L2_CID_CRU_LINEAR_MATRIX_GOF, V4L2_CID_CRU_LINEAR_MATRIX_BOF	0	(-128) - 127
Linear Matrix RR/RG/RB coefficient ⁽⁴⁾	V4L2_CID_CRU_LINEAR_MATRIX_RR, V4L2_CID_CRU_LINEAR_MATRIX_RG, V4L2_CID_CRU_LINEAR_MATRIX_RB	0	(-4096) - 4095
Linear Matrix GR/GG/GB coefficient ⁽⁴⁾	V4L2_CID_CRU_LINEAR_MATRIX_GR, V4L2_CID_CRU_LINEAR_MATRIX_GG, V4L2_CID_CRU_LINEAR_MATRIX_GB	0	(-4096) - 4095
Linear Matrix BR/BG/BB coefficient ⁽⁴⁾	V4L2_CID_CRU_LINEAR_MATRIX_BR, V4L2_CID_CRU_LINEAR_MATRIX_BG, V4L2_CID_CRU_LINEAR_MATRIX_BB	0	(-4096) - 4095

⁽¹⁾ This parameter presented for the available amount of hardware buffers that CRU can support.

Note:

To ensure stable performance, please set the number of capture buffers in userspace higher than value of CRU Hardware buffers. Usually, we should set as below formula:

$$\text{num_bufs_capture_userapp} = \text{minimum_buffers_for_capture} + 2$$

⁽²⁾ This parameter presented for the skipping frames feature that CRU can support to wait stability state from camera sensor. When set this control to 1, first 3 frames are skipped and CRU will get frames after that.

⁽³⁾ All these parameters presented for Statistics feature. To enable this feature, user needs to set V4L2_CID_CRU_STATISTICS to 1 then adjust all remained statistics parameters.

⁽⁴⁾ All these parameters presented for Linear Matrix color correction feature. To enable this feature, user needs to set V4L2_CID_CRU_LINEAR_MATRIX to 1 then adjust all remained RGB offset parameters.

4.5 Field order

This module supports interlaced image in addition to progressive image. The setting value shown in the

The setting value can be specified to use VIDIOC_S_FMT interface.

Table 4-7 Field order

Setting Value	Content
V4L2_FIELD_NONE ^{*1}	Images are in progressive format, not interlaced. Output the image in 1 frame unit.
V4L2_FIELD_INTERLACED_TB	Images contain both fields, interleaved line by line, top field first. The top field is transmitted first. Top field is set odd field. (Full interlace capture mode)
V4L2_FIELD_INTERLACED_BT	Images contain both fields, interleaved line by line, top field first. The bottom field is transmitted first. Top field is set even field. (Full interlace capture mode)
V4L2_FIELD_INTERLACED	Capture with top field first or bottom field first depending on the input signal. (Full interlace capture mode)

Note: ^{*1} This module prohibits to set the value of V4L2_FIELD_NONE in interlaced input.

Currently, OV5645 camera sensor just only support progressive format (V4L2_FIELD_NONE).

5. External Interface

The external interface of this module is based on V4L2 Two API. The device node of this module is shown below.

Table 5-1 CRU device node (RZ/G2L, RZ/G2LC, RZ/G2UL, RZ/V2L, RZ/G3E)

Camera sensor OV5645 Input	Device node	Major number	Minor number
OV5645	/dev/video0	81	3

Table 5-2 CRU device node RZ/V2N

Camera sensor OV5645 Input	Device node	Major number	Minor number
OV5645	/dev/video0	81	3
OV5645	/dev/video1	81	7

Table 5-3 Media controller device node (RZ/G2L, RZ/G2LC, RZ/G2UL, RZ/V2L, RZ/G3E)

Device node	Major number	Minor number
/dev/media0	252	0

Table 5-4 Media controller device node RZ/V2N

Device node	Major number	Minor number
/dev/media0	252	0
/dev/media1	252	1

Table 5-5 Subdevice nodes (RZ/G2L, RZ/G2LC, RZ/G2UL, RZ/V2L, RZ/G3E)

Device node	Major number	Minor number	Remark
/dev/v4l-subdev0	81	0	for controlling MIPI CSI2
/dev/v4l-subdev1	81	1	for controlling OV5645 camera sensor
/dev/v4l-subdev2(*)	81	2	for controlling Image Processing

Table 5-6 Subdevice nodes RZ/V2N

Device node	Major number	Minor number	Remark
/dev/v4l-subdev0/1/3/4	81	0/1/4/5	for controlling MIPI CSI2
/dev/v4l-subdev2/5	81	2/4	for controlling OV5645 camera sensor

(*) since rz-5.10-cip54 and later for RZ/G2L Group and RZ/V2L Group

5.1 Media Controller API

This ability not only works with a local digital subdevice directly attached to a CRU instance in a 1:1 mapping but to be part of a CSI-2 group which share a set of video decoders and CSI-2.

5.1.1 Show current routing

Examine the current routing setup with '**media-ctl -d /dev/media0 -p**'.

media-ctl -d /dev/media0 -p

Example)

With kernel version rz-5.10-cip41 or earlier

```
Media controller API version 5.10.184

Media device information
-----
driver            rzg2l_cru
model             renesas,cru-r9a07g044
serial
bus info          platform:10830000.video
hw revision       0x0
driver version    5.10.184

Device topology
- entity 1: rzg2l_csi2 10830400.csi2 (5 pads, 5 links)
  type V4L2 subdev subtype Unknown flags 0
  device node name /dev/v4l-subdev0
  pad0: Sink
    [fmt:unknown/0x0]
    <- "ov5645 0-003c":0 [ENABLED,IMMUTABLE]
  pad1: Source
    [fmt:unknown/0x0]
    -> "CRU output":0 []
  pad2: Source
    [fmt:unknown/0x0]
    -> "CRU output":0 []
  pad3: Source
    [fmt:unknown/0x0]
    -> "CRU output":0 []
  pad4: Source
    [fmt:unknown/0x0]
    -> "CRU output":0 []

- entity 7: ov5645 0-003c (1 pad, 1 link)
  type V4L2 subdev subtype Sensor flags 0
  device node name /dev/v4l-subdev1
  pad0: Source
    [fmt:UYVY8_2X8/1920x1080 field:none colorspace:srgb
    crop:(0,0)/1920x1080]
    -> "rzg2l_csi2 10830400.csi2":0 [ENABLED,IMMUTABLE]

- entity 15: CRU output (1 pad, 4 links)
  type Node subtype V4L flags 0
  device node name /dev/video0
  pad0: Sink
    <- "rzg2l_csi2 10830400.csi2":1 []
    <- "rzg2l_csi2 10830400.csi2":2 []
    <- "rzg2l_csi2 10830400.csi2":3 []
    <- "rzg2l_csi2 10830400.csi2":4 []
```

Figure 5-1 Current routing for RZ/G2L Group and RZ/V2L Group

Starting from kernel version rz-5.10-cip54 and rz-6.1-cip28.

```

Media controller API version 6.1.107

Media device information
-----
driver      rzg2l_cru
model       renesas, rzv2n-cru
serial
bus info    platform:16010000.cru1
hw revision 0x0
driver version 6.1.107

Device topology
- entity 1: csi-16010400.csi21 (2 pads, 2 links, 0 routes)
    type V4L2 subdev subtype Unknown flags 0
    device node name /dev/v4l-subdev3
    pad0: Sink
        [stream:0 fmt:UYVY8_1X16/320x240 field:none colorspace:srgb]
        <- "ov5645 1-003c":0 [ENABLED,IMMUTABLE]
    pad1: Source
        [stream:0 fmt:UYVY8_1X16/320x240 field:none colorspace:srgb]
        -> "cru-ip-16010000.cru1":0 [ENABLED,IMMUTABLE]

- entity 4: ov5645 1-003c (1 pad, 1 link, 0 routes)
    type V4L2 subdev subtype Sensor flags 0
    device node name /dev/v4l-subdev4
    pad0: Source
        [stream:0 fmt:unknown/0x0
        crop:(0,0)/1920x1080]
        -> "csi-16010400.csi21":0 [ENABLED,IMMUTABLE]

- entity 8: cru-ip-16010000.cru1 (2 pads, 2 links, 0 routes)
    type V4L2 subdev subtype Unknown flags 0
    device node name /dev/v4l-subdev5
    pad0: Sink
        [stream:0 fmt:UYVY8_1X16/320x240 field:none colorspace:srgb]
        <- "csi-16010400.csi21":1 [ENABLED,IMMUTABLE]
    pad1: Source
        [stream:0 fmt:UYVY8_1X16/320x240 field:none colorspace:srgb]
        -> "CRU output":0 [ENABLED,IMMUTABLE]

- entity 17: CRU output (1 pad, 1 link)
    type Node subtype V4L flags 0
    device node name /dev/video1
    pad0: Sink
        <- "cru-ip-16010000.cru1":1 [ENABLED,IMMUTABLE]

```

Figure 5-2 Current routing for RZ/V2N and Group RZ/G3E Group

5.1.2 Activate/Deactivate a link

The Media Controller framework allows user-space to enable/disable a link and that way control the routing of video data. A link is always configured from a CSI-2 instance to a CRU instance, through CRU IP, the same way the video data is flowing. To enable a link, we use the “media-ctl” utility from v4l-utils package:

With kernel version rz-5.10-cip41 or earlier

```
# media-ctl -d /dev/media0 -l "rzg2l_csi2 10830400.csi2":1 -> 'CRU output':0 [1]"
```

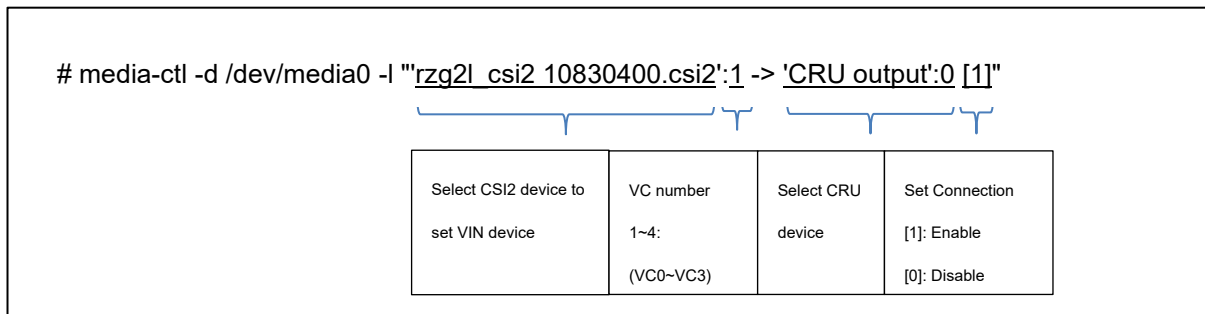


Figure 5-3 Link CSI2 ⇔ CRU

To disable the same link use:

```
# media-ctl -d /dev/media0 -l "rzg2l_csi2 10830400.csi2":1 -> 'CRU output':0 [0]"
```

Starting from kernel version rz-5.10-cip54 and rz-6.1-cip28.

```
# media-ctl -d /dev/media0 -l "rzg2l_csi2 10830400.csi2":1 -> 'cru-ip-10830000.video':0 [1]"
```

```
# media-ctl -d /dev/media0 -l "cru-ip-10830000.video":1 -> 'CRU output':0 [1]"
```

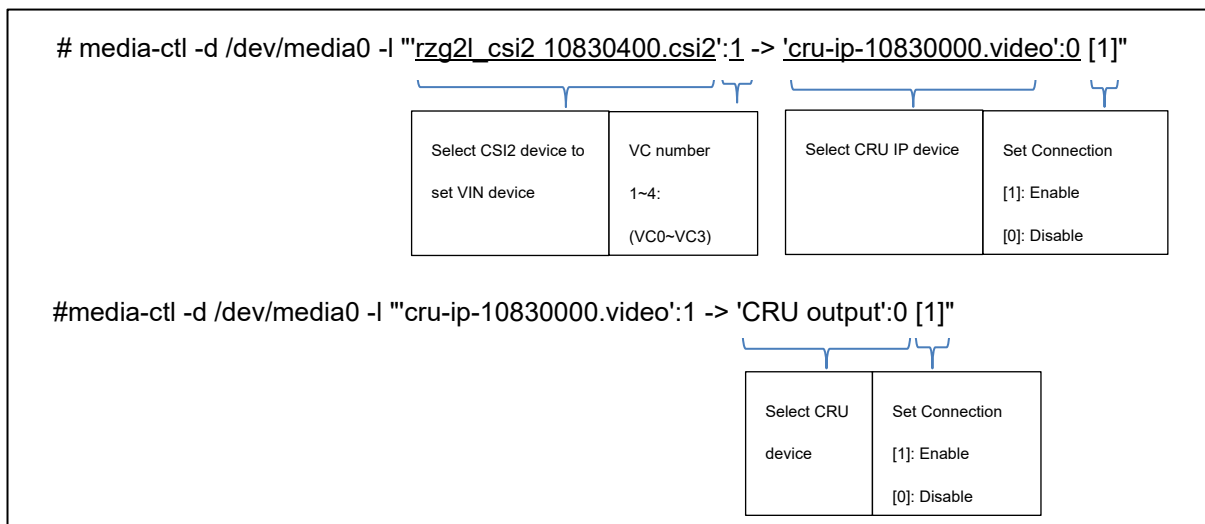


Figure 5-4 Link CSI2 ⇔ CRU-IP ⇔ CRU output

To disable the same link use:

```
# media-ctl -d /dev/media0 -l "rzg2l_csi2 10830400.csi2":1 -> 'cru-ip-10830000.video':0 [0]"
```

```
# media-ctl -d /dev/media0 -l "cru-ip-10830000.video":1 -> 'CRU output':0 [0]"
```

5.1.3 Configuring the pipeline and propagate format

Once the user has configured a pipeline using 'media-ctl' as described 5.1.2 the format needs to be propagated in the pipeline before streaming can start (The capture cannot be performed unless it is set). Please run deactivate all active links as described at 5.1.4 before you run configuring the pipeline and propagate format (The capture cannot be performed unless it is run). The following shows an example of the execution command.

With kernel version rz-5.10-cip41 or earlier

- **1280x960:**

```
# media-ctl -d /dev/media0 -V ""rzg2l_csi2 10830400.csi2':1 [fmt:UYVY8_2X8/1280x960 field:none]"
```

```
# media-ctl -d /dev/media0 -V ""ov5645 0-003c':0 [fmt:UYVY8_2X8/1280x960 field:none]"
```

- **1920x1080:**

```
# media-ctl -d /dev/media0 -V ""rzg2l_csi2 10830400.csi2':1 [fmt:UYVY8_2X8/1920x1080 field:none]"
```

```
# media-ctl -d /dev/media0 -V ""ov5645 0-003c':0 [fmt:UYVY8_2X8/1920x1080 field:none]"
```

- **2592x1944:**

```
# media-ctl -d /dev/media0 -V ""rzg2l_csi2 10830400.csi2':1 [fmt:UYVY8_2X8/2592x1944 field:none]"
```

```
# media-ctl -d /dev/media0 -V ""ov5645 0-003c':0 [fmt:UYVY8_2X8/2592x1944 field:none]"
```

Starting from kernel version rz-5.10-cip54 and rz-6.1-cip28.

- **1280x960:**

```
# media-ctl -d /dev/media0 -V ""rzg2l_csi2 10830400.csi2':1 [fmt:UYVY8_2X8/1280x960 field:none]"
```

```
# media-ctl -d /dev/media0 -V ""ov5645 0-003c':0 [fmt:UYVY8_2X8/1280x960 field:none]"
```

```
# media-ctl -d /dev/media0 -V ""cru-ip-10830000.video' :0 [fmt:UYVY8_2X8/1280x960 field:none]"
```

```
# media-ctl -d /dev/media0 -V ""cru-ip-10830000.video' :1 [fmt:UYVY8_2X8/1280x960 field:none]"
```

- **1920x1080:**

```
# media-ctl -d /dev/media0 -V ""rzg2l_csi2 10830400.csi2':1 [fmt:UYVY8_2X8/1920x1080 field:none]"
```

```
# media-ctl -d /dev/media0 -V ""ov5645 0-003c':0 [fmt:UYVY8_2X8/1920x1080 field:none]"
```

```
# media-ctl -d /dev/media0 -V ""cru-ip-10830000.video' :0 [fmt:UYVY8_2X8/1920x1080 field:none]"
```

```
# media-ctl -d /dev/media0 -V ""cru-ip-10830000.video' :1 [fmt:UYVY8_2X8/1920x1080 field:none]"
```

- **2592x1944:**

```
# media-ctl -d /dev/media0 -V ""rzg2l_csi2 10830400.csi2':1 [fmt:UYVY8_2X8/2592x1944 field:none]"
```

```
# media-ctl -d /dev/media0 -V ""ov5645 0-003c':0 [fmt:UYVY8_2X8/2592x1944 field:none]"
```

```
# media-ctl -d /dev/media0 -V ""cru-ip-10830000.video' :0 [fmt:UYVY8_2X8/2592x1944 field:none]"
```

```
# media-ctl -d /dev/media0 -V ""cru-ip-10830000.video' :1 [fmt:UYVY8_2X8/2592x1944 field:none]"
```

5.1.4 Deactivate all active links

This is a useful command to reset all links before you start enabling new links to make sure you got the biggest possible routing space to start out with.

```
# media-ctl -d /dev/media0 -r
```

6. Integration

6.1 Directory Configuration

The directory configuration is shown below:

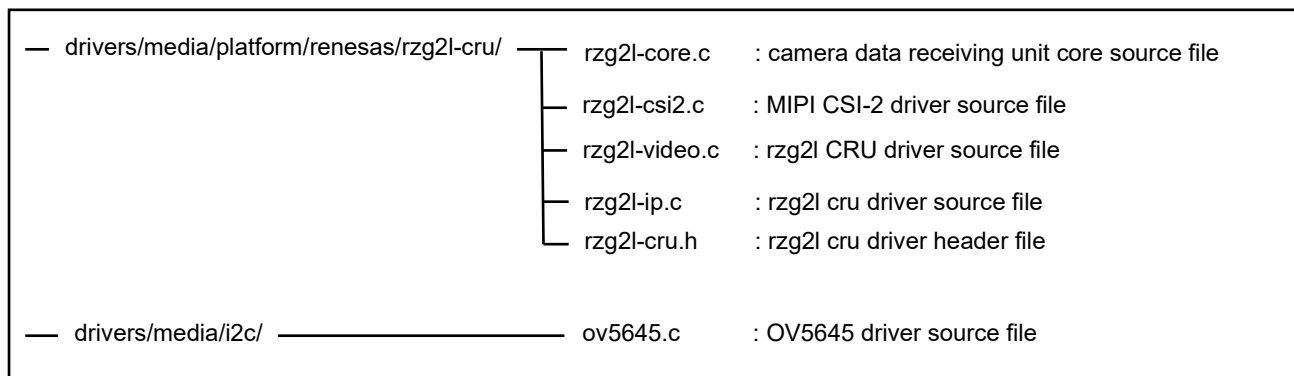


Figure 6-1 Directory configuration

6.2 Integration Procedure

To enable the function of this module, make the following setting with Kernel Configuration.

6.2.1 Camera data Receiving Unit Driver

```
Device Drivers --->
  <*> Multimedia support --->
    Media core support --->
      [*] Media Controller API
    Media drivers --->
      [*] Media platform devices --->
        <*> RZ/G2L MIPI CSI-2 Receiver
        <*> RZ/G2L Camera Receiving Unit (CRU) Driver
    Media ancillary drivers --->
      [*] Camera sensor devices --->
        <*> OmniVision OV5645 sensor support
```

Figure 6-2 Kernel Configuration CRU

6.2.2 I2C Driver

```
Device Drivers --->
  I2C support --->
    I2C Hardware Bus support --->
      <*> Renesas RIIC adapter
```

Figure 6-3 Kernel Configuration I2C Driver

6.3 Option Setting

6.3.1 Module Parameters

There are no module parameters.

6.3.2 Kernel Parameters

There are no kernel parameters.

Revision History	Linux Interface Specification Device Driver Video Capture User's Manual: Software
------------------	--

Rev.	Date	Description	
		Page	Summary
0.5	May. 25, 2021	—	First Edition issued
1.0	Jul. 15, 2021	—	No modification, keep version to keep consistent with other documents
1.1	Sep. 15, 2021	—	Merge RZ/G2L driver manual with RZ/V2L
1.2	Feb. 15, 2022	—	Add RZ/G2LC, RZ/G2UL device
		6, 7	Add NV16 output formats
		8	Add Hardware input control of CRU (V4L2_CID_MIN_BUFFERS_FOR_CAPTURE)
1.3	Mar. 31, 2022	8	Add Hardware input control of CRU (V4L2_CID_CRU_FRAME_SKIP)
1.4	May. 31, 2022	—	No modification, keep version to keep consistent with other documents
1.5	Jun. 24, 2022	—	No modification, keep version to keep consistent with other documents
1.6	Sep. 15, 2022	—	No modification, keep version to keep consistent with other documents
1.7	Dec. 15, 2022	—	No modification, keep version to keep consistent with other documents
1.8	Mar. 15, 2023	1, 2	Add general information about Demosaicing, Linear Matrix color correction and Statistics Data features.
		9	Add Hardware control Parameters of Demosaicing, Linear Matrix color correction and Statistics Data features.
1.9	Mar. 31, 2025	12,13, 14,15	Restructured driver, replaced rzg2l_dma.c and rzg2l_v4l2.c with rzg2l-ip.c and rzg2l-video.c, leading to changes in Media Controller API and the steps to link the device.
1.10	May. 30, 2025	1	- Add MPU information support for both kernel versions v5.10 and v6.1. - Correct Linux version supported Digital Parallel Interface
		9	- Correct default value of V4L2_CID_MIN_BUFFERS_FOR_CAPTURE
		13,14, 15	- Correct Linux version supported
1.11	Jun. 30, 2025	—	Add RZ/V2N information
1.12	Jul. 22, 2025	—	Add RZ/G3E information

Linux Interface Specification Device Driver Video Capture
User's Manual: Software

Publication Date: Rev.1.12 Jul. 22, 2025

Published by: Renesas Electronics Corporation

RZ/G2L Group, RZ/V2L Group, RZ/V2N
Group and RZ/G3E Group



Renesas Electronics Corporation