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Linux Interface Specification Device Driver USB 2.0 Function

User's Manual: Software

R-Car H3/M3/M3N/E3/D3 Series

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How to Use This Manual

- **[Readers]**

This manual is intended for engineers who develop products which use the R-Car H3/M3/M3N/E3/D3 processor.

- **[Purpose]**

This manual is intended to give users an understanding of the functions of the R-Car H3/M3/M3N/E3/D3 processor device driver and to serve as a reference for developing hardware and software for systems that use this driver.

- **[How to Read This Manual]**

It is assumed that the readers of this manual have general knowledge in the fields of electrical

— Engineering, logic circuits, microcontrollers, and Linux.

→ Read this manual in the order of the CONTENTS.

— To understand the functions of a multimedia processor for R-Car H3/M3/M3N/E3/D3

→ See the R-Car H3/M3/M3N/E3/D3 User's Manual.

— To know the electrical specifications of the multimedia processor for R-Car H3/M3/M3N/E3/D3

→ See the R-Car H3/M3/M3N/E3/D3 Data Sheet.

- **[Conventions]**

The following symbols are used in this manual.

Data significance: Higher digits on the left and lower digits on the right

Note: Footnote for item marked with Note in the text

Caution: Information requiring particular attention

Remark: Supplementary information

Numeric representation: Binary ... xxxx, 0bxxxx, or xxxxB

Decimal ... xxxx

Hexadecimal ... 0xxxxx or xxxxH

Data type: Double word ... 64 bits

Word ... 32 bits

Half word ... 16 bits

Byte ... 8 bits

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1. Overview

1.1 Overview

This manual explains the driver module (this module) that controls the USB 2.0 Function controller on R-Car H3/M3/M3N/E3/D3.

1.2 Function

This module controls USB 2.0 Function controller on R-Car H3/M3/M3N/E3/D3, and transmission and reception of data are performed by USB2.0 standard between USB Host connected to the USB interface.

Port 0 and 3 (R-CarH3-SiP System Evaluation Board Salvator-XS only) are used as an OTG device in combination with the USB Host controller. This module supports only role swap not using Host Negotiation Protocol (HNP). No support for Session Request Protocol (SRP).

The following data transfer type is supported.

- Control transfer
- Isochronous transfer
- Bulk transfer
- Interrupt transfer

The number of end points assigned to each data transfer type is as follows.

Type of transfer	The number of end point quota pipes
Control transfer	1
Isochronous transfer	2
Bulk transfer	10
Interrupt transfer	3

1.3 Connected Port

This module supports one USB ports on R-CarH3-SiP/M3-SiP/E3/D3 System Evaluation Board.

Table 1-1 Connected Port (R-Car H3/M3/M3N)

Port No.	Standard	Connector No.	Content
0	USB2.0 Host/Function	CN9	Type micro AB connector
3	USB2.0 Host/Function	CN37	Type micro AB connector (R-CarH3-SiP System Evaluation Board Salvator-XS only)

Note: In R-CarH3/M3/M3N-SiP System Evaluation Board Salvator-X and Salvator-XS, please set up SW15 (Pin 3 side). According to the specification of the System Evaluation Board, the power supply is up to 200 mA. If the required power is above 200 mA, please set it to Pin 1 side.

In R-CarH3-SiP System Evaluation Board Salvator-XS, please set up SW31 (Pin 1, 2, 5, 6 OFF / Pin 3, 4 ON).

Table 1-2 Connected Port (R-Car E3)

Port No.	Standard	Connector No.	Content
0	USB2.0 Host/Function	CN9	Type micro AB connector

Note: In R-CarE3 System Evaluation Board Ebisu, please set up SW15 (Pin 3 side). According to the specification of the System Evaluation Board, the power supply is up to 200 mA. If the required power is above 200 mA, please set it to Pin 1 side.

Table 1-3 Connected Port (R-Car D3)

Port No.	Standard	Connector No.	Content
0	USB2.0 Host/Function	CN9	Type A connector

Note: In R-CarD3 System Evaluation Board Draak, please use:

“echo peripheral > /sys/devices/platform/soc/ee080200.usb-phy/role” for switching USB2.0 Host/Fucntion (role swap).

1.4 Reference Document

1.4.1 Standard

Supported standard of this module is as follows.

Table 1-4 Standard (R-Car H3/M3/M3N/E3/D3)

Reference No.	Issue	Title	Edition	Date
-	USB Implementers Forum, Inc	Universal Serial Bus Specification	Rev.2.0	Apr. 27, 2000

1.4.2 Related Document

Related document of this module is as follows.

Table 1-5 Related Documents (R-Car H3/M3/M3N/E3/D3)

Number	Issue	Title	Edition	Date
-	Renesas Electronics	R-Car Series, 3rd Generation User's Manual: Hardware	Rev.2.20	Jun. 30, 2020
-	Renesas Electronics	R-CarH3-SiP System Evaluation Board Salvator-X Hardware Manual RTP0RC7795SIPB0011S	Rev.1.09	May. 11, 2017
-	Renesas Electronics	R-CarM3-SiP System Evaluation Board Salvator-X Hardware Manual RTP0RC7796SIPB0011S	Rev.0.04	Oct. 3, 2016
-	Renesas Electronics	R-CarH3-SiP/M3-SiP/M3N-SiP System Evaluation Board Salvator-XS Hardware Manual	Rev.2.04	Jul. 17, 2018
-	Renesas Electronics	R-CarE3 System Evaluation Board Ebisu Hardware Manual RTP0RC77990SEB0010S	Rev.0.03	Apr. 11, 2018
-	Renesas Electronics	R-CarE3 System Evaluation Board Ebisu-4D (E3 board 4xDRAM) Hardware Manual	Rev.1.01	Jul. 19, 2018
-	Renesas Electronics	R-CarD3 System Evaluation Board Hardware Manual RTP0RC77995SEB0010S	Rev.1.20	Jul. 25, 2017

1.5 Restrictions

There is no restriction in this module.

1.6 Notice

The notes of this module are shown below.

- The known problem in the standard gadget class driver for Linux is not supported.
- Only the standard Gadget interface for Linux is supported by this module.
- High Bandwidth of interrupt transfer is not supported.
- High Bandwidth of Isochronous transfer is not supported.

2.Terminology

The following table shows the terminology related to this module.

Table 2.1 Terminology

Terms	Explanation
USB	USB Universal Serial Bus
UDC	USB Device Controller
OTG	On-The-Go
EP	Endpoint

3. Operating Environment

3.1 Hardware Environment

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

Table 3.1 Hardware specification (R-Car H3/M3/M3N/E3/D3)

Name	Version	Manufacture
R-CarH3-SiP System Evaluation Board Salvator-X	-	Renesas Electronics
R-CarM3-SiP System Evaluation Board Salvator-X	-	Renesas Electronics
R-CarH3-SiP/M3-SiP/M3N-SiP System Evaluation Board Salvator-XS	-	Renesas Electronics
R-CarE3 System Evaluation Board Ebisu	-	Renesas Electronics
R-CarE3 System Evaluation Board Ebisu-4D	-	Renesas Electronics
R-CarD3 System Evaluation Board Draak	-	Renesas Electronics

3.2 Module Configuration

The following figure shows the configuration of this module.

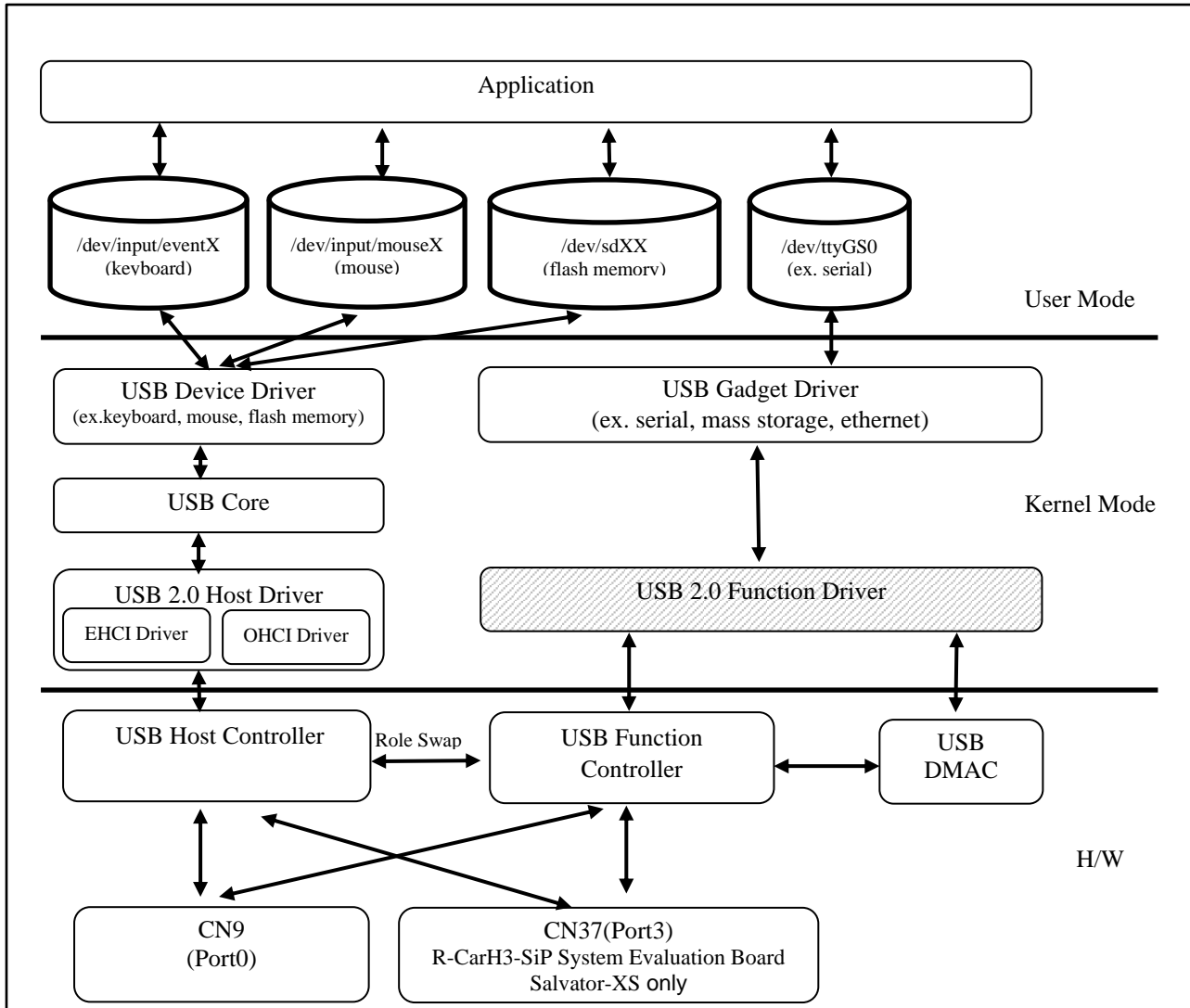


Figure 3-1 Module Configuration (R-Car H3/M3/M3N/E3/D3)

3.3 State Transition Diagram

There is no state transition diagram for this module.

4. External Interface

The supported external interface of this module is explained.

Since it is based on USB standard, the definition described in "include/linux/usb/ch9.h" is omitted.

4.1 Function specification

The interface function list which this module supports is shown below.

When you use these functions, please include the following header file.

```
#include <linux/usb/gadget.h>
```

Table 4.1 List of interface function (register / unregister)

Chapter	Function name	Remarks
4.1.1	usb_gadget_probe_driver	A Gadget driver is registered to UDC
4.1.2	usb_gadget_unregister_driver	A Gadget driver is released from UDC.

Table 4.2 List of interface function (endpoint-specific operations)

Chapter	Function name	Remarks
4.1.3	usb_ep_enable	Configure endpoint, making it usable
4.1.4	usb_ep_disable	endpoint is no longer usable
4.1.5	usb_ep_alloc_request	Allocate a request object to use with this endpoint
4.1.6	usb_ep_free_request	Free a request object
4.1.7	usb_ep_queue	Queue (submit) an I/O request to an endpoint
4.1.8	usb_ep_dequeue	Dequeue (cancel, unlink) an I/O request from an endpoint
4.1.9	usb_ep_set_halt	Endpoint is changed into a STALL state
4.1.10	usb_ep_clear_halt	STALL of Endpoint is canceled.
4.1.11	usb_ep_set_wedge	Endpoint is changed into a STALL state
4.1.12	usb_ep_fifo_status*1	Return number of bytes in FIFO, or error
4.1.13	usb_ep_fifo_flush*1	Flush contents of a FIFO

Notes: 1. This interface is unsupported.

Table 4.3 List of interface function (hardware-specific operations)

Chapter	Function name	Remarks
4.1.14	gadget_is_dualspeed	Return true if the hardware handles high speed
4.1.15	gadget_is_superspeed	Return true if the hardware is super speed ready
4.1.16	gadget_is_otg	Return true if the hardware is OTG-ready
4.1.17	usb_gadget_frame_number	Return the current frame number
4.1.18	usb_gadget_wakeup* ¹	Try to wake up the host connected to this gadget
4.1.19	usb_gadget_set_selfpowered* ¹	Set the device self-powered feature
4.1.20	usb_gadget_clear_selfpowered* ¹	Clear the device self-powered feature
4.1.21	usb_gadget_vbus_connect* ¹	Supply power to VBUS
4.1.22	usb_gadget_vbus_draw* ¹	Notify VBUS power usage
4.1.23	usb_gadget_vbus_disconnect* ¹	Cancel power to VBUS
4.1.24	usb_gadget_connect	Turn on D+ Pull-up
4.1.25	usb_gadget_disconnect	Turn off D+ Pull-up

Notes: 1. This interface is unsupported.

From the following chapter, the function which this module supports is explained according to the following description formats.

[Overview]	Presents an overview of a function.
[Function Name]	Explains the name of the function.
[Calling format]	Explains the format for calling the function.
[Argument]	Explains the argument(s) of the function.
[Return value]	Explains the return value(s) of the function.
[Feature]	Explains the features of the function.
[Remark]	Explains points to be noted when using the function.

4.1.1 usb_gadget_probe_driver

[Overview]	A Gadget driver is registered to UDC	
[Function Name]	usb_gadget_probe_driver	
[Calling format]	<pre>#include <linux/usb/gadget.h> int usb_gadget_probe_driver(struct usb_gadget_driver *driver, int (*bind)(struct usb_gadget*));</pre>	
[Argument]	driver	: Pointer of USB Gadget driver structure
	bind	: Callback function pointer at the time of USB Gadget driver registration
[Return value]	0	: Normal termination
	-ENODEV	: UDC is not registered
	-EBUSY	: Gadget is already registered into UDC
	-EINVAL	: Invalid argument
	less than 0	: other error
[Feature]	<p>A Gadget driver is registered to UDC by setting up a usb_gadget_driver structure and calling this function.</p> <p>The usb_gadget_driver structure can register only one to UDC.</p>	
[Remark]	<p>Please refer to 4.2.6 about usb_gadget_driver structure</p> <p>Please perform acquisition of a workspace memory, registration of driver data, maintenance of a usb_gadget structure, an automatic setup of Endpoint Descriptor, etc. in a callback function at the time of registration.</p> <p>It cannot call out of an interrupt handler.</p>	

4.1.2 usb_gadget_unregister_driver

[Overview]	A Gadget driver is released from UDC	
[Function Name]	usb_gadget_unregister_driver	
[Calling format]	<pre>#include <linux/usb/gadget.h> int usb_gadget_unregister_driver(struct usb_gadget_driver *driver);</pre>	
[Argument]	driver	: Pointer of USB Gadget driver structure
[Return value]	0	: Normal termination
	-ENODEV	: UDC is not registered.
	-EINVAL	: Invalid argument
[Feature]	<p>By setting the usb_gadget_driver structure of the same pointer as the time of registering as an argument, and calling this function, a Gadget driver is released from UDC.</p>	
[Remark]	<p>Please refer to 4.2.6 about usb_gadget_driver structure</p> <p>Please perform release of a workspace memory, deletion of driver data, deletion of a usb_gadget_driver structure, etc. in a callback function at the time of registration release.</p> <p>It cannot call out of an interrupt handler.</p>	

4.1.3 usb_ep_enable

[Overview]	Endpoint is enabled	
[Function Name]	usb_ep_enable	
[Calling format]	<pre>#include <linux/usb/gadget.h> int usb_ep_enable(struct usb_ep *ep, const struct usb_endpoint_descriptor *desc);</pre>	
[Argument]	ep	: Pointer of USB Endpoint structure
	desc	: Pointer Endpoint Descriptor
[Return value]	0	: Normal termination
	-ENODEV	: UDC is not registered.
	-EINVAL	: Invalid argument
	-ENOMEM	: Out of memory
[Feature]	It sets up for enabling Endpoint	
[Remark]	<p>Please refer to 4.2.4 about usb_ep structure</p> <p>Please enable Endpoint with this function after acquiring a usb_ep structure required for Endpoint processing.</p> <p>It can call from an interrupt handler.</p>	

4.1.4 usb_ep_disable

[Overview]	Endpoint is disabled	
[Function Name]	usb_ep_disable	
[Calling format]	<pre>#include <linux/usb/gadget.h> int usb_ep_disable(struct usb_ep *ep);</pre>	
[Argument]	ep	: Pointer of USB Endpoint structure
[Return value]	0	: Normal termination
[Feature]	It sets up for disabling Endpoint	
[Remark]	<p>Please refer to 4.2.4 about usb_ep structure</p> <p>Any pending and uncompleted requests will complete with status indicating disconnect (-ESHUTDOWN) before this call returns.</p> <p>As for Endpoint under transmission, transmission is stopped.</p> <p>In order not to generate a memory leak, a usb_ep_disable() front or status is within the complete call-back of -ESHUTDOWN, Please be sure to release a usb_request structure by usb_ep_free_request().</p> <p>It can call from an interrupt handler.</p>	

4.1.5 usb_ep_alloc_request

[Overview]	Allocate a request object to use with this endpoint	
[Function Name]	usb_ep_alloc_request	
[Calling format]	<pre>#include <linux/usb/gadget.h> struct usb_request *usb_ep_alloc_request(struct usb_ep *ep, gfp_t gfp_flags);</pre>	
[Argument]	ep	: Pointer of USB Endpoint structure
	gfp_flags	: flag of memory acquisition (GFP_KERNEL / GFP_ATOMIC)
[Return value]	Except 0	: Normal termination
	0	: Failed to allocate memory for a request object
[Feature]	The information structure object (USB Endpoint transmission request structure) for performing the transmission and reception to Endpoint is acquired.	
[Remark]	<p>Please refer to 4.2.4 about usb_ep structure</p> <p>Please be sure to acquire using this function, when creating a usb_request structure.</p> <p>Please be sure to perform usb_ep_free_request and to release a memory after the completion of use.</p> <p>By setting up a memory acquisition flag appropriately, it can call from an interrupt handler.</p>	

4.1.6 usb_ep_free_request

[Overview]	A USB Endpoint transmission request structure is released.	
[Function Name]	usb_ep_free_request	
[Calling format]	<pre>#include <linux/usb/gadget.h> void usb_ep_free_request(struct usb_ep *ep, struct usb_request *req);</pre>	
[Argument]	ep	: Pointer of USB Endpoint structure
	req	: Pointer USB Endpoint transmission request structure
[Return value]	none	
[Feature]	The usb_request structure acquired by usb_ep_alloc_request() is released.	
[Remark]	<p>Please refer to 4.2.4 about usb_ep structure</p> <p>Please refer to 4.2.1 about usb_request structure</p> <p>Be careful of whether buffer in a usb_request structure is released before release.</p> <p>It can call from an interrupt handler.</p>	

4.1.7 usb_ep_queue

[Overview]	USB Endpoint transmission is required.		
[Function Name]	usb_ep_queue		
[Calling format]	<pre>#include <linux/usb/gadget.h> int usb_ep_queue(struct usb_ep *ep, struct usb_request *req gfp_t gfp_flags);</pre>		
[Argument]	ep	:	Pointer of USB Endpoint structure
	req	:	Pointer USB Endpoint transmission request structure
	gfp_flags	:	flag of memory acquisition
[Return value]	0	:	Normal termination
	-ESHUTDOWN	:	The speed of USB of operation is un-setting up.
[Feature]	A data transfer setup is performed according to a setup of usb_request structure.		
[Remark]	Please refer to 4.2.4 about usb_ep structure Please refer to 4.2.1 about usb_request structure By setting up a memory acquisition flag appropriately, it can call from an interrupt handler.		

4.1.8 usb_ep_dequeue

[Overview]	USB Endpoint transmission is stopped.		
[Function Name]	usb_ep_dequeue		
[Calling format]	<pre>#include <linux/usb/gadget.h> int usb_ep_dequeue(struct usb_ep *ep, struct usb_request *req);</pre>		
[Argument]	ep	:	Pointer of USB Endpoint structure
	req	:	Pointer USB Endpoint transmission request structure
[Return value]	0	:	Normal termination
[Feature]	A transmission stop will be carried out, if the specified usb_request structure is in transmission queue or it is under transmission. (-ECONNRESET is put into the status member of usb_request and completion call-back is carried out.)		
[Remark]	Please refer to 4.2.4 about usb_ep structure Please refer to 4.2.1 about usb_request structure It can call from an interrupt handler.		

4.1.9 usb_ep_set_halt

[Overview]	Specified Endpoint is changed into a STALL state.	
[Function Name]	usb_ep_set_halt	
[Calling format]	#include <linux/usb/gadget.h> int usb_ep_set_halt(struct usb_ep *ep);	
[Argument]	ep	: Pointer of USB Endpoint structure
[Return value]	0	: Normal termination
	-EAGAIN	: Double call
[Feature]	Specified Endpoint is changed into a STALL state.	
[Remark]	Please refer to 4.2.4 about usb_ep structure. It can call from an interrupt handler.	

4.1.10 usb_ep_clear_halt

[Overview]	STALL of Endpoint is canceled.	
[Function Name]	usb_ep_clear_halt	
[Calling format]	#include <linux/usb/gadget.h> int usb_ep_clear_halt(struct usb_ep *ep);	
[Argument]	ep	: Pointer of USB Endpoint structure
[Return value]	0	: Normal termination
	-EAGAIN	: Double call
[Feature]	STALL of specified Endpoint is canceled.	
[Remark]	Please refer to 4.2.4 about usb_ep structure It can call from an interrupt handler.	

4.1.11 usb_ep_set_wedge

[Overview]	Endpoint is changed into a STALL state.	
[Function Name]	usb_ep_set_wedge	
[Calling format]	<pre>#include <linux/usb/gadget.h> int usb_ep_set_wedge(struct usb_ep *ep);</pre>	
[Argument]	ep	: Pointer of USB Endpoint structure
[Return value]	0	: Normal termination
	-EAGAIN	: Double call
	-EINVAL	: Invalid argument
[Feature]	Specified Endpoint is changed into a STALL state.	
[Remark]	It becomes the same processing as usb_ep_set_halt. Please refer to 4.2.4 about usb_ep structure. It can call from an interrupt handler.	

4.1.12 usb_ep_fifo_status [unsupported]

[Overview]	The data size which remains in the buffer of Endpoint is returned.	
[Function Name]	usb_ep_fifo_status	
[Calling format]	<pre>#include <linux/usb/gadget.h> int usb_ep_fifo_status(struct usb_ep *ep);</pre>	
[Argument]	ep	: Pointer of USB Endpoint structure
[Return value]	-EOPNOTSUPP	: unsupported
[Feature]	The data size which remains in the buffer of specified Endpoint is returned.	
[Remark]	The returned value of this function is (-EOPNOTSUPP) at a usual state for unsupported Please refer to 4.2.4 about usb_ep structure. It can call from an interrupt handler.	

4.1.13 usb_ep_fifo_flush [unsupported]

[Overview]	The buffer of Endpoint is cleared.
[Function Name]	usb_ep_fifo_flush
[Calling format]	#include <linux/usb/gadget.h> void usb_ep_fifo_flush(struct usb_ep *ep);
[Argument]	ep : Pointer of USB Endpoint structure
[Return value]	none
[Feature]	The buffer of specified Endpoint is cleared.
[Remark]	Please refer to 4.2.4 about usb_ep structure. It can call from an interrupt handler.

4.1.14 gadget_is_dualspeed

[Overview]	Transmission Speed which UDC supports is acquired.
[Function Name]	gadget_is_dualspeed
[Calling format]	#include <linux/usb/gadget.h> int gadget_is_dualspeed(struct usb_gadget *g);
[Argument]	g : Pointer of USB Gadget structure
[Return value]	0 : Full Speed or Low Speed 1 : High Speed
[Feature]	Transmission Speed which UDC supports is acquired.
[Remark]	Please refer to 4.2.6 about usb_gadget structure. It can call from an interrupt handler.

4.1.15 gadget_is_superspeed

[Overview]	It is acquired whether UDC is supporting Super Speed.	
[Function Name]	gadget_is_superspeed	
[Calling format]	#include <linux/usb/gadget.h> int gadget_is_superspeed(struct usb_gadget *g);	
[Argument]	g	: Pointer of USB Gadget structure
[Return value]	0	: Super Speed is unsupported
	1	: Super Speed is supported
[Feature]	Transmission Speed which UDC supports is acquired.	
[Remark]	Please refer to 4.2.6 about usb_gadget structure. It can call from an interrupt handler.	

4.1.16 gadget_is_otg

[Overview]	It is acquired whether UDC is supporting OTG.	
[Function Name]	gadget_is_otg	
[Calling format]	<pre>#include <linux/usb/gadget.h> int gadget_is_otg(struct usb_gadget *g);</pre>	
[Argument]	g	: Pointer of USB Gadget structure
[Return value]	0	: OTG is unsupported
	1	: OTG is supported
[Feature]	It is acquired whether UDC is supporting OTG.	
[Remark]	Please refer to 4.2.6 about usb_gadget structure. It can call from an interrupt handler.	

4.1.17 usb_gadget_frame_number

[Overview]	Frame Number is acquired.	
[Function Name]	usb_gadget_frame_number	
[Calling format]	<pre>#include <linux/usb/gadget.h> int usb_gadget_frame_number(struct usb_gadget *gadget);</pre>	
[Argument]	gadget	: Pointer of USB Gadget structure
[Return value]	Integer	: Frame Number
[Feature]	Current Frame Number is acquired.	
[Remark]	Please refer to 4.2.6 about usb_gadget structure. It can call from an interrupt handler.	

4.1.18 usb_gadget_wakeup [unsupported]

[Overview]	A remote wake up is performed to USB HOST.	
[Function Name]	usb_gadget_wakeup	
[Calling format]	#include <linux/usb/gadget.h> int usb_gadget_wakeup(struct usb_gadget *gadget);	
[Argument]	gadget	: Pointer of USB Gadget structure
[Return value]	-EOPNOTSUPP	: Unsupported
[Feature]	A remote wake up is performed to USB HOST.	
[Remark]	The returned value of this function is (-EOPNOTSUPP) at a usual state for unsupported. Please refer to 4.2.6 about usb_gadget structure. It can call from an interrupt handler.	

4.1.19 usb_gadget_set_selfpowered [unsupported]

[Overview]	The electric supply method of a USB device is set as self-power.	
[Function Name]	usb_gadget_set_selfpowered	
[Calling format]	#include <linux/usb/gadget.h> usb_gadget_set_selfpowered(struct usb_gadget *gadget);	
[Argument]	gadget	: Pointer of USB Gadget structure
[Return value]	-EOPNOTSUPP	: Unsupported
[Feature]	A setup using electric power source other than VBUS is performed as electric power of a USB device of operation.	
[Remark]	The returned value of this function is (-EOPNOTSUPP) at a usual state for unsupported. Please refer to 4.2.6 about usb_gadget structure. It can call from an interrupt handler.	

4.1.20 usb_gadget_clear_selfpowered [unsupported]

[Overview]	The electric supply method of a USB device is set as bus power.	
[Function Name]	usb_gadget_clear_selfpowered	
[Calling format]	#include <linux/usb/gadget.h> int usb_gadget_clear_selfpowered(struct usb_gadget *gadget);	
[Argument]	gadget	: Pointer of USB Gadget structure
[Return value]	-EOPNOTSUPP	: Unsupported
[Feature]	The electric supply method of a USB device is set as bus power.	
[Remark]	The returned value of this function is (-EOPNOTSUPP) at a usual state for unsupported. Please refer to 4.2.6 about usb_gadget structure. It can call from an interrupt handler.	

4.1.21 usb_gadget_vbus_connect [unsupported]

[Overview]	A power supply is supplied to VBUS.	
[Function Name]	usb_gadget_vbus_connect	
[Calling format]	#include <linux/usb/gadget.h> int usb_gadget_vbus_connect(struct usb_gadget *gadget);	
[Argument]	gadget	: Pointer of USB Gadget structure
[Return value]	-EOPNOTSUPP	: Unsupported
[Feature]	A power supply is supplied to VBUS.	
[Remark]	The returned value of this function is (-EOPNOTSUPP) at a usual state for unsupported. Please refer to 4.2.6 about usb_gadget structure. It can call from an interrupt handler.	

4.1.22 usb_gadget_vbus_draw [unsupported]

[Overview]	A current consumption value of VBUS is notified.	
[Function Name]	usb_gadget_vbus_draw	
[Calling format]	<pre>#include <linux/usb/gadget.h> int usb_gadget_vbus_draw(struct usb_gadget *gadget, unsigned mA);</pre>	
[Argument]	gadget	: Pointer of USB Gadget structure
	mA	: Consumption current value
[Return value]	0	: Normal termination
[Feature]	It calls at the time of SET_CONFIGURATION, SET_CONFIGURATION processing finishes, and it notifies the consumption current value after operation of apparatus.	
[Remark]	Please refer to 4.2.6 about usb_gadget structure. It can call from an interrupt handler.	

4.1.23 usb_gadget_vbus_disconnect [unsupported]

[Overview]	The electric supply of VBUS is canceled.	
[Function Name]	usb_gadget_vbus_disconnect	
[Calling format]	<pre>#include <linux/usb/gadget.h> int usb_gadget_vbus_disconnect(struct usb_gadget *gadget);</pre>	
[Argument]	gadget	: Pointer of USB Gadget structure
[Return value]	-EOPNOTSUPP	: Unsupported
[Feature]	The electric supply of VBUS is canceled.	
[Remark]	The returned value of this function is (-EOPNOTSUPP) at a usual state for unsupported. Please refer to 4.2.6 about usb_gadget structure. It can call from an interrupt handler.	

4.1.24 usb_gadget_connect

[Overview]	The pull-up resistor of D+ signal is turned ON.
[Function Name]	usb_gadget_connect
[Calling format]	#include <linux/usb/gadget.h> int usb_gadget_connect(struct usb_gadget *gadget);
[Argument]	gadget : Pointer of USB Gadget structure
[Return value]	0 : Normal termination
[Feature]	The pull-up resistor of D+ signal is turned ON.
[Remark]	Please refer to 4.2.6 about usb_gadget structure. It can call from an interrupt handler.

4.1.25 usb_gadget_disconnect

[Overview]	The pull-up resistor of D+ signal is turned OFF.
[Function Name]	usb_gadget_disconnect
[Calling format]	#include <linux/usb/gadget.h> int usb_gadget_disconnect(struct usb_gadget *gadget);
[Argument]	gadget : Pointer of USB Gadget structure
[Return value]	0 : Normal termination
[Feature]	The pull-up resistor of D+ signal is turned OFF.
[Remark]	Please refer to 4.2.6 about usb_gadget structure. It can call from an interrupt handler.

4.2 Structure

The list of structure definitions required of this module is shown as follows.

When you use these structures, please include the following header files.

```
#include <linux/usb/gadget.h>
```

Table 4.4 List of structure

Chapter	Name of symbol in structure	Name of structure
4.2.1	usb_request	USB Endpoint transfer request structure
4.2.2	usb_ep_ops	USB Endpoint operation structure
4.2.3	usb_ep_caps	USB Endpoint capability structure
4.2.4	usb_ep	USB Endpoint structure
4.2.5	usb_gadget_ops	USB Gadget operation structure
4.2.6	usb_gadget	USB Gadget structure
4.2.7	usb_gadget_driver	USB Gadget driver structure

4.2.1 usb_request structure

```
struct usb_request {
    void                *buf;
    unsigned            length;
    dma_addr_t          dma;
    struct scatterlist   *sg;
    unsigned            num_sgs;
    unsigned            num_mapped_sgs;
    unsigned            stream_id:16;
    unsigned            no_interrupt:1;
    unsigned            zero:1;
    unsigned            short_not_ok:1;
    void                (*complete)(struct usb_ep *ep, struct usb_request *req);
    void                *context;
    struct list_head     list;
    int                 status;
    unsigned            actual;
};
```

buf	: Transfer buffer address
length	: Data length of transmission and reception
dma	: DMA address structure pointer
sg	: A scatter list for SG(Scatter/Gather)-capable controllers
num_sgs	: Number of SG entries
num_mapped_sgs	: Number of SG entries mapped to DMA (internal)
stream_id	: The stream id, when USB3.0 bulk streams are being used
no_interrupt:1	: Transmission discontinuation unnecessary flag
zero:1	: Zero length packet addition flag
short_not_ok:1	: Short packet improper flag
complete()	: Completion callback function pointer
context	: transfer context
list	: list structure (Write-protected)
status	: status of transfer (Write-protected)
actual	: The completion data length of transmission(Write-protected)

4.2.2 usb_ep_ops structure

```

struct usb_ep_ops {
    int                (*enable) (struct usb_ep *ep, const struct usb_endpoint_descriptor *desc);
    int                (*disable) (struct usb_ep *ep);
    struct usb_request (*alloc_request) (struct usb_ep *ep, gfp_t gfp_flags);
    void               (*free_request) (struct usb_ep *ep, struct usb_request *req);
    int                (*queue) (struct usb_ep *ep, struct usb_request *req, gfp_t gfp_flags);
    int                (*dequeue) (struct usb_ep *ep, struct usb_request *req);
    int                (*set_halt) (struct usb_ep *ep, int value);
    int                (*set_wedge) (struct usb_ep *ep);
    int                (*fifo_status) (struct usb_ep *ep);
    void               (*fifo_flush) (struct usb_ep *ep);
};

```

enable()	: Endpoint enable function pointer
disable()	: Endpoint disable function pointer
alloc_request()	: usb_request structure acquisition pointer
free_request()	: usb_request structure release function pointer
queue()	: Transfer request function pointer
dequeue()	: Transfer stop function pointer
set_halt()	: Setting status of STALL function pointer
set_wedge()	: Setting status of STALL function pointer
fifo_status()	: Status of FIFO acquisition function pointer
fifo_flush()	: FIFO FLUSH function pointer

4.2.3 usb_ep_caps structure

```

struct usb_ep_caps {
    unsigned            type_control:1;
    unsigned            type_iso:1;
    unsigned            type_bulk:1;
    unsigned            type_int:1;
    unsigned            dir_in:1;
    unsigned            dir_out:1;
};

```

type_control	: Endpoint supports control type (reserved for ep0)
type_iso	: Endpoint supports isochronous transfers
type_bulk	: Endpoint supports bulk transfers
type_int	: Endpoint supports interrupt transfers
dir_in	: Endpoint supports IN direction
dir_out	: Endpoint supports OUT direction

4.2.4 usb_ep structure

```
struct usb_ep {
    void                *driver_data;
    const char          *name;
    const struct usb_ep_ops *ops;
    struct list_head    ep_list;
    struct usb_ep_caps   caps;
    bool                claimed;
    bool                enabled;
    unsigned             maxpacket:16;
    unsigned             maxpacket_limit:16;
    unsigned             max_streams:16;
    unsigned             mult:2;
    unsigned             maxburst:5;
    u8                  address;
    const struct         usb_endpoint_descriptor *desc;
    const struct         usb_ss_ep_comp_descriptor *comp_desc;
};
```

driver_data	: driver data
name	: Endpoint name
ops	: USB Endpoint operation function structure
ep_list	: list structure(Write-protected)
caps	: The structure describing types and directions supported by endpoint.
claimed	: This is used autoconfig.
enabled	: This is used usb_enable/disable_endpoint.
maxpacket:16	: MaxPacketSize(Write-protected)
maxpacket_limit:16	: MaxPacketSize(Write-protected)
max_stream:16	: The maximum number of streams supported by this EP (0 - 16, actual number is 2^n)
mult:2	: multiplier, 'mult' value for SS Isoc EPs
maxburst:5	: The maximum number of bursts supported by this EP (for usb3)
address	: used to identify the endpoint when finding descriptor that matches connection speed
desc	: endpoint descriptor. This pointer is set before the endpoint is enabled and remains valid until the endpoint is disabled.
comp_desc	: In case of SuperSpeed support, this is the endpoint companion descriptor that is used to configure the endpoint

4.2.5 usb_gadget_ops structure

```
struct usb_gadget_ops {
    Int                (*get_frame)(struct usb_gadget *);
    Int                (*wakeup)(struct usb_gadget *);
    Int                (*set_selfpowered) (struct usb_gadget *, int is_selfpowered);
    Int                (*vbus_session) (struct usb_gadget *, int is_active);
    Int                (*vbus_draw) (struct usb_gadget *, unsigned mA);
    Int                (*pullup) (struct usb_gadget *, int is_on);
    Int                (*ioctl)(struct usb_gadget *, unsigned code, unsigned long param);
    Void               (*get_config_params)(struct usb_dcd_config_params *);
    Int                (*udc_start)(struct usb_gadget *, struct usb_gadget_driver *);
    Int                (*udc_stop)(struct usb_gadget *, struct usb_gadget_driver *);

    struct usb_ep      (*match_ep)(struct usb_gadget *,
                                   struct usb_endpoint_descriptor *,
                                   struct usb_ss_ep_comp_descriptor * );
};
```

get_frame()	: Frame number acquisition function pointer
wakeup()	: Remote wake up function pointer
set_selfpowered()	: Self / Bus power setting function pointer
vbus_session()	: VBUS Status notification function pointer
vbus_draw()	: Consumption current notification function pointer
pullup()	: Pull-up status control function pointer
ioctl()	: IO Control function pointer
get_config_params()	: get_config_params function pointer
udc_start()	: UDC start function pointer
udc_stop()	: UDC stop function pointer
match_ep()	: UDC match ep function pointer

4.2.6 usb_gadget structure

```
struct usb_gadget {
    struct work_struct          work;
    struct usb_udc              *udc;
    /* readonly to gadget driver */
    const struct usb_gadget_ops *ops;
    struct usb_ep               *ep0;
    struct list_head            ep_list; /* of usb_ep */
    enum usb_device_speed        speed;
    enum usb_device_speed        max_speed;
    enum usb_device_state        state;
    const char                   *name;
    struct device                dev;
    unsigned                     out_epnum;
    unsigned                     in_epnum;
    struct usb_otg_caps          *otg_caps
    unsigned                     sg_supported:1;
    unsigned                     is_otg:1;
    unsigned                     is_a_peripheral:1;
    unsigned                     b_hnp_enable:1;
    unsigned                     a_hnp_support:1;
    unsigned                     a_alt_hnp_support:1;
    unsigned                     quirk_ep_out_aligned_size:1;
    unsigned                     quirk_altset_not_supp:1;
    unsigned                     quirk_stall_not_supp:1;
    unsigned                     quirk_zlp_not_supp:1;
    unsigned                     is_selfpowered:1;
    unsigned                     deactivated:1;
    unsigned                     connected:1;
};
```

ops	: The operation structure for Gadget
ep0	: Endpoint_0 information structure
ep_list	: usb_ep storing list
speed	: USB operation speed
max_speed	: Maximal speed the UDC can handle. UDC must support this and all slower speeds.
state	: the state we are now (attached, suspended, configured, etc)
name	: device name
dev	: device structure
out_epnum	: last used out ep number
in_epnum	: last used in ep number
*otg_caps	: OTG capabilities of this gadget
sg_supported	: true if we can handle scatter-gather
is_otg:1	: OTG supported flag

is_a_peripheral:1	: A_PERIPHERAL status flag when OTG operate
b_hnp_enable:1	: B_HNP_ENABLE status flag when OTG operate
a_hnp_support:1	: A_HNP_SUPPORT status flag when OTG operate
a_alt_hnp_support:1	: A_ALT_HNP_SUPPORT status flag when OTG operate
quirk_ep_out_aligned_size:1	: ep out requires buffer size to be aligned to MaxPacketSize
quirk_altset_not_supp:1	: alt set not supported flag
quirk_stall_not_supp:1	: stall not supported flag
quirk_zlp_not_supp:1	: zero length packet not supported flag
is_selfpowered:1	: gadget is self-powered
deactivated:1	: True if gadget is deactivated - in deactivated state it cannot be connected
connected:1	: True if gadget is connected

4.2.7 usb_gadget_driver structure

```

struct usb_gadget_driver {
    Char                *function;
    enum usb_device_speed max_speed;
    Int                 (*bind)(struct usb_gadget *gadget, struct usb_gadget_driver *driver);
    Void                (*unbind)(struct usb_gadget *);
    Int                 (*setup)(struct usb_gadget *, const struct usb_ctrlrequest *);
    Void                (*disconnect)(struct usb_gadget *);
    Void                (*suspend)(struct usb_gadget *);
    Void                (*resume)(struct usb_gadget *);
    Void                (*reset)(struct usb_gadget *);

    struct device_driver driver;
    Char                *udc_name;
    struct list_head    pending;
};

```

function	: function name
max_speed	: Max operation speed
bind()	: Callback function pointer at the time of registration
unbind()	: Callback function pointer at the time of registration release
setup()	: Callback function pointer at the time of setup reception
disconnect()	: Callback function pointer at the time of USB disconnecting
suspend()	: Callback function pointer at the time of USB suspended
resume ()	: Callback function pointer at the time of USB resumed
driver	: device driver structure
reset ()	: Callback function pointer at the time of USB reset
driver	: device driver structure
udc_name	: device driver name
pending	: It is used for deferred probe.

4.3 Global Variables and Constants**4.3.1 Global variables**

There are no global variables for this module.

4.3.2 Global constants

There are no global constants for this module.

5. Integration

5.1 Directory Configuration

The directory configuration is shown below.

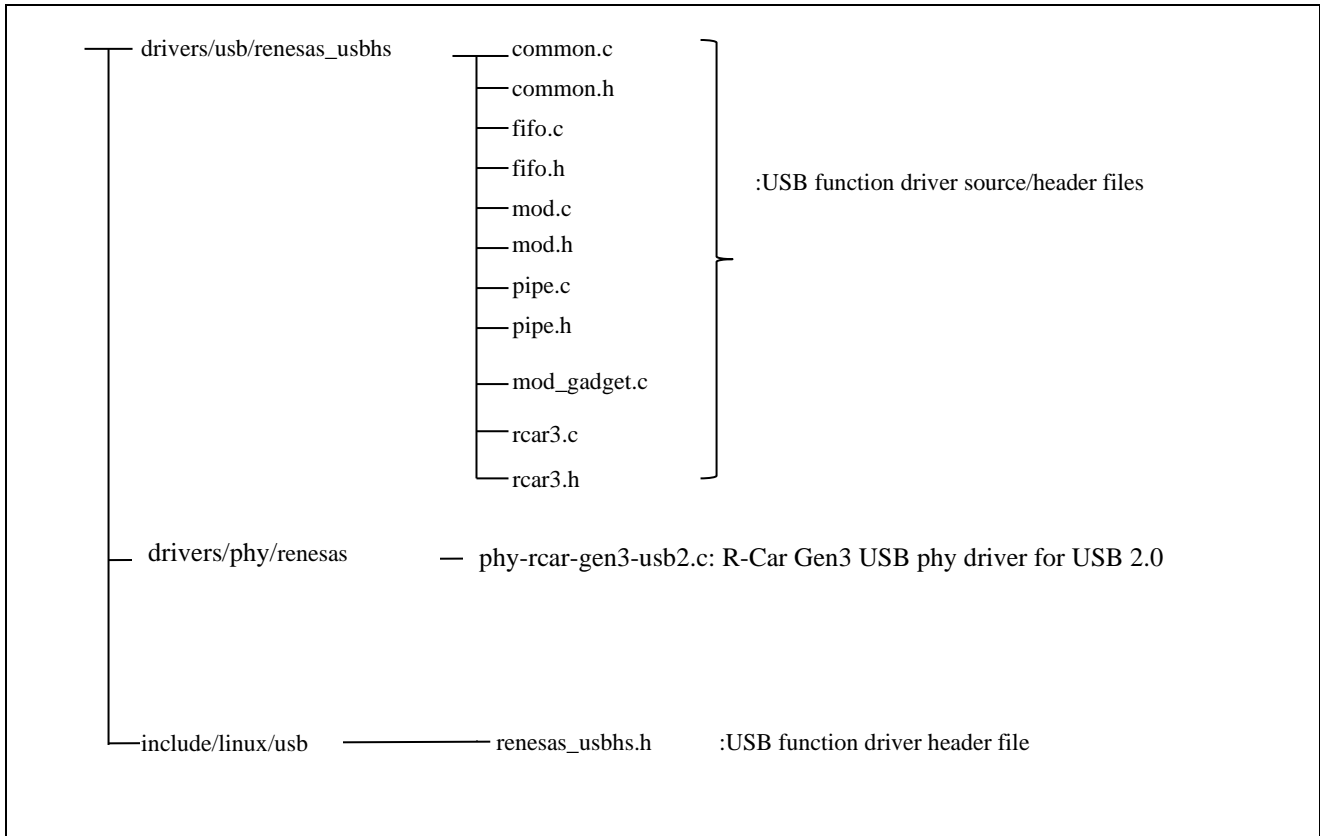
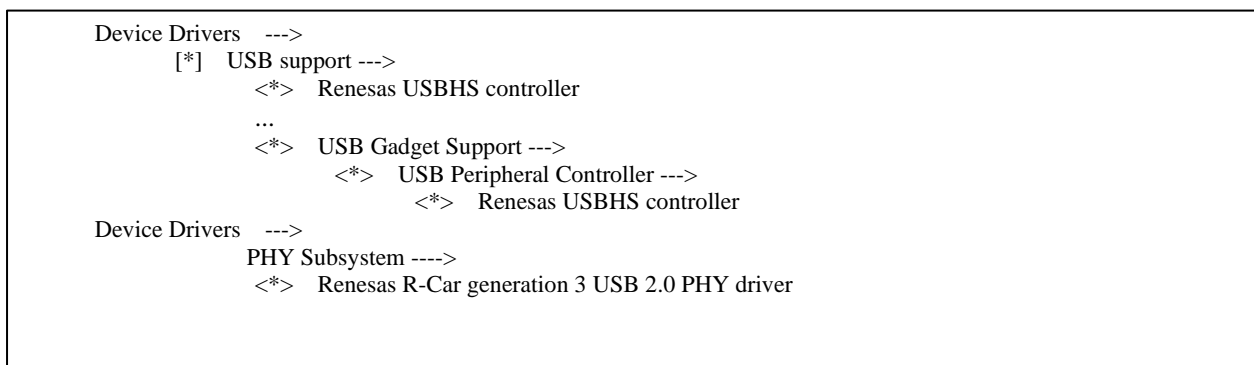


Figure 5-1 Directory Configuration (R-car H3/M3/M3N/E3/D3)

5.1.1 Integration of a USB Function control driver



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

Figure 5-2 Kernel configuration for this module (R-Car H3/M3/M3N/E3/D3)

5.1.2 Integration of a USB gadget driver

The example of integration of a USB gadget driver is shown below.

Please perform the following setup, when you integrate Mass Storage Gadget as module.

1. Please enable (input "Y") the following item in "USB Gadget Support".

```
Device Drivers --->
  [*] USB support --->
    <*> USB Gadget Support --->
      <M> USB Gadget precomposed configurations
      <M> Mass Storage Gadget
```

Figure 5-3 Kernel configuration for USB Mass Storage Gadget driver(R-Car H3/M3/M3N/E3/D3)

5.2 Option Setting

5.2.1 Module Parameters

There are no module parameters.

5.2.2 Kernel Parameters

There are no kernel parameters.

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REVISION HISTORY		Linux Interface Specification Device Driver USB 2.0 Function User's Manual: Software	
Rev.	Date	Description	
		Page	Summary
0.1	Mar. 18, 2016	—	New creation.
0.2	Apr. 15, 2016	All	Add R-Car M3 support.
		2	Update related documents.
0.3	Aug. 5, 2016	2	Update related documents.
		1, 2, 4	Add OTG supports only HNP.
		29	Delete dts file setting.
		1, 5	Add port 3(CN37).
0.4	Mar. 15, 2017	2, 4	Update related documents.
0.5	Jun. 14, 2017	2	Update related documents.
1.00	Aug. 8, 2017	All	Update document format.
1.01	Oct. 24, 2017	All	Update document format. Add R-Car M3N support.
1.50	Jan. 29, 2018	30	Add Role Swap Interface.
1.51	Mar. 28, 2018	All	Add R-Car E3 support.
		2	Updated connected port for R-Car E3.
		2	Updated Related Document for R-Car E3.
		5	Updated Hardware specification for R-Car E3.
		7	Added Module configuration for R-Car E3.
		33	Remove Role Swap usage.
1.52	Oct. 22, 2018	2	Update Related Documents.
2.00	Dec. 25, 2018	2	Update Related Documents.
		5	Update Hardware Specification.
		-	Update Address List.
2.01	Apr. 17, 2019	2	Update Related Documents.
		-	Update Address List.
2.50	Apr. 21, 2021	All	Add R-Car D3 support.
		-	Add Kernel v5.10 support.
2.51	Aug. 16, 2021	2	Add Role Swap usage for R-CarD3.
3.00	Dec. 10, 2021	-	Add Kernel v5.10.41 support

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Linux Interface Specification
Device Driver
USB 2.0 Function



Renesas Electronics Corporation