RENESAS

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Linux Interface Specification Device Driver USB 3.0 Host

User's Manual: Software

R-Car H3/M3/M3N/E3 Series

Renesas Electronics
www.renesas.com

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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 processor.

- **[Purpose]**

  This manual is intended to give users an understanding of the functions of the R-Car H3/M3/M3N/E3 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
  → See the R-Car H3/M3/M3N/E3 User's Manual.
  — To know the electrical specifications of the multimedia processor for R-Car H3/M3/M3N/E3
  → See the R-Car H3/M3/M3N/E3 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 ... ××××, 0b××××, or ××××B
  Decimal ... ××××
  Hexadecimal ... 0x×××× or ××××H
  Data type: Double word … 64 bits
  Word … 32 bits
  Half word ... 16 bits
  Byte ... 8 bits

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Table of Contents

1. Overview

1.1 Overview

This manual explains the driver module (this module) that controls the USB 3.0 Host controller on R-Car H3/M3/M3N/E3.

1.2 Function

This module controls the USB 3.0 Host controller on R-Car H3/M3/M3N/E3, transmits/receives data to/from the USB device.

The function of this module is based on xHCI of standard Linux.

- USB memory device support
- USB keyboard device support
- USB mouse device support

1.3 Connected Port

This module supports following USB port on R-Car H3-SiP/M3-SiP/M3N-SiP/E3 System Evaluation Board.

Table 1.1 Connected Port

Port No.	Standard	Connector No.	Content
0	USB3.0 Host	CN11	Type A connector

1.4   Reference

1.4.1   Standard

The following table shows the document related to this module.

Table 1.2   Standard

Reference No.	Issue	Title	Edition	Date
-	USB Implementers Forum, Inc	Universal Serial Bus 3.0 Specification	Rev.1.0	Jun. 6, 2011

1.4.2   Related Documents

The following table shows the document related to this module.

Table 1.3   Related Documents

Reference No.	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

1.5   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
USB	Universal Serial Bus
HCD	Host Controller Driver
xHCI	Extensible Host Controller Interface

3.   Operating Environment

3.1   Hardware Environment

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

Table 3.1   Hardware Environment

Name	Version	Manufacturer
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

3.2   Module Configuration

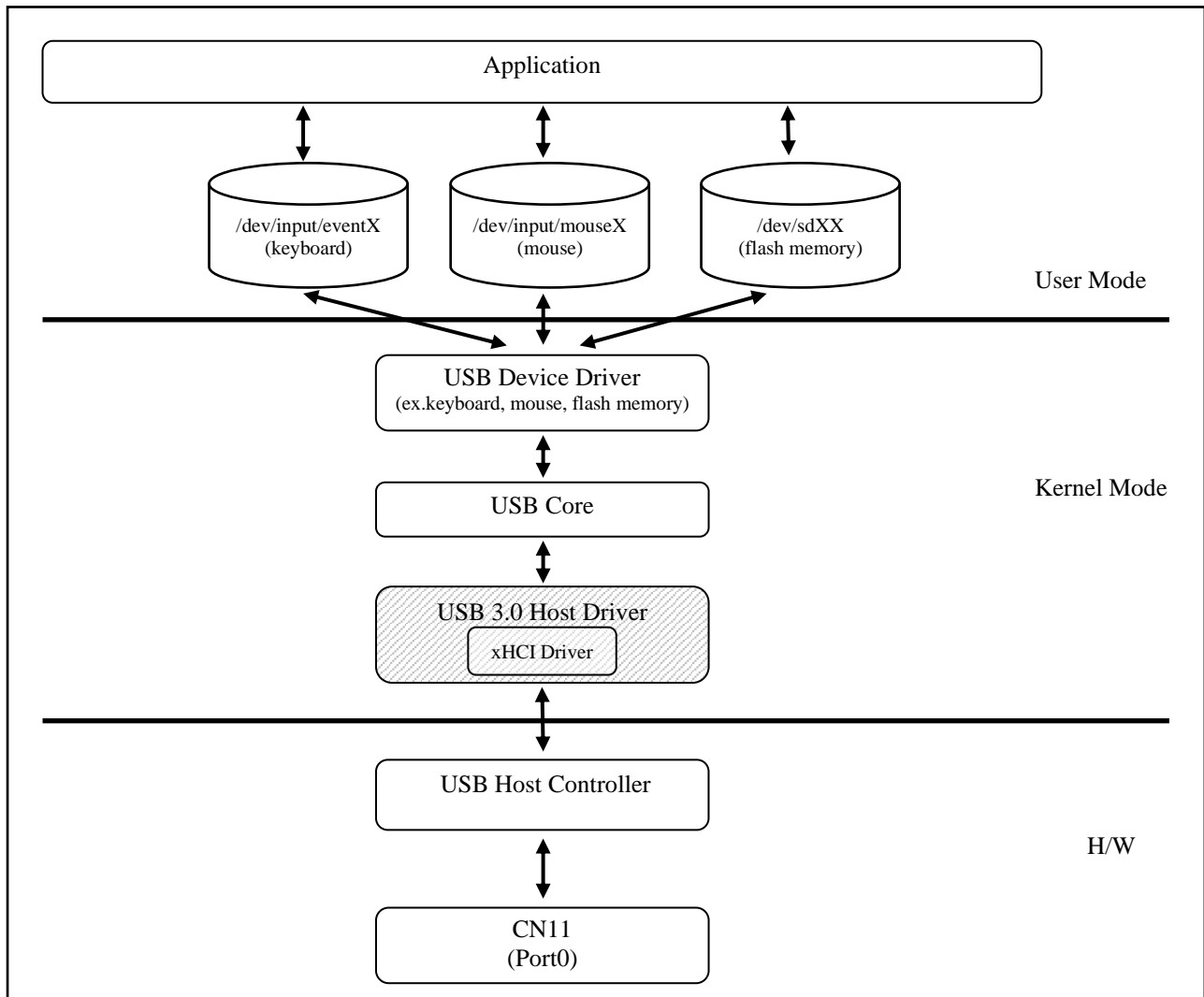The following figure shows the configuration of this module.

Figure 3-1 Modules Configuration

3.3   State Transition Diagram

The following table shows the state transition of this module.
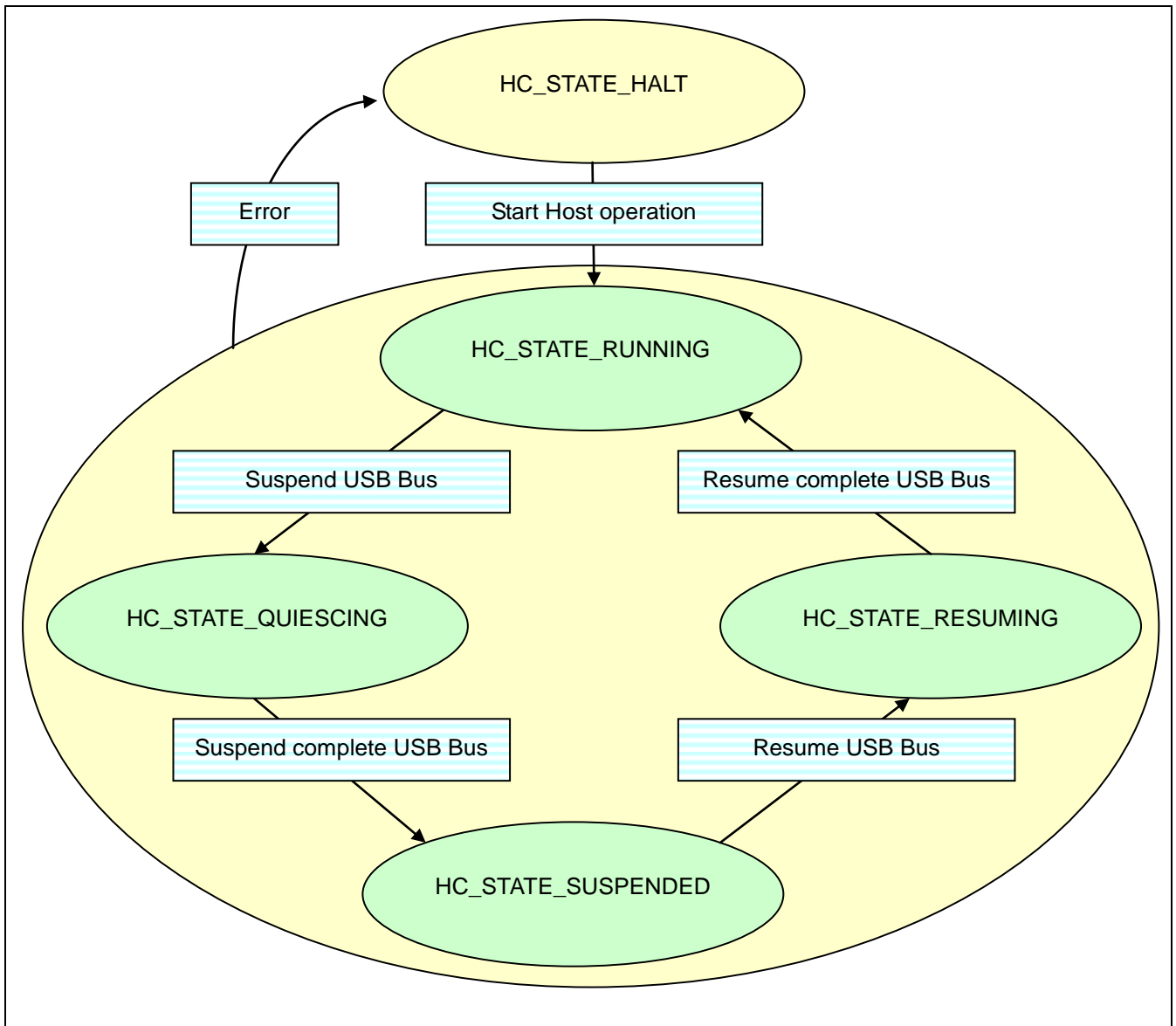

Figure 3-2 State Transition Diagram

4. External Interface

Detailed explanation is skipped because the external interface of this module is based on Linux.

4.1 Device Node

Device node of this module is shown below.

Table 4.1   Device Node

Device	Channel	Device node	Major number	Minor number
Keyboard	0	/dev/input/eventX*	13	64*
Mouse	0	/dev/input/mouseX1	13	32*
USB memory	0	/dev/sdX1	8	0*

Note: * The numerical value may differ according to the system. (ex, /dev/input/event0)

4.2   Optional USB3.0 Clock setting

The USB3.0 module supports an input reference clock from both external and on-chip clock sources.

The on-chip clock source is supplied through USB_XTAL/USB_EXTAL to share the reference clocks with other USB2.0 channels.

In addition, we will explain how to use SSC.

If you do not use the on-chip clock source with USB 3.0, the setting in this chapter is unnecessary.

Refer to the "R-Car Series, 3rd Generation User's Manual:Hardware (Figure 76.1 Clock Distribution)".

R-Car E3 is not support USB3.0 Clock Setting Register.

4.2.1   The on-chip clock source setting

This section explains how to use USB 2.0 Crystal Oscillator as USB 3.0 clock source.
This function is in "drivers/phy/renesas/phy-rcar-gen3-usb3.c".

The definition for supplying the on-chip clock source is shown below. The following description indicates a difference from the default setting. ("-": Delete a description (default setting), "+": Setting after the modification))

Figure 4-3 and 4-4 are write to .dts.file.

Directory: arch/arm64/boot/dts/renesas/

- salvator-common.dtsi

```
- &usb3s0_clk {
-         clock-frequency = <100000000>;
- };
```

Figure 4-1 Board setting for using the USB3.0 clock frequency

```
  &xhci0 {
-         pinctrl-0 = <&usb30_pins>;
-         pinctrl-names = "default";
+         phys = <&usb3_phy0>;
+         phy-names = "usb";
          status = "okay";
  };
```

Figure 4-2 Board setting for using the USB3.0 PHY

4.2.2   The on-chip external clock source setting

This shows how to connect and using an external Oscillator to USB_EXTAL. Add the following definition to "4.2.1 The on-chip clock source setting".
This function is in "drivers/clk/renesas/rcar-usb2-clock-sel.c".

The definition for supplying the on-chip clock source via USB_EXTAL is shown below. The following description indicates a difference from the default setting. ("-": Delete a description (default setting), "+": Setting after the modification))

Directory: arch/arm64/boot/dts/renesas/

- r8a77951.dtsi (R-Car H3 Ver.2.0 or later)
- r8a77961.dtsi (R-Car M3 Ver.3.0)
- r8a77965.dtsi (R-Car M3N)

```
        compatible = "renesas,r8a77965";

+       usb_xtal_clk: usb_xtal {
+               compatible = "fixed-clock";
+               #clock-cells = <0>;
+               clock-frequency = <0>;
+       };

        soc {

+               usb2_clock_sel: clock-controller@e6590630 {
+                       compatible = "renesas,rcar-gen3-usb2-clock-sel";
+                       reg = <0 0xe6590630 0 0x02>;
+                       clocks = <&cpg CPG_MOD 703>, <&cpg CPG_MOD 704>,
+                                   <&usb_extal_clk>,   <&usb_xtal_clk>;
+                       clock-names = "ehci_ohci", "hs-usb-if", "usb_extal", "usb_xtal";
+                       #clock-cells = <0>;
+                       power-domains = <&sysc R8A7795_PD_ALWAYS_ON>;*1
+                       resets = <&cpg 703>,   <&cpg 704>;
+                       reset-names = "ehci_ohci",   "hs-usb-if";
+               };
```

Figure 4-3 Board setting for using clock source

Directory: arch/arm64/boot/dts/renesas/

- salvator-common.dtsi (R-Car H3/M3/M3N)

```
    &ohci0 {
            dr_mode = "otg";
            status = "okay";
+           clocks = <&usb2_clock_sel>, <&cpg CPG_MOD 703>;
    };

    &ohci1 {
            status = "okay";
+           clocks = <&usb2_clock_sel>, <&cpg CPG_MOD 702>;
    };

    &ehci0 {
            dr_mode = "otg";
            status = "okay";
+           clocks = <&usb2_clock_sel>, <&cpg CPG_MOD 703>;
    };

    &ehci1 {
            status = "okay";
+           clocks = <&usb2_clock_sel>, <&cpg CPG_MOD 702>;
    };
```

Figure 4-4 Board setting for using clock source with ohci/ehci (R-Car H3/M3/M3N)

The following boards support different number of channels. Make settings for each board to be used.

Directory: arch/arm64/boot/dts/renesas/

- r8a77951-salvator-x.dts (Salvator-X board of R-Car H3 Ver.2.0 or later)
- r8a77951-salvator-xs.dts (Salvator-XS board of R-Car H3 Ver.2.0 or later)

```
&ohci2 {
        status = "okay";
+       clocks = <&usb2_clock_sel>, <&cpg CPG_MOD 701>;
 };

&ehci2 {
        status = "okay";
+       clocks = <&usb2_clock_sel>, <&cpg CPG_MOD 701>;
};
```

Figure 4-5 Board setting for using clock source with ohci/ehci (Salvator-X board of R-Car H3 Ver.2.0 or later)

```
&ohci2 {
        status = "okay";
+       clocks = <&usb2_clock_sel>, <&cpg CPG_MOD 701>;
 };

&ohci3 {
        status = "okay";
+       clocks = <&usb2_clock_sel>, <&cpg CPG_MOD 700>;
 };

&ehci2 {
        status = "okay";
+       clocks = <&usb2_clock_sel>, <&cpg CPG_MOD 701>;
};

&ehci3 {
        status = "okay";
+       clocks = <&usb2_clock_sel>, <&cpg CPG_MOD 700>;
};
```

Figure 4-6 Board setting for using clock source with ohci/ehci (Salvator-XS board of R-Car H3 Ver.2.0 or later)

4.2.3   USB3.0 SSC (Spread Spectrum Enable) setting

SSC (Spread Spectrum Enable) function can be used in case of setting to use on-chip clock source with USB3.0 (Refer to 4.2.1).
This function is in "drivers/phy/renesas/phy-rcar-gen3-usb3.c".

The following description explain how to enable SSC function. The following description indicates a difference from the default setting. ("-": Delete a description (default setting), "+": Setting after the modification))

Directory: arch/arm64/boot/dts/renesas/

- salvator-common.dtsi

```
   &usb3_phy0 {
+         renesas,ssc-range = <4492>;      <-- Add this line SSC enable.
          status = "okay";
   };
```

Figure 4-7 Board setting for using SSC function with xHCI

Table 4.2 "renesas,ssc-range" parameters

Value	Description
0 (or the property doesn't exist)	disable the ssc
4980	enable the ssc as -4980 ppm
4492	enable the ssc as -4492 ppm
4003	enable the ssc as -4003 ppm

5.   Integration

5.1   Directory Configuration
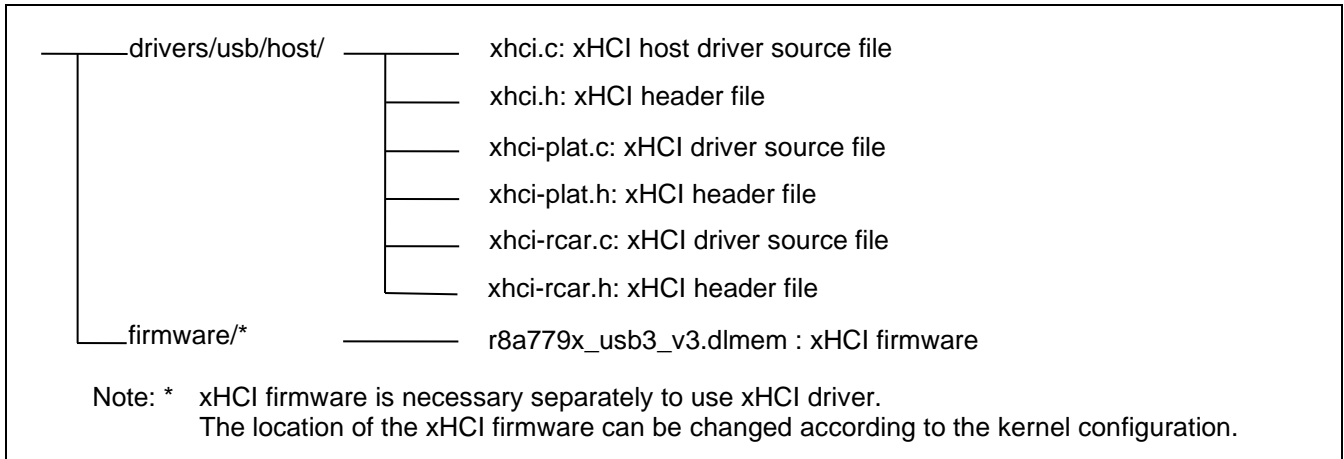
The directory configuration is shown below.

```
        drivers/usb/host/              xhci.c: xHCI host driver source file

                                       xhci.h: xHCI header file

                                       xhci-plat.c: xHCI driver source file

                                       xhci-plat.h: xHCI header file

                                       xhci-rcar.c: xHCI driver source file

                                       xhci-rcar.h: xHCI header file

        firmware/*                     r8a779x_usb3_v3.dlmem : xHCI firmware

    Note: *   xHCI firmware is necessary separately to use xHCI driver.
              The location of the xHCI firmware can be changed according to the kernel configuration.
```

Figure 5-1 Directory Configuration

5.2 Integration Procedure

5.2.1 Kernel Configuration

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

```
Device Drivers    --->
        Generic Driver Options    --->
                -*- Userspace firmware loading support
                (r8a779x_usb3_v3.dlmem) External firmware blobs to build into the kernel binary
                (firmware) Firmware blobs root directory

Device Drivers    --->
        [*]    USB support ---->
                <*>    Support for Host-side USB
                ...
                <*>        xHCI HCD (USB 3.0) support
                -*-            Generic xHCI driver for a platform device
                <*>            xHCI support for Renesas R-Car SoCs
        PHY Subsystem    --->
                -*- PHY Core
                ...
                <*> Renesas R-Car generation 3 USB 2.0 PHY driver
                <*> Renesas R-Car generation 3 USB 3.0 PHY driver
```

Figure 5-2   Kernel configuration for this module

Please get the firmware. You should copy the file to the firmware directory.
Please register the appropriate file name to the "Generic Driver Options" -> "External firmware blobs to build into the kernel binary" on kernel configuration.

Acquisition method of firmware is indicated below.

File Name:
    Firmware file name is selected accord to R-Car Sip revision. (See Table 5.1)

Table 5.1 Selection of firmware file name

	R-Car Sip revision			
	R-Car H3	R-Car M3	R-Car M3N	R-Car E3
	Ver.2.0 or later	Ver.1.1 or later	Ver.1.1 or later	Ver.1.0 or later
Firmware file name				
r8a779x_usb3_v3.dlmem	✓	✓	✓	✓

Firmware to get(git):
    https://git.kernel.org/pub/scm/linux/kernel/git/firmware/linux-firmware.git

Firmware to get(file download):
    https://git.kernel.org/pub/scm/linux/kernel/git/firmware/linux-firmware.git/tree/

The following shows an example of integration of standard USB class drivers.

```
        Device Drivers    --->
                [*]    USB support ---->
                                *** NOTE: USB_STORAGE depends on SCSI but BLK_DEV_SD may ***
                                *** also be needed; see USB_STORAGE Help for more info ***
                        <*> USB Mass Storage support

        Device Drivers    --->
                        Input device support ---->
                          <*> Event interface

        Device Drivers    --->
                        HID support ---->
                          <*> Generic HID driver
                                USB HID support    ---->
                                        <*> USB HID transport layer
```

Figure 5-3   Kernel configuration for standard USB class drivers

5.2.2   USB 3.0 Clock select Configuration

To enable the function in section 4.2.2, set the following in the kernel setting.

```
    Device Drivers    --->
            Common Clock Framework    --->
                    -*- Clock driver for ARM Reference designs

                    ...
                    -*- Renesas SoC clock support
                    [*]    Renesas R-Car USB2 clock selector support
            PHY Subsystem    --->
                    -*- PHY Core

                    ...
                    <*> Renesas R-Car generation 3 USB 2.0 PHY driver
                    < > Renesas R-Car generation 3 USB 3.0 PHY driver
```

Figure 5-4   Kernel configuration for the on-chip external clock source setting

To enable the function in section 4.2.3, set the following in the kernel setting.

```
    Device Drivers    --->
            Common Clock Framework    --->
                    -*- Clock driver for ARM Reference designs

                    ...
                    -*- Renesas SoC clock support
                    [ ]    Renesas R-Car USB2 clock selector support
            PHY Subsystem    --->
                    -*- PHY Core

                    ...
                    <*> Renesas R-Car generation 3 USB 2.0 PHY driver
                    <*> Renesas R-Car generation 3 USB 3.0 PHY driver
```

Figure 5-5   Kernel configuration for USB3.0 SSC

5.3   Option Setting

5.3.1   Module Parameters

There are no module parameters.

5.3.2   Kernel Parameters

There are no kernel parameters.

REVISION HISTORY		Linux Interface Specification Device Driver USB 3.0 Host 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	1.4.2 Related Documents Update related documents.

0.3	Aug. 5, 2016	2	Table 1.3 Related Documents(R-Car H3/M3)
			  H3 Document Update.
			  Add M3 Document.

		6, 7	Add "4.4 IPMMU Setting".
		10	5.2.1 Kernel Configuration Add "file download".
0.4	Dec. 16, 2016	6	4.2 IPMMU setting Change R-Car H3 Device tree file name.(r8a7795.dtsi)
0.5	Mar. 15, 2017	1	1.3 Connected Port Fix "R-Car H3/M3 System" to "R-Car H3-Sip/M3-Sip System".
		2	1.4.2 Related Documents Add User's Manual: Hardware Rev0.53.

		7	4.2 IPMMU setting
			  Add R-Car H3 Ver.2.0 Device tree file(r8a7795.dtsi).
			  Add hardware revision to the description of device tree file name(r8a7795.dtsi,
			  r8a7795-es1.dtsi).

		7, 8	4.2 IPMMU setting Figure 4.1, 4.2 and 4.3 Change Figure and description.
		9	5.1 Directory Configuration Add firmware file name "r8a779x_usb3_v3.dlmem"

		10	5.2.1 Kernel Configuration
			  Fix "register the file name ..." to "register the appropriate file name ...".
			  Add "Table 5.1 Selection of firmware file name"

0.6	Apr. 14, 2017	10	Table 5.1 Selection of firmware file name Add R-Car M3 Ver.1.1/Ver.1.2
0.7	Jun. 14, 2017	7, 8	4.2 IPMMU Setting Figure 4.3 Device settings for using the xHCI of IPMMU(R-Car H3/M3) Table 5.1 Selection of firmware file name Change of version notation.
		9	Add 4.3 USB3.0 Clock setting
1.00	Aug. 8, 2017	All	Update document format.
		17, 18	Add USB 3.0 Clcok select Configuration
1.0.1	Oct. 24, 2017	All	Add R-Car M3N support.

1.50	Jan. 29, 2018	2	Table 1.3 Related Documents (R-Car H3/M3/M3N)
			  Delete User's Manual: Hardware Rev0.51.
			  Delete User's Manual: Hardware Rev0.55.
			  Add User's Manual: Hardware Rev0.80.

		7	Delete 4.2 IPMMU Setting

		7	Update 4.2 USB3.0 Clock setting
		12	Update "4.3.2 The on-chip external clock source setting"
		16	Update "Table 5.1 Selection of firmware file name"
		17	Update "5.2.2 USB 3.0 Clock select Configuration"
1.51	Mar. 28, 2018	All	Add R-Car E3 support.
1.52	Jun. 27, 2018	26	Fix Revision History.
1.53	Oct. 22, 2018	2	1.4.2 Related Documents Update Related Documents
		8, 9, 11	Fix Figure 4-1, 4-2 and 4-5.

1.54	Oct. 29, 2018	8	4.2 Optional USB3.0 Clock setting
			  Fix R-Car E3 support and setting
			4.2.1 The on-chip clock source setting.
			  Fix Figure 4-1, 4-2

		9	4.2.2 The on-chip external clock source setting Fix Figure 4-3
		12	4.2.3 USB3.0 SSC(Spread Spectrum Enable) setting. Fix Figure 4-7 Board setting for using SSC function with xHCI
		14	5.2.1 Kernel Configuration Fix Figure 5-2 Kernel configuration for this module
		16	5.2.2 USB3.0 Clock select Configuration Fix Figure 5-4, 5-5
2.00	Dec. 25, 2018	2	1.4.2 Related Documents Update Table 1.3 Related Documents

		4	3.1 Hardware Environment
			  Update Hardware Environment
			  Add Ebisu-4D Board

		-	Update AddressList
2.01	Apr. 17, 2019	2	1.4.2 Related Documents Update Table 1.3 Related Documents
		-	Update AddressList
2.50	Apr. 21, 2021	2	1.4.2 Related Documents Update Revision of Hardware User's Manual
		9	Update device tree information
3.00	Dec. 10, 2021	-	Add Kernel v5.10.41 support

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Linux Interface Specification
Device Driver
USB 3.0 Host

Renesas Electronics Corporation