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# Linux Interface Specification Device Driver PCIEC

User's Manual: Software

R-Car H3/M3/M3N/E3/V3H 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/V3H processor.

- **[Purpose]**

This manual is intended to give users an understanding of the functions of the R-Car H3/M3/M3N/E3/V3H 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/V3H

→ See the R-Car H3/M3/M3N/E3/V3H User's Manual.

— To know the electrical specifications of the multimedia processor for R-Car H3/M3/M3N/E3/V3H

→ See the R-Car H3/M3/M3N/E3/V3H 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 bit

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 PCIe Controller on R-Car H3/M3/M3N/E3/V3H.

## 1.2 Function

This module controls the PCIe Controller on R-Car H3/M3/M3N/E3/V3H, acting as a PCIe Host Controller. It allows PCIe Endpoint devices to be used with R-Car H3/M3/M3N/E3/V3H. The following functionality is supported:

- Configuration read and writes.
- Host initiated IO (legacy) reads and writes.
- Host initiated memory reads and writes.
- Slave initiated memory reads and writes (bus mastering).
- MSI interrupts.
- Supports one lane (x1) or two lanes (x2) (two lanes correspond to R-Car V3H only).

Note that the PCIe Host Controller on R-Car H3/M3/M3N/E3/V3H only supports MSI interrupt at the moment. Therefore, it might not work as expected when connecting to some legacy PCI Endpoint devices that only support INTx interrupt.

## 1.3 Connected Port

Tables 1.1, 1.2 and 1.3 represent supported connector of this module on R-Car H3/M3/M3N/E3/V3H.

**Table 1.1 Connected Port (R-Car H3/M3/M3N Salvator-X board)**

Channel	Connected to	Support status	Remark
PCIE0	CN5	YES	-
PCIE1	CN6	YES	*1

Note: \*1) If you use Salvator-XS board, setting pin 7 of SW12 to “ON” position.

**Table 1.2 Connected Port (R-Car E3 Ebisu board)**

Channel	Connected to	Support status	Remark
PCIE0	CN5	YES	*1
PCIE0	CN6	YES	*2

Note: \*1) To use PCIe, setting SW49 to “OFF” position.

\*2) To use this port, setting SW49 to “ON” position.

**Table 1.3 Connected Port (R-Car V3H Condor-I board)**

Channel	Connected to	Support status	Remark
PCIE0	CN32	YES	*1
PCIE0	CN31 (HSSTP)	NO	*2

Note: \*1) Setting SW14 to “OFF” position.

\*2) Setting SW14 to “ON” position.

## 1.4 Related Document

Tables 1.4 and 1.5 list the data relevant to this module.

**Table 1.4 Standard**

Number	Issue	Title	Edition	Date
-	PCI-SIG	PCI Express Base Specification	Rev.2.0	Dec. 20, 2006

### 1.4.1 Related document

**Table 1.5 Related document**

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-Car H3-SiP System Evaluation Board Salvator-X Hardware Manual RTP0RC7795SIPB0011S	Rev.1.09	May. 11, 2017
-	Renesas Electronics	R-Car M3-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-Car V3H_2 Additional Document for User's Manual: Hardware	Rev.0.50	Jul. 31, 2020
-	Renesas Electronics	R-CarV3H System Evaluation Board Condor-I Hardware Manual	Rev.0.02	Nov. 11, 2019

## 1.5 Restrictions

For R-Car V3H only, this module only use legacy memory area, because IPMMU is not implemented.

## 2. Terminology

Table 2.1 shows the terminology related to this module.

**Table 2.1 Terminology**

Terms	Explanation
MSI	Message Signaled Interrupt
PCI	Peripheral Component Interconnect
PCIe	PCI Express
PCIEC	PCI Express Controller
RC	Root Complex



## **3. Operating Environment**

### **3.1 Hardware Environment**

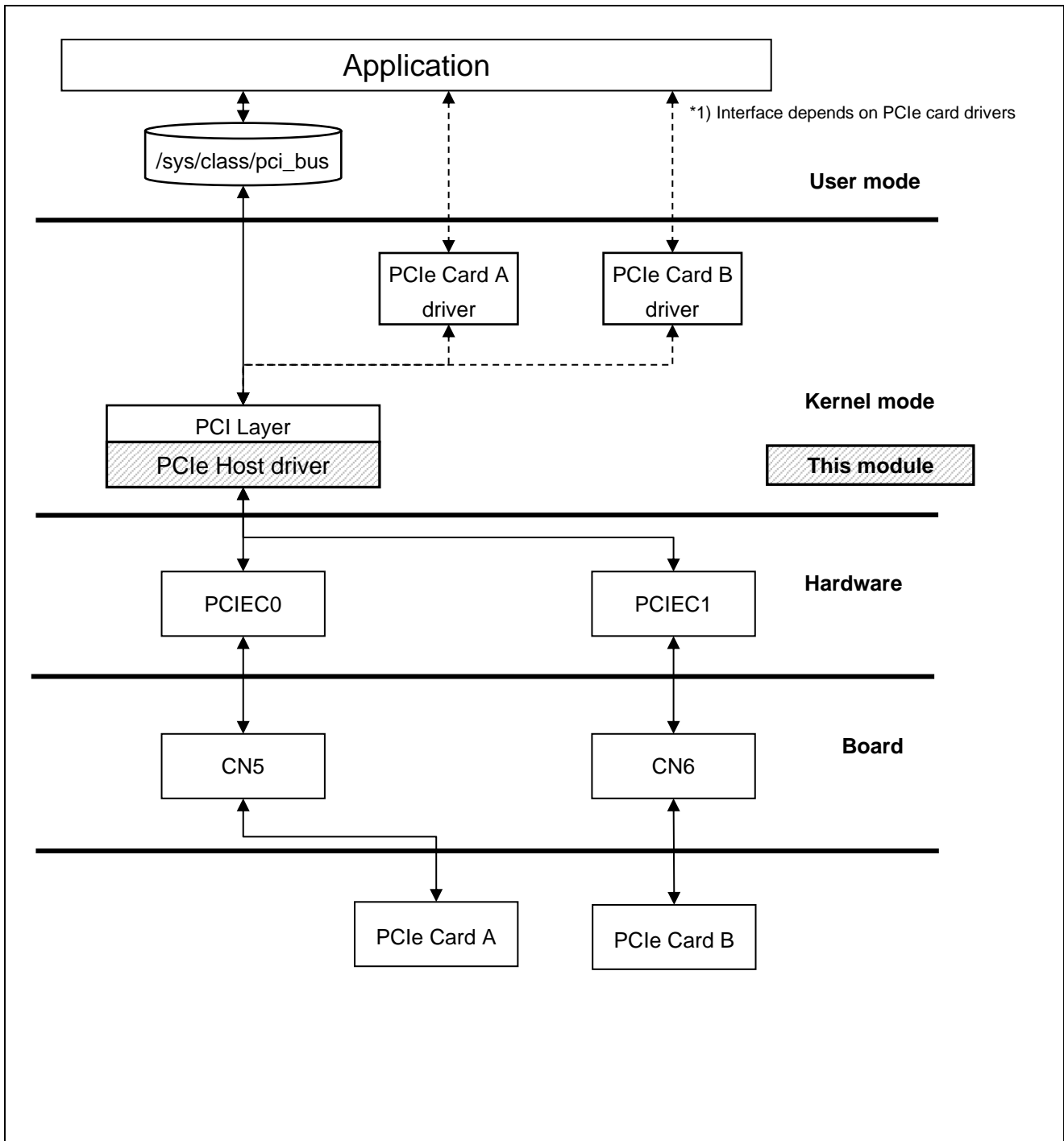
Table 3.1 lists the hardware needed to use this module.

**Table 3.1 Hardware Environment (R-Car H3/M3/M3N/E3/V3H)**

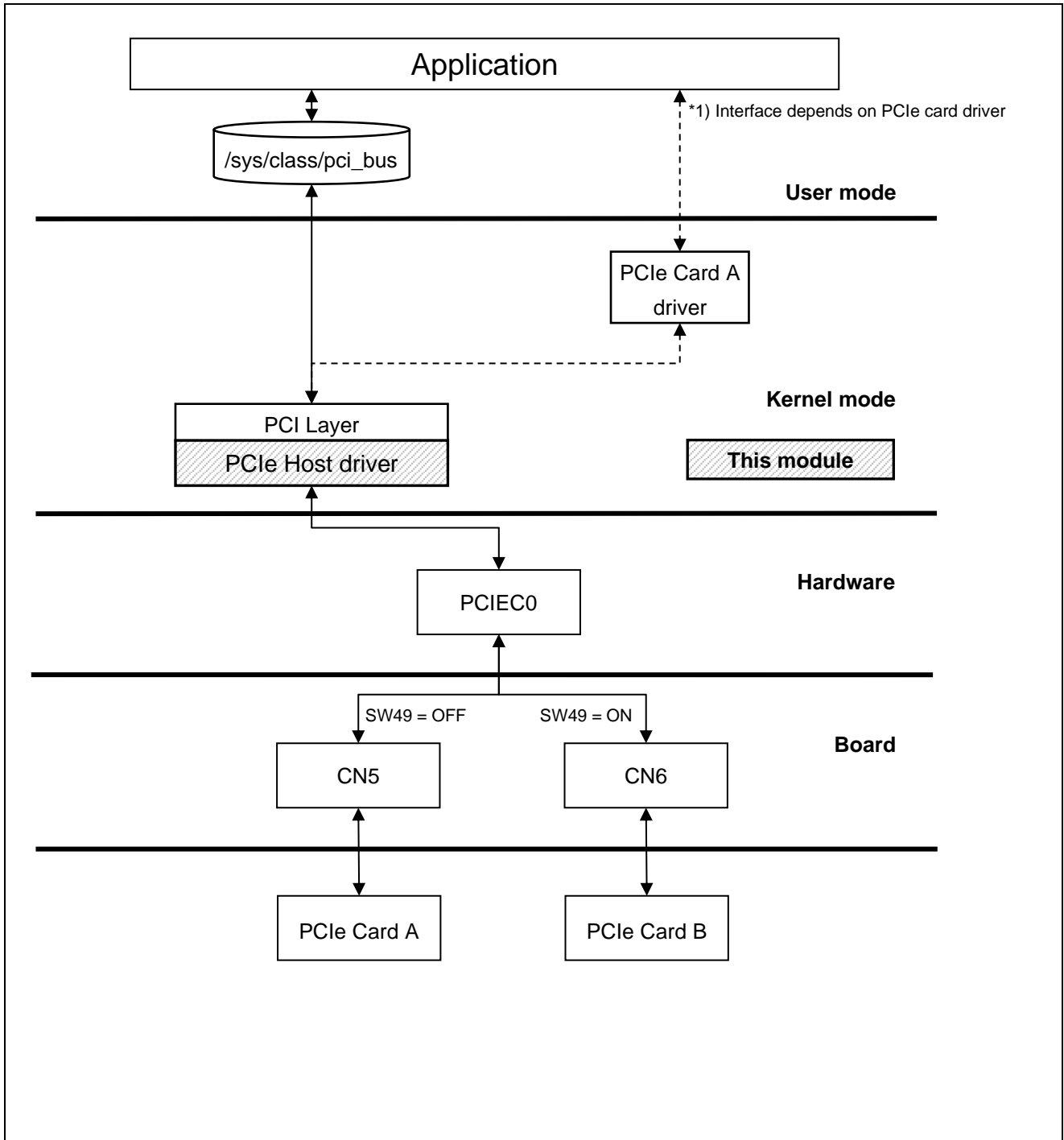
<b>Name</b>	<b>Version</b>	<b>Manufacture</b>
R-CarH3-SiP System Evaluation Board Salvator-X	-	Renesas Electronics
R-CarM3-SiP System Evaluation Board Salvator-X	-	Renesas Electronics
R-CarH3-SiP/M3-SiP/M3N-SiP System Evaluation Board Salvator-XS	-	Renesas Electronics
R-CarE3 System Evaluation Board Ebisu	-	Renesas Electronics
R-CarE3 System Evaluation Board Ebisu-4D	-	Renesas Electronics
R-CarV3H System Evaluation Board Condor-I	-	Renesas Electronics

## 3.2 Module Configuration

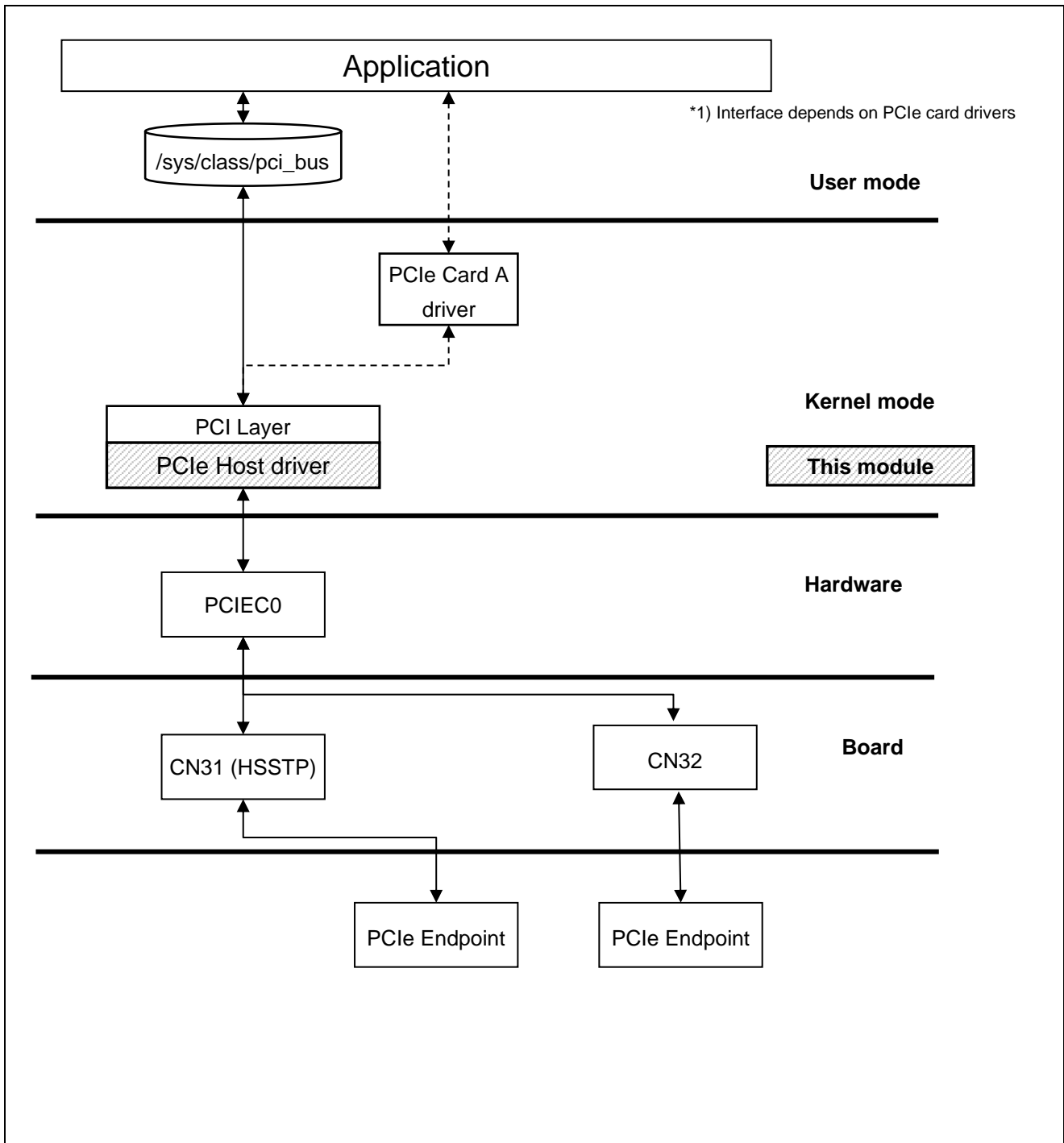
Figures 3.1, 3.2 and 3.3 illustrate the configuration of this module.



**Figure 3.1 Module configuration (R-Car H3/M3/M3N)**



**Figure 3.2 Module configuration (R-Car E3)**



**Figure 3.3 Module configuration (R-Car V3H)**

### 3.3 PCIe Operation

The PCIe standard describes a set of configuration registers that allow a Host controller to determine what devices are connected to the PCIe bus, and what resources they provide. This process is called bus enumeration. Bus enumeration is performed by attempting to read the Vendor and Device ID register for each combination of bus number and device number, at the device's function number 0. Each PCIe Endpoint implements one or more PCIe Functions. If a PCI-to-PCI bridge is found, the system must assign the secondary PCI bus beyond the bridge a bus number other than 0, and then enumerate the devices on that secondary bus.

For each Function, the Endpoint provides details of the IO and memory resources on the device that can be accessed. In addition, it provides information on the type of interrupts, INTx, MSI or MSI-X, that are supported.

The Linux PCI sub-system will assign local addresses within ranges provided by the PCIe host controller (e.g. PCIEC) driver. These are 'Windows' to the IO and memory on the card. For the R-Car H3/M3/M3N, table 3.2 details these windows.

**Table 3.2 Hardware Environment (R-Car H3/M3/M3N)**

R-Car H3/M3/M3N Local Address	Channel	PCIe access type
0xFE10 0000 to 0xFE1F FFFF (1 MB)	PCIE0	I/O
0xFE20 0000 to 0xFE3F FFFF (2 MB)	PCIE0	32-bit Mem (non prefetchable)
0x3000 0000 to 0x37FF FFFF (128 MB)	PCIE0	32-bit Mem (non prefetchable)
0x3800 0000 to 0x3FFF FFFF (128 MB)	PCIE0	32-bit Mem (prefetchable)
0xEE90 0000 to 0xEE9F FFFF (1 MB)	PCIE1	I/O
0xEEA0 0000 to 0xEEBF FFFF (2 MB)	PCIE1	32-bit Mem (non prefetchable)
0xC000 0000 to 0xC7FF FFFF (128 MB)	PCIE1	32-bit Mem (non prefetchable)
0xC800 0000 to 0xCFFF FFFF (128 MB)	PCIE1	32-bit Mem (prefetchable)

For the R-Car E3/V3H, table 3.3 details these windows.

**Table 3.3 Hardware Environment (R-Car E3/V3H)**

R-Car E3/V3H Local Address	Channel	PCIe access type
0xFE10 0000 to 0xFE1F FFFF (1 MB)	PCIE0	I/O
0xFE20 0000 to 0xFE3F FFFF (2 MB)	PCIE0	32-bit Mem (non prefetchable)
0x3000 0000 to 0x37FF FFFF (128 MB)	PCIE0	32-bit Mem (non prefetchable)
0x3800 0000 to 0x3FFF FFFF (128 MB)	PCIE0	32-bit Mem (prefetchable)

The PCI sub-system will read the unique PCI ID from any attached cards and use this to find the required PCI Card drivers. The PCI Card driver will then request INTx, MSI or MSI-X interrupts from the PCI sub-system.

Whilst the PCIEC hardware supports DMA, it is not normally used when configured as a PCIe Host. Since systems can potentially use many PCIe Endpoints at the same time, the DMA requirements depend on the Endpoints in use. For this reason, the Endpoints implement DMA if required. This use requires that Endpoints act as a Bus Masters, and as such the Host's memory must be accessible by the Endpoint. Typically, the Card driver running on the R-Car H3/M3/M3N/E3/V3H will allocate buffers in DDR and use PCI sub-system functions to obtain the PCI addresses of the buffers. These PCI address are written to registers on the card, and the card can then perform DMA. Note that the PCIEC driver provides a one to one mapping between the PCI addresses and the Local addresses.

## **4. External Interface**

The external interface of this module is based on Linux.

The PCI sub-system provides a number of controls that can be accessed via /sys/class/pci\_bus. Please see <https://www.kernel.org/doc/Documentation/filesystems/sysfs-pci.txt>.

## 5. Integration

### 5.1 Directory Configuration

The directory configuration of PCIe controller is shown in figure 5.1 below.

—— drivers/pci/controller	—— pcie-rcar.c	: PCIe Controller source file (*)
---------------------------	----------------	-----------------------------------

**Figure 5.1 Directory configuration of PCIe controller driver**

(\*) For Linux kernel v4.17 or older, the directory is “drivers/pci/host/pcie-rcar.c”.

In addition, there is PCIe PHY driver that is applicable to R-Car V3H only (figure 5.2).

—— drivers/phy/renesas	—— phy-rcar-gen3-pcie.c	: PCIe PHY source file
------------------------	-------------------------	------------------------

**Figure 5.2 Directory configuration of PCIe PHY driver**

## 5.2 Integration Procedure

### 5.2.1 Kernel Configuration

From Linux kernel v5.0 to v5.7, to enable the function of this module, make the following setting with kernel configuration shown in figure 5.3. This module is selected only built-in module.

<pre>Device Drivers ---&gt;   [*] PCI support     *- Message Signaled Interrupts (MSI and MSI-X)       PCI controller drivers ---&gt;         [*] Renesas R-Car PCIe controller</pre>
---

**Figure 5.3 Kernel configuration from Linux kernel v5.0 to v5.7 (R-Car H3/M3/M3N/E3/V3H)**

If R-Car V3H is used, one additional kernel configuration needs to selected as built-in as demonstrated in figure 5.4.

<pre>Device Drivers ---&gt;   PHY Subsystem ---&gt;     *- PHY Core       &lt;*&gt; Renesas R-Car generation 3 PCIe PHY driver</pre>
--

**Figure 5.4 Kernel configuration for PCIe PHY driver (R-Car V3H)**

For Linux kernel v4.20 or older, kernel configuration is illustrated in figure 5.5.

```
Bus support --->
[*] PCI support
--* Message Signaled Interrupts (MSI and MSI-X)
    PCI host controller drivers --->
    [*] Renesas R-Car PCIe controller
```

**Figure 5.5 Kernel configuration for Linux kernel v4.20 and older (R-Car H3/M3/M3N/E3)**

From Linux kernel v5.8 onwards, kernel configuration is illustrated in figure 5.6.

```
Device Drivers --->
[*] PCI support
--* Message Signaled Interrupts (MSI and MSI-X)
    PCI controller drivers --->
    [*] Renesas R-Car PCIe host controller
```

**Figure 5.6 Kernel configuration from Linux kernel v5.8 onwards (R-Car H3/M3/M3N/E3/V3H)**

On R-Car H3-SiP/M3N-SiP System Evaluation Board Salvator-X/XS, PCIE1 shares EXIO connector A (CN6) with SATA. Therefore, from Linux kernel v5.4 onwards, SATA should be disabled in device node before using PCIE1 to prevent the confliction. The following figure shows example on R-Car H3. It is similar for R-Car M3N.

```
arch/arm64/boot/dts/renesas/r8a77951-salvator-xs.dts

-           &pca9654 {
-               pcie_sata_switch {
-                   gpio-hog;
-                   gpios = <7 GPIO_ACTIVE_HIGH>;
-                   output-low; /* enable SATA by default */
-                   line-name = "PCIE/SATA switch";
-               };
-           };
...
-           /* SW12-7 must be set 'Off' (MD12 set to 1) which is not the default! */
-           &sata {
-               status = "okay";
-           };
-
```

**Figure 5.7 How to disable SATA device node**

Beside above setting SW12-7 must be set 'ON' (MD12 set to 0) to select PCIE1 PHY.

## 5.3 Option Setting

### 5.3.1 Module Parameters

There are no module parameters

### 5.3.2 Kernel Parameters

By adding the 'pci=noms' kernel parameter, e.g. by adding it to the U-Boot bootargs environment variable, the use of MSI can be disabled.



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REVISION HISTORY		Linux Interface Specification Device Driver PCIEC User's Manual: Software	
Rev.	Date	Description	
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0.1	Nov. 20, 2015	—	New version
0.2	Apr.15, 2016	All	Add R-Car M3 Support.
0.3	Aug. 5, 2016	2	Table 1.3 Related documents - H3 Document Update. - Add M3 Document.
0.4	Dec. 16, 2016	7	Correct the URL in Hyperlink.
0.5	Mar. 15, 2017	1	Table 1.1 Connected Port. - Add Note description for Salvator-XS board.
		2	Table 1.3 Related documents. - Add R-Car Series, 3rd Generation User's Manual: Hardware - Add R-CarH3-SiP/M3-SiP System Evaluation Board Salvator-XS Hardware Manual
		4	Table 3.1 Hardware Environment - Add R-CarH3-SiP/M3-SiP System Evaluation Board Salvator-XS
		8	5.2.1 Kernel Configuration - Add explanation that this module support build-in module only.
0.6	Jun 14 2017	2	Table 1.3 Related documents. - Update R-Car Series, 3rd Generation User's Manual: Hardware
1.00	Aug. 8, 2017	All	Update document format.
1.01	Oct. 24, 2017	All	Add R-Car M3N Support
1.50	Jan. 29, 2018	2	Update Related documents
1.51	Mar. 28, 2018	All	Add R-Car E3 Support
1.52	Oct. 22, 2018	2	Update Related documents
2.00	Dec. 25, 2018	2	Update Related documents
		4	Update Ebisu-4D in Hardware Environment
		-	Update Address List
2.01	Apr. 17, 2019	2	Update Related documents
		-	Update Address List
2.02	Jun. 24, 2020	2	Update Related documents
		9	Update Directory configuration Update Kernel configuration
		-	Update Address List
2.03	Dec. 1, 2020	1	Update Function support
2.04	Jan. 29, 2021	All	Add R-Car V3H support
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2.51	Aug. 16, 2021	11	Add guide to disable SATA for using PCIE1
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# Linux Interface Specification Device Driver PCIEC



Renesas Electronics Corporation