

Linux Interface Specification Device Driver PCIe

User's Manual: Software

RZ/V2N Group and RZ/G3E Group

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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. A basic knowledge of electric circuits, logical circuits, and MPUs is necessary in order to use this manual.

The manual comprises an overview of the product; descriptions of the CPU, system control functions, peripheral functions, and electrical characteristics; and usage notes.

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/V2N group and RZG3E 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/V2N Group User's Manual: Hardware	---
		RZ/G3E Group User's Manual: Hardware	---
User's manual for Software	Description of PCIe Linux interface Specification	Linux Interface Specification Device Driver PCIe	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
PCI	Peripheral Component Interconnect
PCIe	Peripheral Component Interconnect Express
MSI	Message Signaled Interrupt
EP	Endpoint
RC	Root Complex
BAR	Base Address Register

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1. Overview

1.1 Overview

This manual explains the driver module (this module) that controls the PCIe 3.0 Controller on RZ/V2N Group and RZ/G3E Group.

Note: Currently, the device can support the following Linux kernel version:

- v6.1: RZ/V2N Group, RZG3E Group.

1.2 Function

1.2.1 Root Complex

This module controls the PCIe Controller on RZ/V2N and RZ/G3E acting as a PCIe Host Controller. It allows PCIe Endpoint devices to be used with RZ/V2N and RZ/G3E. 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 reading and writing (bus mastering).
- MSI interrupts.

1.2.2 Endpoint

This module controls the PCIe Controller on RZ/G3E acting as a PCIe Endpoint Controller. It allows RZ/G3E be used as PCIe Endpoint device. The following functionality is supported:

- Configuration Base Address Register (BAR)
- Read/Write/Copy data.
- MSI Interrupt.

1.3 Connected Port

The supported connectors of this module are listed below.

Table 1-1 Connected Port (RZ/V2N EVK board)

Channel	Connected to	Support status	Remark
PCIE0	CN13	YES	

PCIE RC drivers can control the Endpoint device through 3 interfaces connectors on RZ/G3E SMARC.

Table 1-2 Connected Port (RZ/G3E SMARC board)

Channel	Connected to	Support status	Remark
PCIE0	PCI SLOT	YES	
PCIE0	M2 KEY-B	YES	
PCIE0	M2 KEY-E	NO	

1.4 Related Document

The data relevant to this module is as follows.

1.4.1 Standard

Table 1-3 Standard

Number	Issue	Title	Edition	Date
-	PCI-SIG	PCI Express Base Specification	Rev.3.0	Nov 10, 2010

1.4.2 Related document

There is no related document for this module.

1.5 Restrictions

This module only uses legacy memory area, because IPMMU is not implemented.

2. Terminology

The following table shows the terminology related to this module.

Table 2-1 Terminology

Terms	Explanation
MSI	Message Signaled Interrupt
PCI	Peripheral Component Interconnect
PCIe	PCI Express
RC	Root Complex
EP	Endpoint
BAR	Base Address Register

3. Operating Environment

3.1 Hardware Environment

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

Table 3-1 Hardware Environment

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

3.2 Module Configuration

The following figure shows the configuration of this module.

Root Complex Mode.

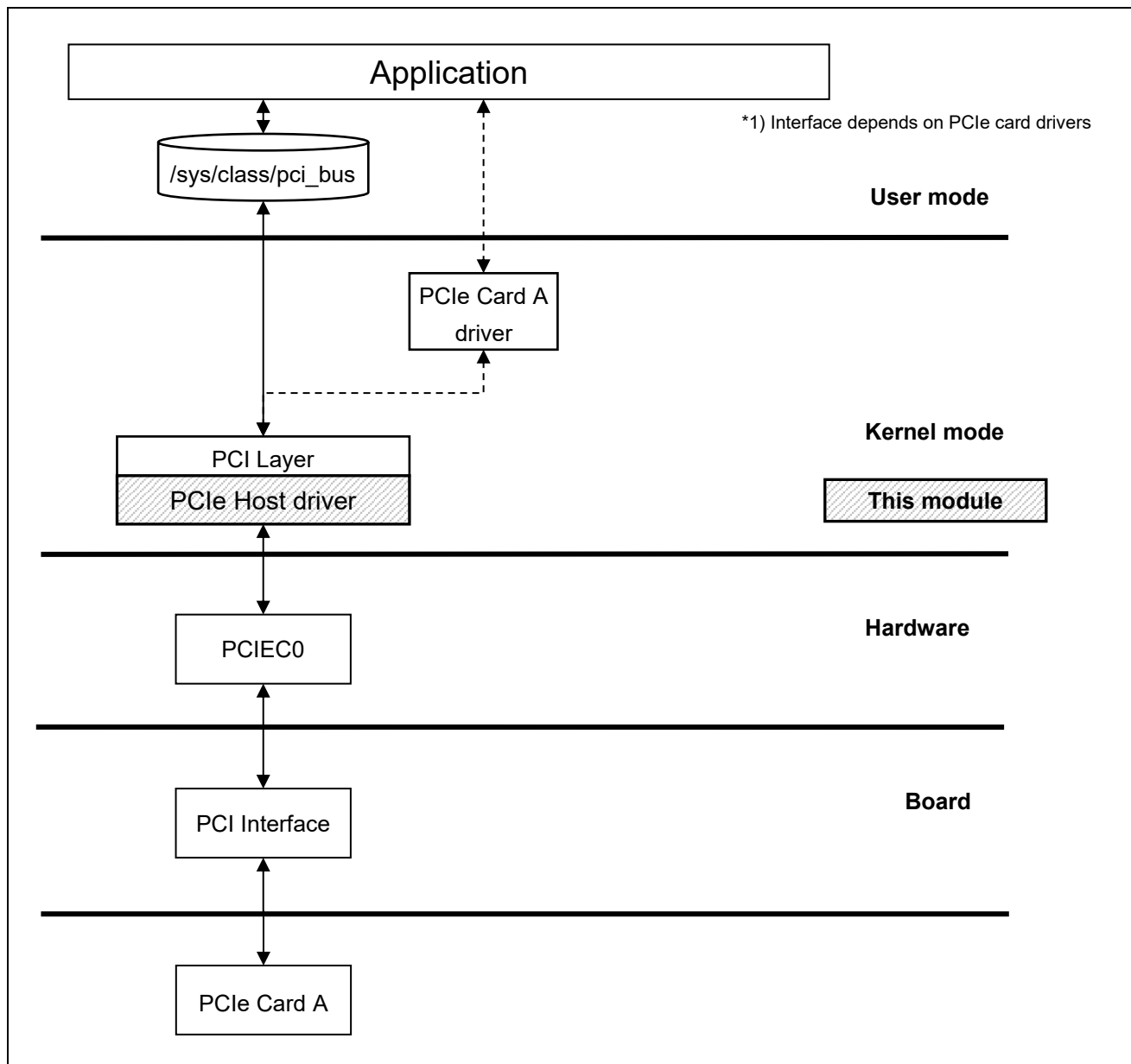
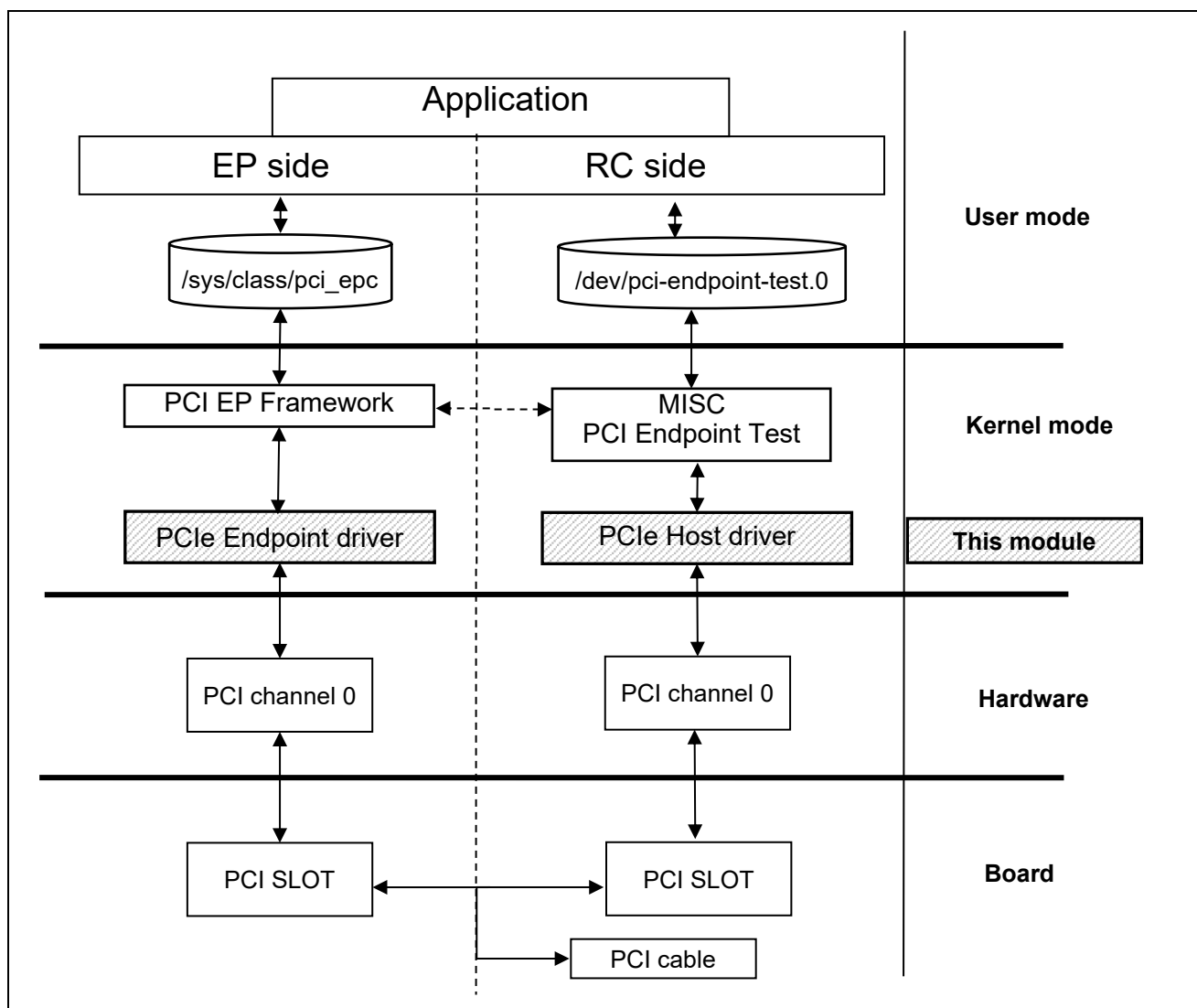


Figure 3-1 Module configuration (RZ/V2N EVK and RZ/G3E SMARC)

Endpoint Mode.**Figure 3-2 Module configuration (RZ/G3E SMARC)**

3.3 PCIe Address Map space

The Linux PCI sub-system will assign local addresses within ranges provided by the PCIe host controller (e.g. PCIEC) driver. The card can be access by “Window” memory. For the RZ/V2N and RZ/G3E, the following table details these windows.

Table 3-2 Hardware Environment (RZ/V2N)

RZ/V2N Local Address	Channel	PCIe access type
0x3000 0000 to 0x37FF FFFF	PCIE0	32-bit Memory

Table 3-3 Hardware Environment (RZ/G3E)

RZ/G3E Local Address	Channel	PCIe access type
0x0_3000_0000 to 0x0_37FF_FFFF	PCIE0	32-bit Memory
0x4_4000_0000 to 0xA_4000_0000	PCIE0	64-bit Memory

3.4 Device ID (Root Complex - Endpoint)

The PCI device ID, vendor ID for RZ/V2N Group and RZ/G3E Group:

Table 3-4 Hardware Configuration (RZ/G3E and RZ/V2N)

Board	Vendor ID	RC device ID	EP device ID
RZ/V2N	0x1912	0x003b	0x003a
RZ/G3E	0x1912	0x0039	0x0038

4. External Interface

4.1 Device access.

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>.

4.2 Definitions.

4.2.1 Device information in Device Tree

The PCIe RC device properties are shown below.

```
pcie0: pcie@13400000 {
    compatible = "renesas,rzg3e-pcie";
    device_type = "pci";
    reg = <0 0x13400000 0 0x10000>;
    clocks = <&cpg CPG_MOD 0xc4>,
            <&cpg CPG_MOD 0xc5>;
    power-domains = <&cpg>;
    resets = <&cpg 0xb2>;
    ranges = <0x02000000 0x0 0x30000000 0x0 0x30000000 0x0 0x08000000>,
            <0x42000000 0x4 0x48000000 0x4 0x48000000 0x1 0x00000000>;
    dma-ranges = <0x42000000 0 0x48000000 0 0x48000000 0 0xf8000000>;
    interrupts = <GIC_SPI 796 IRQ_TYPE_LEVEL_HIGH>;
    #interrupt-cells = <1>;
    interrupt-map-mask = <0 0 0 0>;
    interrupt-map = <0 0 0 0 &gic GIC_SPI 796 IRQ_TYPE_LEVEL_HIGH>;
    bus-range = <0x0 0xff>;
    linux,pci-domain = <0x0>;
    #address-cells = <3>;
    #size-cells = <2>;
    pcie,channel = <0>;
    renesas,pcie-sys = <&sys>;
    status = "disabled";
};
```

Figure 4-1 Example PCIe channel 0 Root Complex (RZ/G3E SMARC)

Note: All the information in the above device tree example is used for RZ/G3E boards. For others, please use corresponding properties (compatible, clock, and reset) as below.

The PCIe device required properties:

compatible:

Must be set to "renesas,rzv2n-pcie" for R9A09G056 (RZ/V2N).

Must be set to "renesas,rzg3e-pcie" for R9A09G047 (RZ/G3E).

device_type:

Must be set to "pci"

reg:

Base address and length of the memory resource used by the PCIe CH0.

clocks:

slot 1:

The 1st cell is a node or label of CPG clock to be used.

The 2nd cell must be set to CPG_MOD.

The 3rd cell must be set to GPG_MOD clock index

slot 2:

The 1st cell is a node or label of CPG clock to be used.

The 2nd cell must be set to CPG_MOD.

The 3rd cell must be set to GPG_MOD clock index

reset:

The 1st cell is a node or label of CPG clock to be used.

The 2nd cell must be set to GPG_MOD reset index

Ranges: support 32 bit area and 64 bit area.

For RZ/G3E, must be set:

<0x02000000 0x0 0x30000000 0x0 0x30000000 0x0 0x08000000>,

<0x42000000 0x4 0x40000000 0x4 0x48000000 0x1 0x00000000>,

For RZ/V2N, must be set:

<0x02000000 0x0 0x30000000 0x0 0x30000000 0x0 0x08000000>,

dma-ranges: a single range for the inbound memory region.

For RZ/G3E, must be set: <0x42000000 0 0x48000000 0 0x48000000 0 0xF8000000>;

pcie,channel:

Must be set to "0" to choose channel 0 in probe.

interrupt:

interrupt for PCIE device

#interrupt-cells: must be 1.

interrupt-map: standard property used to define the mapping of the PCI interrupts to the GIC interrupts.

interrupt-map-mask: standard property that helps to define the interrupt mapping.

bus-range:

The PCI bus number range; as this is a single bus, the range should be specified as the same value twice.

renesas,pcie-sys:

For RZ/G3E only, must be set <&sys> to system control setting for PCI.

```
sys: system-controller@10430000 {
    compatible = "renesas,r9a09g047-sys", "syscon";
    reg = <0 0x10430000 0 0x10000>;
    clocks = <&cpg CPG_CORE R9A09G047_SYS_0_PCLK>;
    resets = <&cpg 48>;
    #renesas,sysc-signal-cells = <2>;
};
```

Figure 4-2 Example SYS node (RZ/G3E SMARC)

The PCIe EP device properties are shown below, currently only supported for RZ/G3E Group

```
pcie0_ep: pcie-ep@13400000 {
    compatible = "renesas,rzg3e-pcie-ep";
    reg = <0x0 0x13400000 0x0 0x10000>,
        <0x0 0x30000000 0x0 0x04000000>,
        <0x0 0x34000000 0x0 0x04000000>;
    reg-names = "apb-base", "memory0", "memory1";
    interrupts = <GIC_SPI 791 IRQ_TYPE_LEVEL_HIGH>;
    clocks = <&cpg CPG_MOD 0xc4>,
        <&cpg CPG_MOD 0xc5>;
    power-domains = <&cpg>;
    resets = <&cpg 0xb2>;
    pcie,channel = <0>;
    renesas,pcie-sys = <&sys>;
    status = "disabled";
};
```

Figure 4-3 Example PCIe channel 0 Endpoint (RZ/G3E SMARC)

Note: All the information in the above device tree example is used for RZ/G3E boards. For others, please use corresponding properties as below.

compatible:

Must be set to "renesas,rzg3e-pcie-ep" for R9A09G047 (RZ/G3E).

reg:

For RZ/G3E, must be set to:

```
<0x0 0x13400000 0x0 0x10000>,
<0x0 0x30000000 0x0 0x04000000>,
<0x0 0x34000000 0x0 0x04000000>;
```

Other parameters, please set the same as RC.

Enable device in device-tree can be enable in file “**r9a09g056n44-evk.dts**” in directory “**arch/arm64/boot/dts/renesas/**”

The RZ/V2N PCIe device properties are shown below

```
&pcie0 {
    /* Map all possible DDR as inbound ranges */
    dma-ranges = <0x42000000 0 0x40000000 0 0x40000000 0x2 0x00000000>;
    status = "okay";
};
```

Figure 4-4 Example enable PCIe RC channel 0 (RZ/V2N EVK)

Enable device in device-tree can be enable in file “**rzg3e-smarc.dtsi**” in directory “**arch/arm64/boot/dts/renesas/**”

The RZ/G3E PCIe device properties are shown below

Note: Manual modify the PCI RC/EP mode by macro **SEL_PCIE_MODE**.

```
* SEL_PCIE_MODE:
* - 0: Root Complex (default)
* - 1: Endpoint
*/
#define SEL_PCIE_MODE 0
&pinctrl {
    pcie0_pins: pcie0 {
        pinmux = <RZV2H_PORT_PINMUX(G, 7, 1)>; /* PCIE_SLOT_RST */
    };
};

#if (!SEL_PCIE_MODE)
&pcie0 {
    status = "okay";
    pinctrl-0 = <&pcie0_pins>;
    pinctrl-names = "default";
};
#else
&pcie0_ep {
    status = "okay";
    pinctrl-0 = <&pcie0_pins>;
    pinctrl-names = "default";
};
#endif
```

Figure 4-5 Example enable PCIe RC and EP channel 0 (RZ/G3E SMARC)

5. Integration

5.1 Directory Configuration

The directory configuration is shown below.

—— drivers/pci/controller	—— pcie-rzv2h.h	: PCIe header file
	—— pcie-rzv2h-window.c	: PCIe common instruction support file
	—— pcie-rzv2h-host.c	: PCIe Host Controller source file
	—— pcie-rzv2h-ep.c	: PCIe Endpoint Controller source file

Figure 5-1 Directory configuration

5.2 Integration Procedure

5.2.1 Kernel Configuration

To enable the function of this module, make the following setting with Kernel Configuration. This module is selected only build-in module.

```
Device Drivers --->
  [*] PCI support
    PCI controller drivers --->
      <*> Renesas RZ/V2H Series PCIe controller
    [*] Message Signaled Interrupts (MSI)
```

Figure 5-2 Kernel configuration for RC (RZ/V2N and RZ/G3E)

```
Device Drivers --->
  [*] PCI support
    PCI controller drivers --->
      <*> Renesas RZ/V2H Series PCIe endpoint controller
    PCI Endpoint support --->
      [*] PCI Endpoint Configfs Support
      <*> PCI Endpoint Test driver
    Misc devices --->
      <*> PCI Endpoint Test driver
    [*] Message Signaled Interrupts (MSI)
```

Figure 5-3 Kernel configuration for EP (RZ/G3E)

```
CONFIG_RZV2H_PCIE=y
```

Figure 5-4 Kernel configuration symbol for RC

```
CONFIG_RZV2H_PCIE_EP=y
CONFIG_PCI_ENDPOINT=y
CONFIG_PCI_EPF_TEST=y
CONFIG_PCI_ENDPOINT_TEST=y
```

Figure 5-5 Kernel configuration symbol for EP

5.3 Option Setting

5.3.1 Module Parameters

There are no module parameters

5.3.2 Kernel Parameters

There are no kernel parameters

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