User's Manual

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Linux Interface Specification Device Driver Thermal Sensor

User's Manual: Software

R-Car H3/M3/M3N/E3/D3/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/D3/V3H processor.

- **[Purpose]**
  This manual is intended to give users an understanding of the functions of the R-Car H3/M3/M3N/E3/D3/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/D3/V3H
  → See the R-Car H3/M3/M3N/E3/D3/V3H User's Manual.
  — To know the electrical specifications of the multimedia processor for R-Car H3/M3/M3N/E3/D3/V3H
  → See the R-Car H3/M3/M3N/E3/D3/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 ... ××××, 0b××××, or ××××B
  Decimal ... ××××
  Hexadecimal ... 0x×××× or ××××H
  Data type: Double word ... 64 bits
  Word … 32 bits
  Half word ... 16 bits
  Byte ... 8 bits

Table of Contents

1. Overview

1.1 Overview

This manual explains the driver module (this module) that controls the Thermal Sensor Module on R-Car H3/M3/M3N/E3/D3/V3H.

1.2 Function

This module controls Thermal Sensor Controller on R-Car H3/M3/M3N/E3/D3/V3H. It supports the following functions:

(1) Get current temperature of SoC by accessing sysfs. The accuracy is about ± 2℃ if driver uses hardware chip characteristic parameters to calculate temperature. Otherwise, the accuracy is about ± 8-10℃.

(2) Halt the system when SoC temperature exceeds predefined threshold. About how to change the threshold, please refer to section 4.2.

1.3 Related Document

The following table shows the documents related to this module.

Table 1-1 Related document (R-Car H3/M3/M3N/E3/D3/V3H)

Number	Issue	Title	Edition	Date
-	Renesas Electronics	R-Car Series, 3rd Generation User's Manual: Hardware	Rev.2.20	Jul. 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-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
-	Renesas Electronics	R-CarD3 System Evaluation Board Hardware Manual RTP0RC77995SEB0010S	Rev.1.20	Jul. 25, 2017

1.4 Restriction

None

1.5 Notice

None.

2. Terminology

The following table shows terminology related to this module.

Table 2-1 Terminology

Terms	Explanation
THS	**Th**ermal **S**ensor.
TSC	**T**hermal **S**ensor **C**ontroller.
Thermal zone	Represents a region managed by thermal framework.

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/V3H)

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 R-CarE3 System Evaluation Board Ebisu-4D	-	Renesas Electronics
R-CarV3H System Evaluation Board Condor-I	-	Renesas Electronics
R-CarD3 System Evaluation Board Draak	-	Renesas Electronics

3.2 Software Configuration

The following figure shows the configuration of this module.

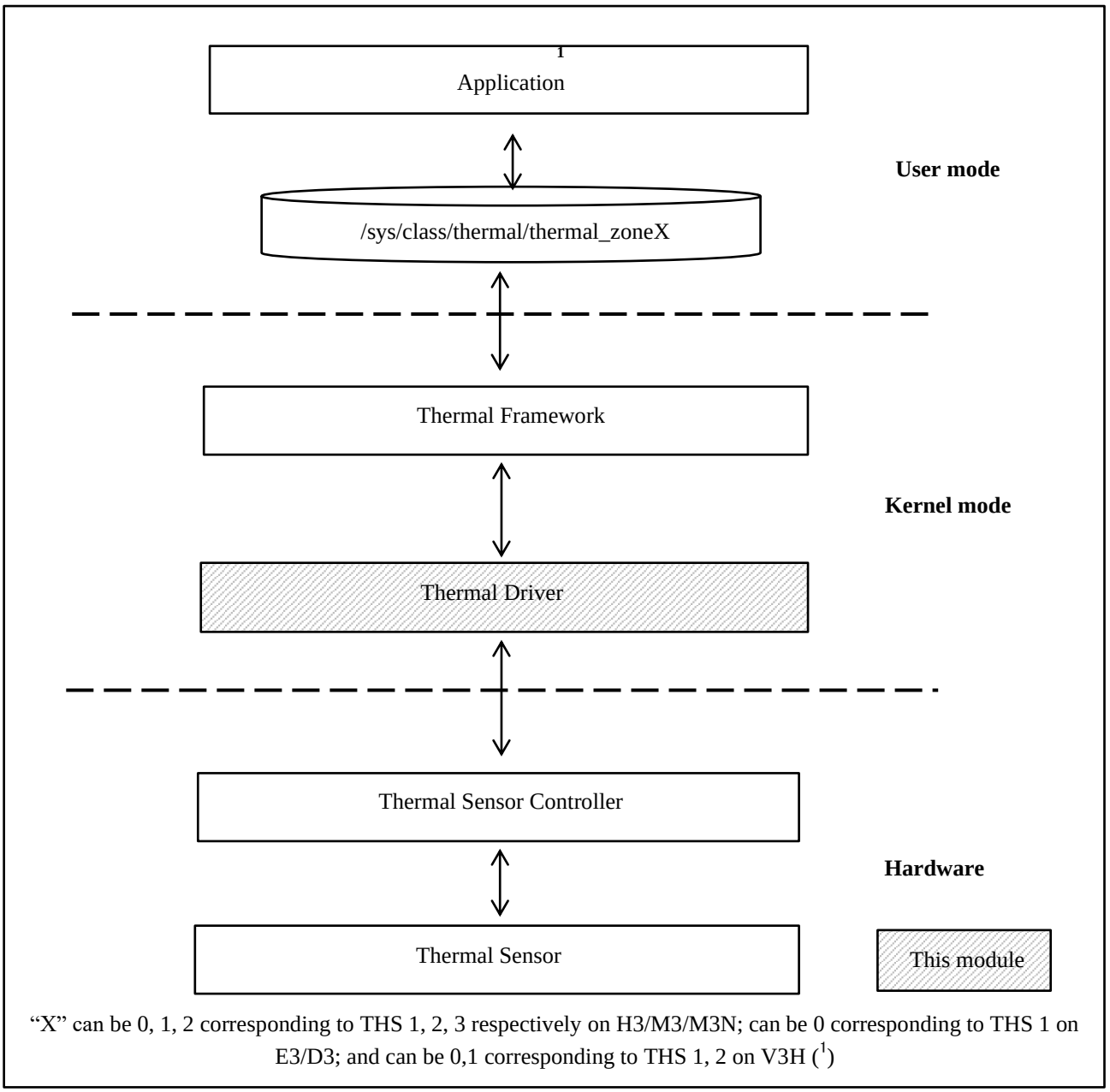

Figure 3-1 Module Configuration

[1] - On R-Car H3/M3/M3N, thermal module supports three channels (THS1/2/3) and three thermal zones. On R-Car E3/D3, thermal module supports only one channel (THS1) and one thermal zone. And on R-Car V3H, thermal module supports two channels (THS1,2) and two thermal zones.

The following figure shows the software flowchart of this module.

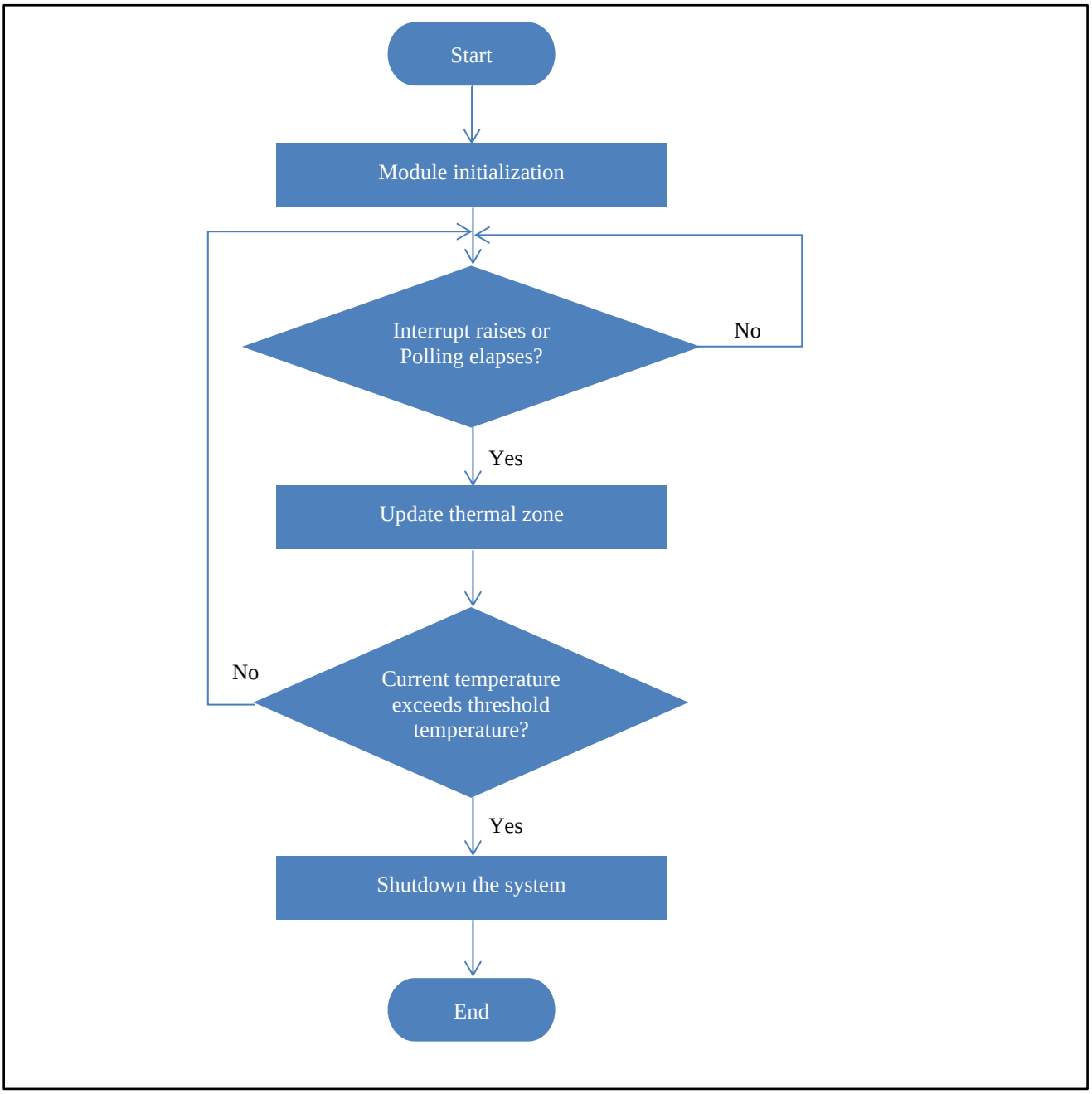

Figure 3-2 Thermal Sensor Software Flowchart

4. External Interface

4.1 Sysfs Interface

Thermal driver does not provide directly external interface for user application. Instead, with thermal user interface, application can get current temperature of this SoC and trip point information as described in the table below.

Table 4-1 System information of thermal sensor driver

Thermal Zone Interfaces	Notes
/sys/class/thermal/thermal_zoneX/temp	Current temperature of this SoC (millicelsius)
/sys/class/thermal/thermal_zoneX/trip_point_Y_type	Trip point type
/sys/class/thermal/thermal_zoneX/trip_point_Y_temp	Trip point temperature

Note:

- Thermal zones are registered by this thermal device driver to thermal framework.
- There are three thermal zones corresponding to three thermal channels. Thermal_zone0, thermal_zone1, thermal_zone2 will correspond to THS1, THS2, and THS3 respectively. ([1])
- There are some other nodes under thermal_zone, but they are not mentioned here.
- X, Y: depends on how many zone, trip point is defined.

4.2 Change Thermal Threshold

Thermal framework will halt the system when SoC temperature exceeds predefined threshold. Please modify device tree to define desired threshold temperature of corresponding thermal zone. Otherwise, it will be set to default value of 120000 (millicelsius).

It is able to apply different setting to each of three supported thermal zones ([1]). Below figure is an example of thermal zone 0 of R-Car H3.

```
thermal-zones {
      sensor_thermal1: sensor-thermal1 {
            polling-delay-passive = <250>;
            polling-delay = <0>;
            /* sensor ID */
            thermal-sensors = <&tsc 0>;
            sustainable-power = <6313>;

            trips {
                  sensor1_crit: sensor1-crit {
                        temperature = <120000>; <-- Change this value
                        hysteresis = <2000>;
                        type = "critical";
                  };
            };
      };
```

Figure 4-1 Device tree source file

4.3 Setting for Interrupt or Polling Mode

This setting is available on R-Car H3/M3/M3N/V3H which supports two modes - polling and interrupt. On R-Car E3/D3, only one interrupt mode is supported so please skip this section.

By default, the driver will use interrupt mechanism to update temperature of thermal zone. Please modify device tree to use polling if desire.

It is able to apply different selection to each of three supported thermal zones ([1]). Below figure is an example of thermal zone 0 of R-Car H3.

```
thermal-zones {
      sensor_thermal1: sensor-thermal1 {
             polling-delay-passive = <250>;
             polling-delay = <0>;              <-- Change this value to any number bigger
              /* sensor ID */                  than 0 to use polling mode
             thermal-sensors = <&tsc 0>;
             sustainable-power = <6313>;


             trips {
                    sensor1_crit: sensor1-crit {
                           temperature = <120000>;
                           hysteresis = <2000>;
                           type = "critical";
                    };
             };
      };
```

Figure 4-2 Configuration Example for Polling Support

(*) Polling-delay is the maximum number of milliseconds to wait between polls when checking whether trip points have been crossed.

5. Integration

5.1 Directory Configuration

The Thermal driver software directory configuration is shown below.

```
arch/arm64/boot/dts/renesas/
      ├── r8a7795.dtsi
      ├── r8a77965.dtsi
      ├── r8a7796.dtsi
      ├── r8a77990.dtsi
      ├── r8a77980.dtsi
drivers/thermal/
      ├── rcar_gen3_thermal.c  :R-Car H3/M3/M3N/V3H thermal driver source code.
      ├── rcar_thermal.c      :R-Car E3/D3 thermal driver source code.
```

Figure 5-1 Directory Configuration

5.2 Integration Procedure

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

```
Device Drivers --->
       --- Generic Thermal sysfs driver
       [ ]   Thermal state transition statistics
       (0)   Emergency poweroff delay in milli-seconds
       [*]   Expose thermal sensors as hwmon device
       [*]   APIs to parse thermal data out of device tree
       [ ]   Enable writable trip points
             Default Thermal governor (step_wise)  --->
       [ ]   Fair-share thermal governor
       -*-   Step_wise thermal governor
       [ ]   Bang Bang thermal governor
       [ ]   User_space thermal governor
       [*]   Power allocator thermal governor
       [*]   Generic cpu cooling support
       [ ]   Generic clock cooling support
       [ ]   Generic device cooling support
       [*]   Thermal emulation mode support
       < >   Generic Thermal MMIO driver
       < >   Hisilicon thermal driver
       < >   Temperature sensor driver for Freescale i.MX SoCs
       < >   Temperature sensor driver for Maxim MAX77620 PMIC
       < >   QorIQ Thermal Monitoring Unit
       < >   Rockchip thermal driver
       <*>   Renesas R-Car thermal driver
       <*>   Renesas R-Car Gen3 thermal driver
       < >   Marvell EBU Armada SoCs thermal management
       < >   Temperature sensor driver for mediatek SoCs
       ...
```

Figure 5-2 Kernel Configuration

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 Thermal Sensor User's Manual: Software

Rev.	Date	Description	
		Page	Summary
0.1	Nov. 20, 2015	—	New creation.
0.2	Mar. 18, 2016	1	- Add restriction for interrupt mode. - Add temperature range to function description.
		6	- Change Thermal threshold. - Clarify the description for changing thermal threshold.
		7	- Default mode for Thermal sensor driver is changed from Polling to Interrupt. - Clarify the description for Interrupt/Polling mode switching.
		8	- New directory structure of Thermal sensor driver for R-Car H3. - Update Figure 5-2 Kernel Configuration.
0.3	Apr. 15, 2016	All	- Add R-Car M3 support. - Improve paragraph description.
		8	- Add new device tree source file for R-Car M3.
0.4	Aug. 12, 2016	1	- Remove restriction for interrupt mode. - Update R-Car Series, 3rd Generation User's Manual: Hardware to Rev 0.52.
		6	- Add "sustainable-power" property in sample thermal configuration.
		7	- Add "sustainable-power" property in sample thermal configuration in device tree.
		8	- Update Figure 5-2 Kernel Configuration.
0.5	Dec. 16, 2016	3	- Table 3-1: Add hardware specification for M3.
		8	- Figure 5-1: Add r8a7795-es1.dtsi: H3 ES1.x device file
		8	- Figure 5-2: Update kernel configuration.
0.6	Mar. 15, 2017	1	- Table 1-1. Add R-Car Series, 3rd Generation LSI hardware manual Rev0.53 and R-CarH3-SiP/M3-SiP System Evaluation Board Salvator-XS Hardware Manual Rev2.00.
		3	- Table 3-1. Add R-CarH3-SiP/M3-SiP System Evaluation Board Salvator-XS
		8	- Figure 5-1: Use 'WS' instead of 'ES' in file name description.
0.7	Jun. 14, 2017	1	- Table 1-1: Change HWM version from "Rev.0.53 Dec.31,2016" to "Rev.0.54 Apr.14, 2017."
		8	- Figure 5-1: Change H3 WS1.1 to H3 Ver.1.1 and H3 WS2.0 to H3 Ver.2.0.
1.00	Aug. 8, 2017	All	-Update document format
1.01	Oct. 24, 2017	All	- Add support for M3N (change M3 to M3/M3N.)
		8	- Figure 5-1: Add file directory for M3N.
1.50	Jan. 29, 2018	All	Notice: use version 2017
		All	Address list: use version 2018
		1	Table 1-1: Remove reference "R-Car Series, 3rd Generation User's Manual: Hardware - Rev.0.51".
		6-7	- Figure 4-1, Figure 4-2: Change: "thermal-sensors = <&tsc1>;" -> to "thermal-sensors = <&tsc 0>;"
1.51	Mar. 28, 2018	All	- Add support for R-Car E3 in description.
		1	- Table 1-1: Add "R-CarE3 System Evaluation Board Ebisu Hardware Manual RTP0RC77990SEB0010S"
		3	- Table 3-1: Add "R-CarE3 System Evaluation Board Ebisu"
		4	- Add footnote 1: "- On R-Car H3/M3/M3N, thermal module supports three channels (THS1/2/3) and three thermal zones. And on R-Car E3, thermal module supports only one channel (THS1) and one thermal zone." - Figure 3-1: Revise " "X" can be 0, 1, 2 corresponding to THS 1, 2, 3 respectively on H3/M3/M3N; and can be 0 corresponding to THS 1 on E3. (1)"
		6-7	- Add reference to footnote 1 in description of Chapter 4.1, 4.2, 4.3.
		8	- Figure 5-1: Add support for r8a77990 and update the format of description.
1.52	Jun. 27, 2018		- Change Gen3 to R-Car Series, 3rd Generation
1.53	Sep. 26, 2018	1	Table 1-1: Change version of R-Car Series, 3rd Generation User's Manual: Hardware from Rev.0.80 : Oct. 31, 2017 to Rev.1.00 : Apr. 30, 2018

2.00	Dec. 25, 2018	-	- Update AddressList
		1	- Table 1-3: Change Salvator-XS board information as: ・R-CarH3-SiP/M3-SiP/M3N-SiP System Evaluation Board Salvator-XS Hardware Manual ・Rev.2.04 ・Jul. 17, 2018 ・R-CarH3-SiP System Evaluation Board Salvator-X Hardware Manual RTP0RC7795SIPB0011S ・Rev.1.09 ・May. 11, 2017 R-CarM3-SiP System Evaluation Board Salvator-X Hardware Manual RTP0RC7796SIPB0011S ・Rev.0.04 ・Oct. 3, 2016 R-CarE3 System Evaluation Board Ebisu Hardware Manual RTP0RC77990SEB0010S ・Rev.0.03 ・Apr. 11, 2018
		3	- Table 3-1: + Change Salvator-XS board name as “R-CarH3-SiP/M3-SiP/M3N-SiP System Evaluation Board Salvator-XS” + Append Ebisu-4D board to Ebisu board type as below: R-CarE3 System Evaluation Board Ebisu R-CarE3 System Evaluation Board Ebisu-4D
2.01	Apr. 17, 2019	2	- Update Related documents
		-	- Update Address List
2.02	Jun. 24, 2020	1	Update Related documents + Change revision of R-Car Series, 3rd Generation HWM from ‘Rev.1.50’ to ‘Rev.2.00’
		-	Update Address List
		7	4.3 Setting for Interrupt or Polling Mode + This setting is available for H3/M3/M3N only
		8	5. Integration + Add SW directory for R-Car E3 source code + Update kernel configuration for R-Car thermal driver support
2.03	Jan. 29, 2021	All	- Add R-Car V3H v2.0 support.
2.50	Apr. 21, 2021	-	- Add R-Car D3 support.
		-	- Add Kernel v5.10 support.
3.00	Dec. 10, 2021	-	- Add Kernel v5.10.41 support.

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Linux Interface Specification
Device Driver Thermal Sensor

Renesas Electronics Corporation