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 $\pm$ 2℃ if driver uses hardware chip characteristic parameters to calculate temperature. Otherwise, the accuracy is about $\pm$ 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
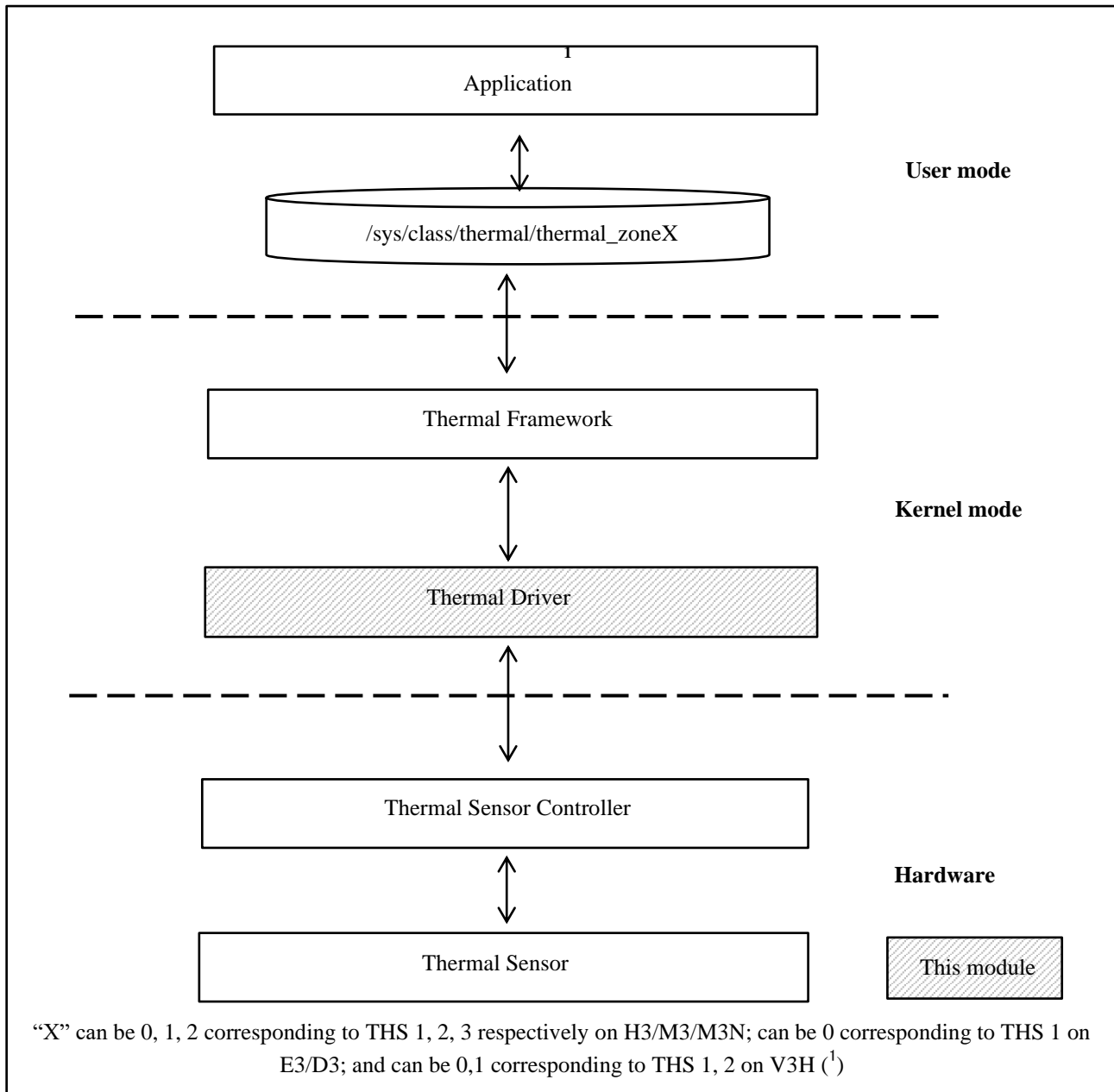
The following figure shows the configuration of this module.

Figure 3-1 Module Configuration

The following figure shows the software flowchart of this module.
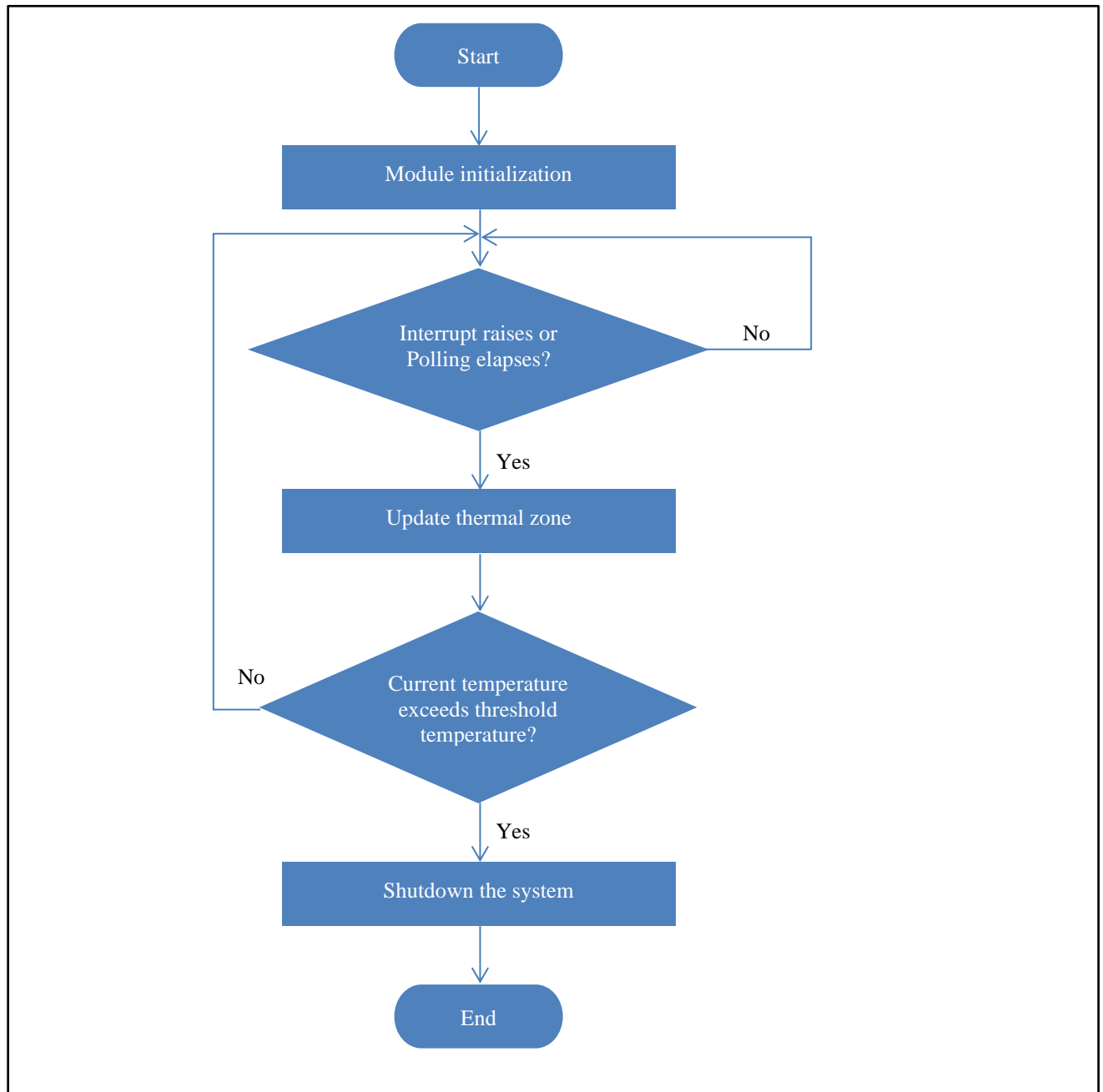

Figure 3-2 Thermal Sensor Software Flowchart

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.