RENESAS TECHNICAL UPDATE

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<tr><td>Product Category</td><td colspan="2">MPU/MCU</td><td>Document No.</td><td>TN-SY*-A028A/E</td><td>Rev.</td><td>1.00</td></tr>
<tr><td>Title</td><td colspan="2">Additional information to the Temperature Sensor (TSN) of S5D9 and S5D5</td><td>Information Category</td><td colspan="3">Technical Notification</td></tr>
<tr><td rowspan="2">Applicable Product</td><td rowspan="2">Renesas Synergy™ S5D9 and S5D5 MCU Groups</td><td>Lot No.</td><td rowspan="2">Reference Document</td><td colspan="3" rowspan="2">S5D9 User's Manual Rev.1.00,
S5D5 User's Manual Rev.1.10</td></tr>
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Renesas added additional information to the Temperature Sensor chapters of the S5D9 and S5D5 User's Manuals.

1. Overview

[Before]

Table 1. Temperature sensor specifications

Parameter	Specifications
Temperature sensor voltage output	Temperature sensor outputs a voltage to the 12-Bit A/D Converter (ADC12)
Module-stop function	Module-stop state can be set to reduce power consumption

[After]

Table 1. Temperature sensor specifications

Parameter	Specifications
Temperature sensor voltage output	Temperature sensor outputs a voltage to the 12-Bit A/D Converter (ADC12)
Module-stop function	Module-stop state can be set to reduce power consumption
Temperature Sensor Calibration Data	Reference data measured for each chip at factory shipment is stored

2. Register Descriptions

[Before]

No register description for Temperature Sensor Calibration Data Register (TSCR)

[After]

Temperature Sensor Calibration Data Register (TSCDR)

Addresses: TSN.TSCDR 407F B17Ch

	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Value after reset:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
	—	—	—	—												
Value after reset:	0	0	0	0	Unique value for each chip											

The TSCDR register stores temperature sensor calibration data measured for each MCU at factory shipment.

Temperature sensor calibration data is a digital value obtained using the 12-bit A/D converter unit 0 to convert the voltage output by the temperature sensor under the condition Ta = Tj = 127°C and AVCC0 = 3.3 V.

The TSCDR register is a 32-bit read-only register and should be read in 32-bit units.

3. Preparation for Using the Temperature Sensor

[Before]

The temperature (T) is proportional to the sensor voltage output (Vs), so temperature is calculated with the following formula:

T = (Vs – V1)/slope + T1

T: Measured temperature (°C)

Vs: Voltage output by the temperature sensor when temperature is measured (V)

T1: Temperature experimentally measured at one point (°C)

V1: Voltage output by the temperature sensor when T1 is measured (V)

T2: Temperature at the experimental measurement of another point (°C)

V2: Voltage output by the temperature sensor when T2 is measured (V)

Slope: Temperature gradient of the temperature sensor (V/°C); slope = (V2 – V1)/(T2 – T1)

Determine the values for formula parameters (V1, T1, slope) measurement. These values vary from sensor to sensor, and Renesas recommends making the following experimental measurement at two different temperatures to determine the values for these parameters:

1. Use the ADC12 to measure the voltage V1 output by the temperature sensor at temperature T1.
2. Use the ADC12 to measure the voltage V2 output by the temperature sensor at a different temperature T2. Obtain the temperature gradient (slope = (V2 – V1)/(T2 – T1)) from these results.
3. Obtain subsequent temperatures by substituting the slope into the formula for the temperature characteristic (T = (Vs – V1)/slope + T1).

(S5D9) If the temperature gradient given in section 60, Electrical Characteristics is used as the slope value, only one experimental measurement is required to determine V1 and T1. However, this method gives less accurate temperature results than those obtained using the method described for measurement at two points.

(S5D5) If the temperature gradient given in section 55, Electrical Characteristics is used as the slope value, only one experimental measurement is required to determine V1 and T1. However, this method gives less accurate temperature results than those obtained using the method described for measurement at two points.

[After]

The temperature (T) is proportional to the sensor voltage output (Vs), so temperature is calculated with the following formula:

T = (Vs – V1)/slope + T1

T: Measured temperature (°C)

Vs: Voltage output by the temperature sensor when temperature is measured (V)

T1: Temperature experimentally measured at one point (°C)

V1: Voltage output by the temperature sensor when T1 is measured (V)

T2: Temperature at the experimental measurement of another point (°C)

V2: Voltage output by the temperature sensor when T2 is measured (V)

Slope: Temperature gradient of the temperature sensor (V/°C); slope = (V2 – V1)/(T2 – T1)

Determine the values for formula parameters (V1, T1, slope) measurement. These values vary from sensor to sensor, and Renesas recommends making the following experimental measurement at two different temperatures to determine the values for these parameters:

1. Use the ADC12 to measure the voltage V1 output by the temperature sensor at temperature T1.
2. Use the ADC12 to measure the voltage V2 output by the temperature sensor at a different temperature T2. Obtain the temperature gradient (slope = (V2 – V1)/(T2 – T1)) from these results.
3. Obtain subsequent temperatures by substituting the slope into the formula for the temperature characteristic (T = (Vs – V1)/slope + T1).

(S5D9) If you are using the temperature slope given in Table 60.45 of section 60, Electrical Characteristics, use the 12-bit A/D converter unit 0 to measure the voltage V1 output by the temperature sensor at temperature T1, then calculate the temperature characteristic by using the following formula.

T = (Vs – V1)/Slope + T1

T: Measured temperature (°C)

Vs: Voltage output by the temperature sensor when the temperature is measured (V)

T1: Sample temperature measurement at first point (°C)

V1: Voltage output by the temperature sensor when T1 is measured (V)

Slope: Temperature slope given in Table 60.45 ÷ 1000 (V/°C)

In this MCU, the TSCDR register stores the temperature value (CAL127) of the temperature sensor measured under the condition Ta = Tj = 127°C and AVCC0 = 3.3 V. By using this value as the sample measurement result at the first point, preparation before using the temperature sensor can be omitted.

If V1 is calculated from CAL127,

V1 = 3.3 × CAL127/4096 [V]

Using this, the measured temperature can be calculated according to the following formula.

T = (Vs - V1)/Slope + 127 [°C]

T: Measured temperature (°C)

Vs: Voltage output by the temperature sensor when the temperature is measured (V)

V1: Voltage output by the temperature sensor when Ta = Tj = 127°C and AVCC0 = 3.3 V (V)

Slope: Temperature slope given in Table 60.45 ÷ 1000 (V/°C)

(S5D5) If you are using the temperature slope given in Table 55.40 of section 55, Electrical Characteristics, use the 12-bit A/D converter unit 0 to measure the voltage V1 output by the temperature sensor at temperature T1, then calculate the temperature characteristic by using the following formula.

T = (Vs – V1)/Slope + T1

T: Measured temperature (°C)

Vs: Voltage output by the temperature sensor when the temperature is measured (V)

T1: Sample temperature measurement at first point (°C)

V1: Voltage output by the temperature sensor when T1 is measured (V)

Slope: Temperature slope given in Table 55.40 ÷ 1000 (V/°C)

In this MCU, the TSCDR register stores the temperature value (CAL127) of the temperature sensor measured under the condition Ta = Tj = 127°C and AVCC0 = 3.3 V. By using this value as the sample measurement result at the first point, preparation before using the temperature sensor can be omitted.

If V1 is calculated from CAL127,

V1 = 3.3 × CAL127/4096 [V]

Using this, the measured temperature can be calculated according to the following formula.

T = (Vs - V1)/Slope + 127 [°C]

T: Measured temperature (°C)

Vs: Voltage output by the temperature sensor when the temperature is measured (V)

V1: Voltage output by the temperature sensor when Ta = Tj = 127°C and AVCC0 = 3.3 V (V)

Slope: Temperature slope given in Table 55.40 ÷ 1000 (V/°C)