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Estimating Peak Junction Temperature Using TMU Sensors

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Introduction

The Thermal Monitoring Unit (TMU) helps in measuring the junction temperature through sensors embedded in the silicon. There are multiple TMU sensors placed within the ADSP-2159x/ SC592/SC594 processor to report the maximum junction temperature. Although these sensors are strategically placed, they might not capture the peak junction temperature during high performance activity. Each area of the chip dissipates a different amount of heat due to the transistor switching across the chip. The heat depends on the type of activity running on the processor. For example, a SHARC+ core running a high activity application will generate more heat than surrounding areas. This activity causes a non-uniform thermal profile within the chip. The result is a difference between the actual peak junction temperature within the silicon and the sensor reading.

The TMU senses the maximum temperature automatically by reading all the sensors internally and reporting the temperature from the one with the highest value in the chip. This value can be used to estimate the peak junction temperature. The maximum temperature within the silicon can be read from the `TMU0_MAXTEMP.VALUE` bit field through data from multiple TMU sensors in the silicon die. The maximum temperature reading value sticks to the highest temperature (when enabled using the `TMU0_CTL.MAXEN` bit). AlertHi and FaultHi events can be generated for the maximum temperature (by enabling the `TMU0_CTL.EN_MAX_ALRTHI` and `TMU0_CTL.EN_MAX_FLTHI` bits) and the `TMU0_TEMP` register value.

TMU Calibration

TMU sensors in the silicon have gain and offset errors. Calibration settings are provided in the hardware reference manual[1]. The configuration is comprised of gain and offset settings for error correction of the corresponding TMU sensors. These settings are common for all the sensors in silicon.

The calibration setting ensures that the reported temperature approximates the actual die temperature at its location (within the accuracy specified in the data sheet [2]). The TMU Calibration Settings table in the hardware reference manual provides the calibration settings for the processor.

The accuracy given in the data sheet is with recommended gain and offset settings and TMU averaging enabled. Accuracy is not guaranteed for temperatures below room temperature.

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Estimating Peak Junction Temperature

The peak junction temperature can be estimated from the maximum temperature value by adding an additional **2.5°C**. This peak value can be used to estimate/accommodate precise system level thermal management, if needed.

The gain and offset settings are valid for the TMU sensor and maximum temperature sensors because they are independent of the peak junction temperature. This data is a known enhancement for improved thermal estimations.

Programming Sequence

The attached zip file [3] includes reference code to read the instantaneous max temperature value and the peak junction temperature in the silicon.

When enabled, the `TMU0_MAXTEMP.VALUE` is a sticky bit field that records the highest temperature. The instantaneous max temperature can also be read using the following sequence:

1. Set the `TMU0_CTL.MAXEN` bit.
2. Set the `TMU0_CTL.EN_MAX_ALRTHI` and `TMU0_CTL.EN_MAX_FLTHI` bits.
3. Clear the `TMU0_STAT.ALRTHI` bit.
4. Wait for 60K TMU clock cycles.
5. Read the `TMU0_MAXTEMP.VALUE` field.

Recommendations

Consider the following best practices:

- Use software averaging of around eight readings when reading the instantaneous max temperature value. This practice improves accuracy and eliminates false reading due to any noise in the reference voltage.
- Implement a filter circuit on the *VREF_P_ADC* and *VDD_A* pins as shown in Figure 1, the reference schematic of EV-SC594-SOM[4].

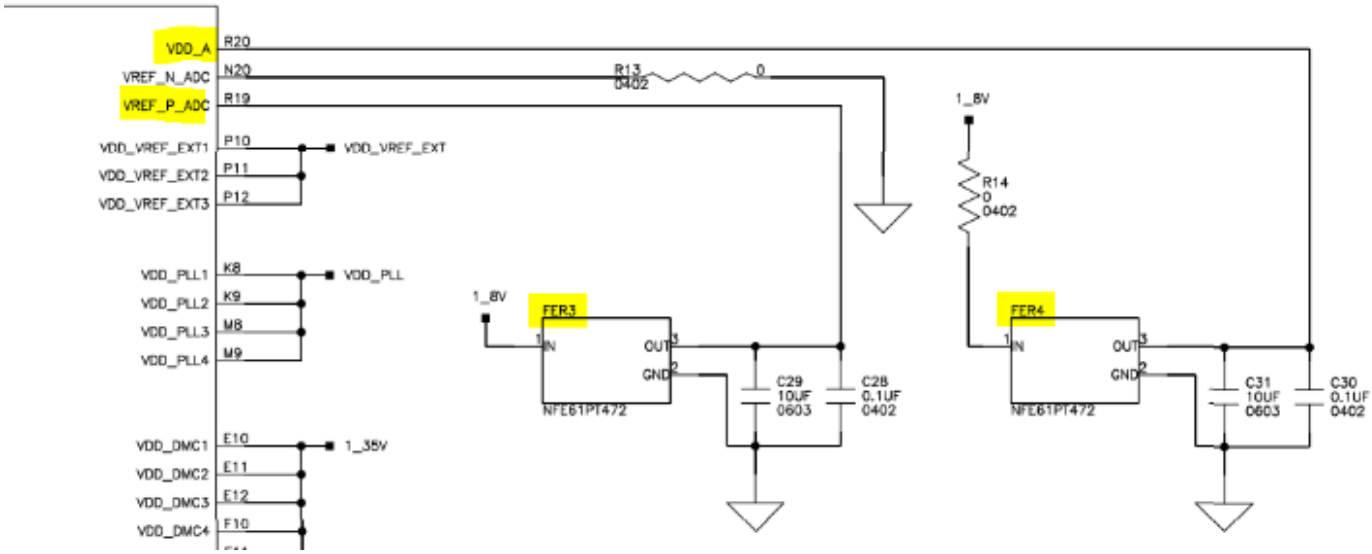

Figure 1:Reference Filter Circuit

References

[1] *ADSP-2159x /ADSP-SC592/594 SHARC+ Processor Hardware Reference. Rev 0.6, May 2023. Analog Devices, Inc.*

[2] *ADSP-21593/21594/ADSP-SC592/SC594 SHARC+ Dual Core DSP with Arm Cortex-A5 Data Sheet. Rev. E, March 2024. Analog Devices, Inc.*

[3] *Associated ZIP file (EE458v01.zip) for Estimation of Peak Junction Temperature Using TMU Sensors (EE-458).* March 2024. Analog Devices, Inc.

[4] *EV-SC594-SOM Schematic Rev. B, September 2020. Analog Devices, Inc.*

Document History

Revision	Description
Rev 1 – May 22, 2024 *by Manoj Chitneedi*	Initial Release