

How to Monitor Die Temperature

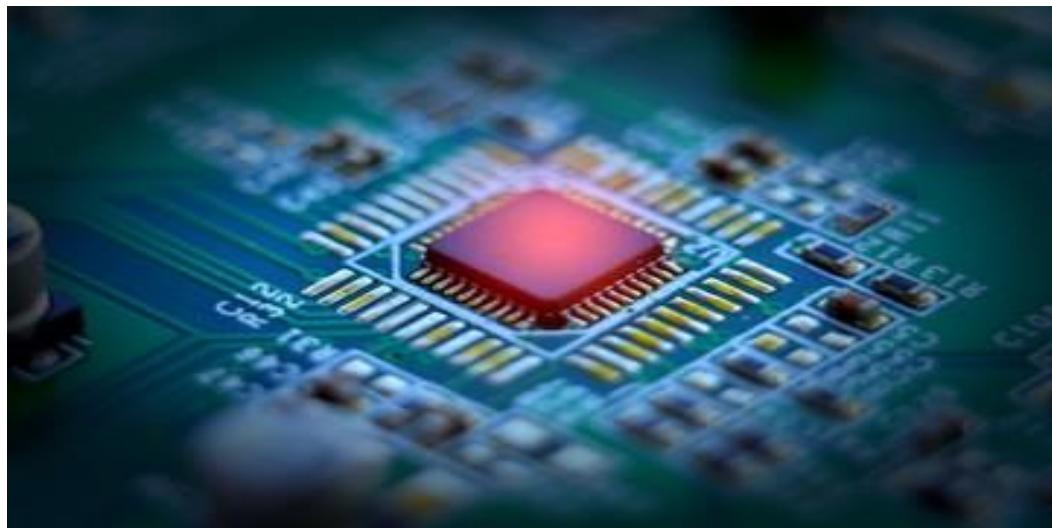
TI Precision Labs – Temperature Sensors

Presented by TJ Cartwright

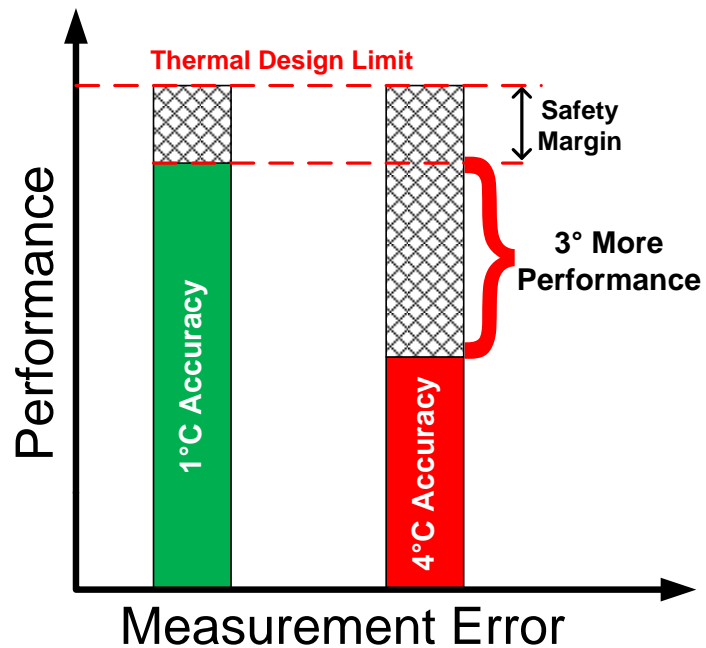
Prepared by David Vaseliou

Why Monitor Die Temperature?

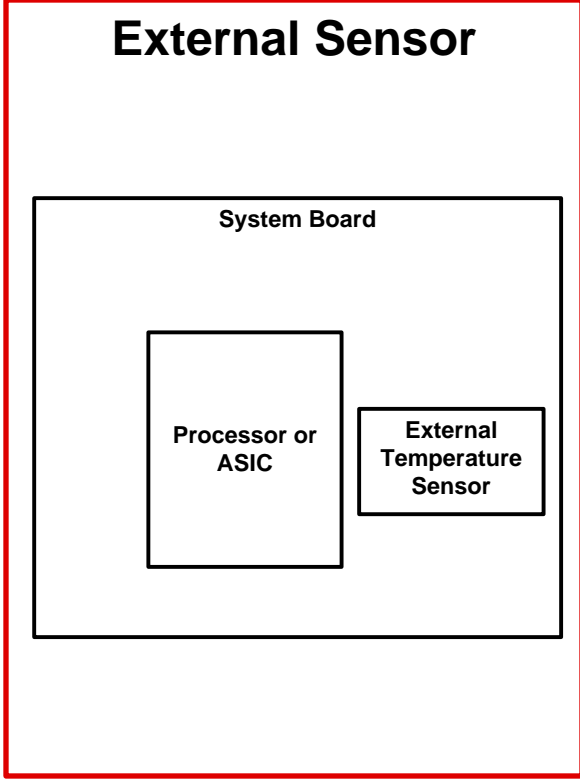
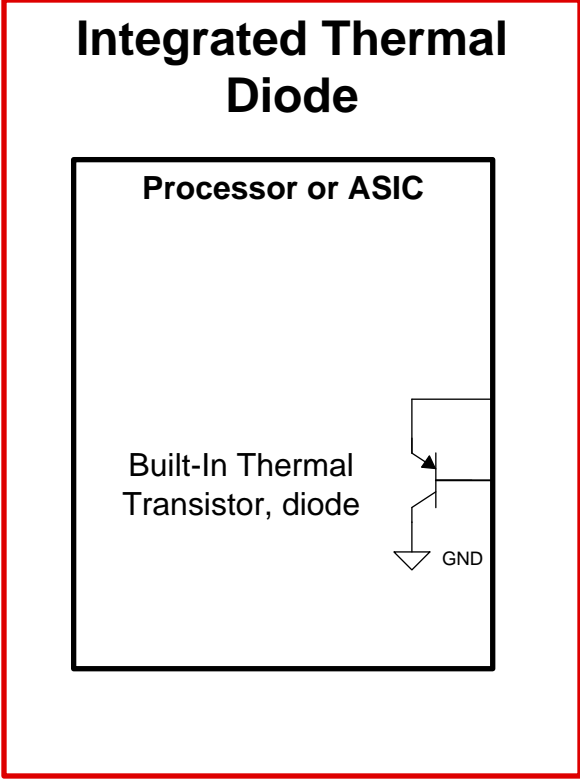
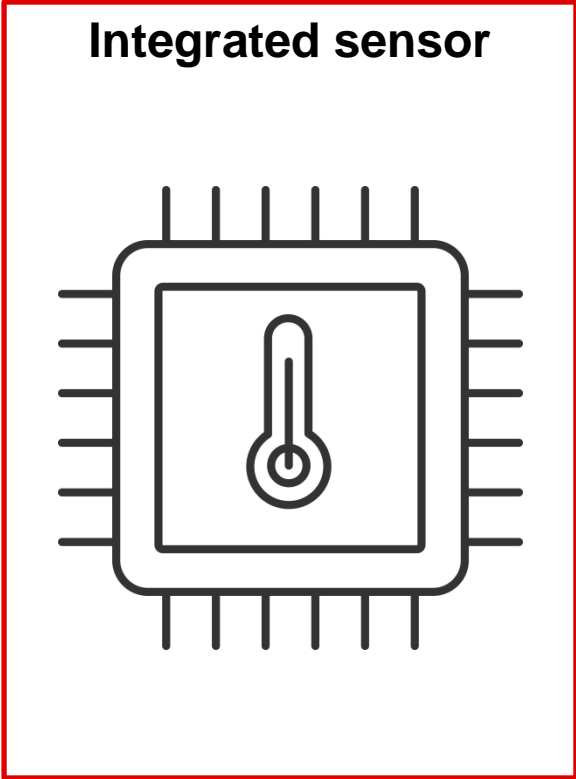
Protect Systems



Optimize Performance

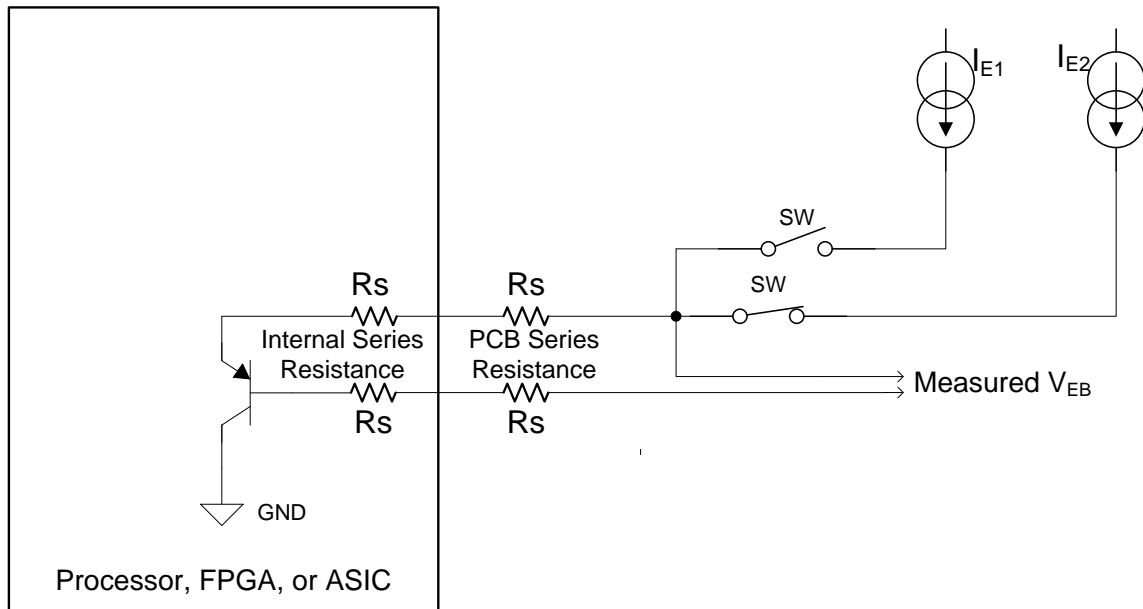


How to Monitor Die Temperature



Die Temperature Monitoring Integrated Thermal Diode

Integrated PNP Transistor-
connected Configuration



$$T = \frac{q \Delta V_{EB}}{\eta k \ln \frac{I_{C2}}{I_{C1}}}$$

If $\beta \gg \gg$ then $I_C \approx I_E$

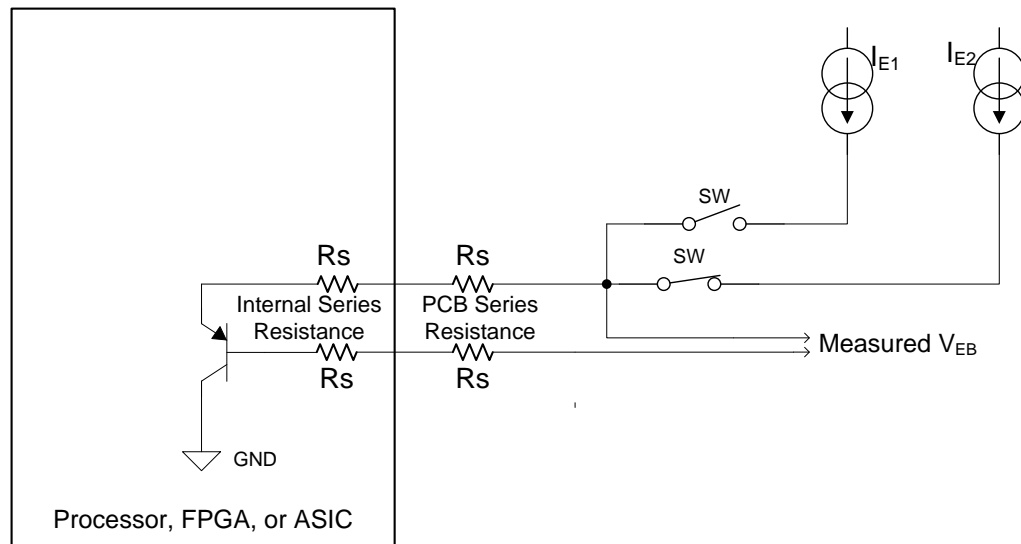
T = Temperature
 q = charge of electron
 V_{EB} = Emitter-Base Voltage
 η = ideality factor
 k = Boltzmann Constant
 I_C = Collector Current
 I_E = Emitter Current
 β = Gain of the transistor

Integrated Thermal Diode Sources of Error

Thermal Diode error sources:

- η -factor Variation
- β Variation
- Series Resistance
- Noise Injection

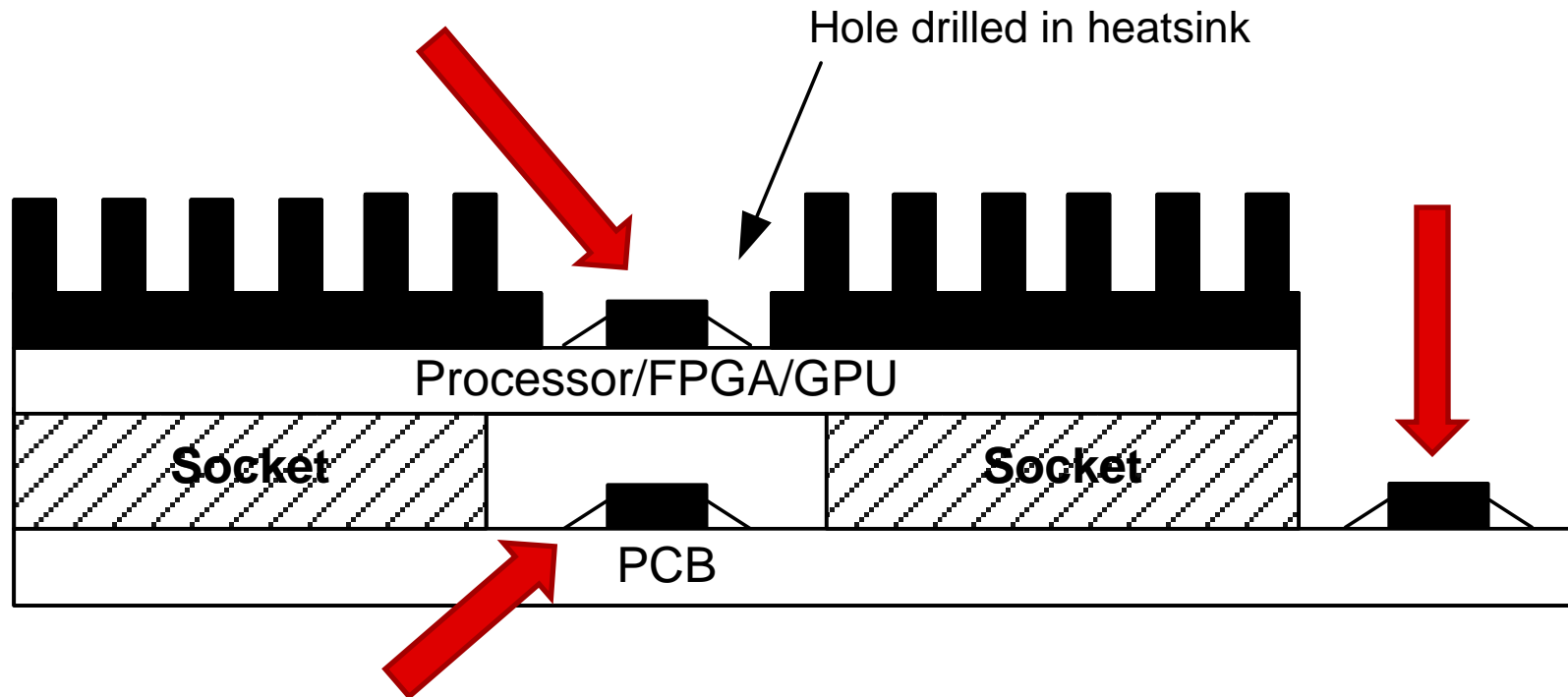
Integrated PNP Transistor-
connected Configuration



$$T = \frac{q\Delta V_{EB}}{\eta k \ln \frac{I_{C2}}{I_{C1}}}$$

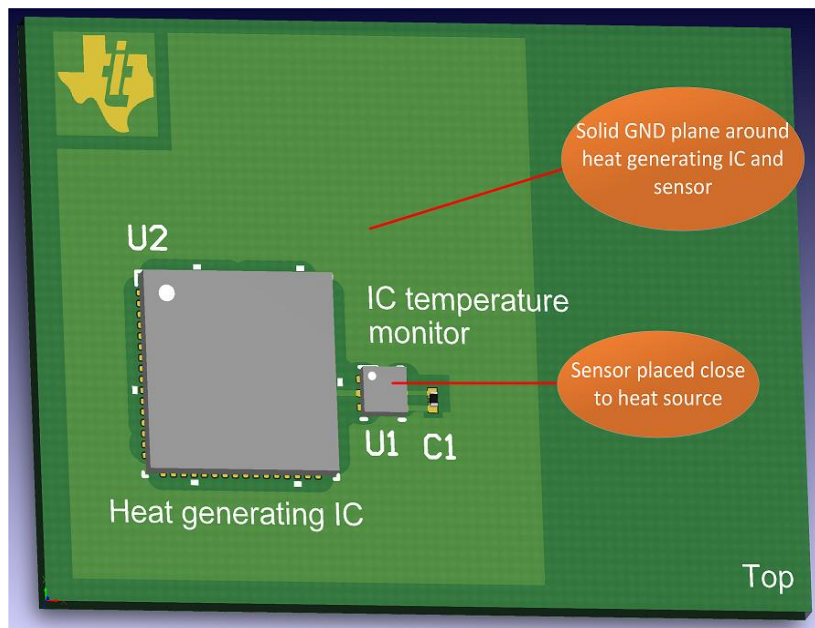
If $\beta \gg 1$ then $I_C \approx I_E$

Die Temperature Monitoring External Temperature Sensor

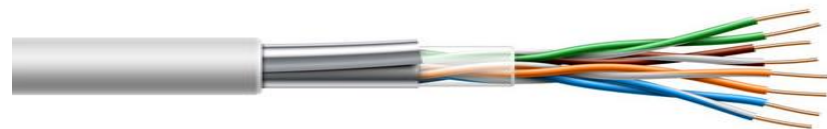
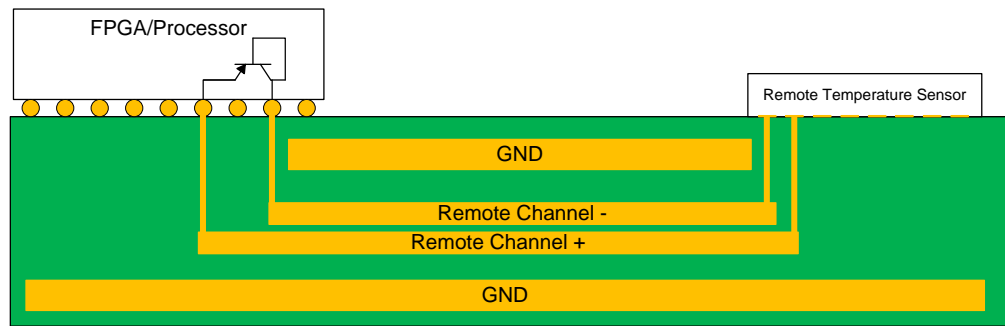


Die Temperature Monitoring Temperature Sensor Design Guidelines

External Temperature Sensor



Integrated Thermal Diode



Thank you!

To find more temperature sensor resources and products visit ti.com/temperature

How to Monitor Die Temperature

TI Precision Labs – Temperature Sensors

Quiz

How to Monitor Die Temperature – quiz

1. In which devices is die temperature monitoring important?
 - a) CPUs and GPUs
 - b) ASICs and CPUs
 - c) FPGAs and GPUs
 - d) All of the above

2. What is **not** a device used for measuring die temperature
 - a) Integrated thermal diodes
 - b) External temperature sensors
 - c) Thermal ferrite beads
 - d) Integrated temperature sensors

How to Monitor Die Temperature – quiz

3. What source of error is caused by PCB traces or cabling when using the integrated thermal diode method?
- a) Series resistance
 - b) Noise injection
 - c) η -factor variation
 - d) β variation
4. What source of error is trying to be avoided by using shielded twisted pair cables?
- a) Series resistance
 - b) Noise injection
 - c) η -factor variation
 - d) β variation

How to Monitor Die Temperature – quiz

5. What factor is not used by remote temperature sensors to calculate temperature?
- a) η -factor
 - b) Boltzmann constant
 - c) Power consumption of the remote junction
 - d) Base Emitter Voltage
6. What is an important design guideline when using an external temperature sensor?
- a) Differential pair routing
 - b) Shield twisted pair cabling
 - c) Sharing a solid ground plane
 - d) Both a and b

Answers

How to Monitor Die Temperature – quiz

1. In which devices is die temperature monitoring important?
 - a) CPUs and GPUs
 - b) ASICs and CPUs
 - c) FPGAs and GPUs
 - d) All of the above

2. What is **not** a method of measure die temperature
 - a) Integrated thermal diodes
 - b) External temperature sensors
 - c) Thermal ferrite beads
 - d) Integrated temperature sensors

How to Monitor Die Temperature – quiz

3. What source of error is caused by PCB traces or cabling when using the integrated thermal diode method?
- a) Series resistance
 - b) Noise injection
 - c) η -factor variation
 - d) β variation
4. Shielded twisted pair cables are used to avoid what source of error?
- a) Series resistance
 - b) Noise injection
 - c) η -factor variation
 - d) β variation

How to Monitor Die Temperature – quiz

5. What is not used by remote temperature sensors to calculate temperature?
- a) η -factor
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6. What is an important design guideline when using an external temperature sensor?
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