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

Performance

Measurement Error

1°C Accuracy

4°C Accuracy

Thermal Design Limit

Safety Margin

3° More Performance

1°C Accuracy

4°C Accuracy

Thermal Design Limit

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1°C Accuracy

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Thermal Design Limit

Safety Margin

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How to Monitor Die Temperature

**Integrated sensor**

**Integrated Thermal Diode**

**External Sensor**

System Board

Processor or ASIC

External Temperature Sensor

Processor or ASIC

Built-In Thermal Transistor, diode

GND
Die Temperature Monitoring
Integrated Thermal Diode

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

If \( \beta \gg \gg \) then \( I_C \approx I_E \)

\( T = \) Temperature
\( q = \) charge of electron
\( V_{EB} = \) Emitter-Base Voltage
\( \eta = \) ideality factor
\( k = \) Boltzmann Constant
\( I_C = \) Collector Current
\( I_E = \) Emitter Current
\( \beta = \) Gain of the transistor

Processor, FPGA, or ASIC
Integrated Thermal Diode Sources of Error

Thermal Diode error sources:

- $\eta$ -factor Variation
- $\beta$ Variation
- Series Resistance
- Noise Injection

$$T = \frac{q\Delta V_{EB}}{\eta k \ln \frac{I_{c2}}{I_{c1}}}$$

If $\beta >>$ then $I_C \approx I_E$
Die Temperature Monitoring
External Temperature Sensor
Die Temperature Monitoring
Temperature Sensor Design Guidelines

External Temperature Sensor

- Solid GND plane around heat generating IC and sensor
- Sensor placed close to heat source

Integrated Thermal Diode

- Remote Channel +
- Remote Channel -
- GND

FPGA/Processor
Remote Temperature Sensor

Heat generating IC
IC temperature monitor
U1 C1

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Thank you!

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