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Intel® 82801EB I/O Controller Hub 5 (ICH5) and Intel® 82801ER I/O Controller Hub 5 R (ICH5R)

Thermal Design Guide

April 2003

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Revision History

Revision Number	Description	Date
-001	• Initial Release.	April 2003

1 Introduction

As the complexity of computer systems increases, so do power dissipation requirements. The additional power of next generation systems must be properly dissipated. Heat can be dissipated using improved system cooling, selective use of ducting, and/or passive heatsinks.

The objective of thermal management is to ensure that the temperature of all components in a system is maintained within functional limits. The functional temperature limit is the range within which the electrical circuits can be expected to meet specified performance requirements. Operation outside the functional limit can degrade system performance, cause logic errors, or cause component and/or system damage. Temperatures exceeding the maximum operating limits may result in irreversible changes in the operating characteristics of the component. The goal of this document is to provide an understanding of the operating limits of the Intel® 82801EB I/O Controller Hub 5 (ICH5) / Intel® 82801ER I/O Controller Hub 5R (ICH5R) components.

The simplest and most cost-effective method is to improve the inherent system cooling characteristics of the ICH5 through careful design and placement of fans, vents, and ducts. When additional cooling is required, component thermal solutions may be implemented in conjunction with system thermal solutions. The size of the fan or heatsink can be varied to balance size and space constraints with acoustic noise.

This document has presented the conditions and requirements to properly design a cooling solution for systems that implement the ICH5. Properly designed solutions provide adequate cooling to maintain the ICH5 component case temperature at or below thermal specifications. This is accomplished by providing a low local-ambient temperature, ensuring adequate local airflow, and minimizing the case to local-ambient thermal resistance. By maintaining the ICH5 case temperature at or below maximum specifications, a system designer can ensure the proper functionality, performance, and reliability of this component.

Note: Unless otherwise specified, the term ICH5 in this document refers to both the 82801EB ICH5 and 82801ER ICH5R.

1.1 Terminology

Term	Description
BGA	Ball Grid Array. A package type defined by a resin-fiber substrate where a die is mounted, bonded and encapsulated in molding compound. The primary electrical interface is an array of solder balls attached to the substrate opposite the die and molding compound.
MBGA	Mini Ball Grid Array. A smaller version of the BGA with a ball pitch of 1.00 mm [0.039 in].
T_C	The measured case temperature of a component. For processors, it is measured at the geometric center of the integrated heat spreader (IHS). For other component types, it is generally measured at the geometric center of the die or case.
T_{C-MAX}	The maximum case/die temperature with an attached heatsink. This temperature is measured at the geometric center of the top of the package case/die.

Term	Description
$T_{C\text{-}MIN}$	The minimum case/die temperature with an attached heatsink. This temperature is measured at the geometric center of the top of the package case/die.
TDP	Thermal Design Power is specified as the highest sustainable power level of most or all of the real applications expected to be run on the given product, based on extrapolations in both hardware and software technology over the life of the component. Thermal solutions should be designed to dissipate this target power level.
TIM	Thermal Interface Material (TIM) is the thermally conductive material installed between two surfaces to improve heat transfer and reduce interface contact resistance.
LFM	Linear Feet per Minute. Units of airflow velocity.

1.2 Reference Documents

Document	Location/ Document Number
Intel® 82801EB I/O Controller Hub 5 (ICH5) and Intel® 82801ER I/O Controller Hub 5 R (ICH5R) Datasheet	http://developer.intel.com/design/chipsets/datashts/252516.htm
Intel® 875P Chipset Datasheet	http://developer.intel.com/design/chipsets/datashts/252525.htm
Intel® Pentium® 4 Processor with 512-KB L2 Cache on 0.13 Micron Process	http://developer.intel.com/design/pentium4/datashts/298643.htm
BGA/OLGA Assembly Development Guide	Contact your Intel Representative
Various System Thermal Design Suggestions	http://www.formfactors.org

2 Product Specifications

2.1 Package Description

The ICH5 is available in a 460 ball, 31 mm square mBGA package shown in Figure 2 (Appendix A).

2.2 Thermal Specifications

To ensure proper operation and reliability of the ICH5, the temperature must be at or below the maximum value specified in Table 1. If the temperature of the component exceeds the maximum temperature listed, system or component level thermal enhancements are required to dissipate the heat generated. Chapter 3 provides the thermal metrology guidelines for case temperature measurements.

The component should be operated above the minimum case temperature specification listed in Table 1.

Table 1. Intel® ICH5 Case Temperature Specifications

Parameter	Value
$T_{C\text{-}MAX}$	115 °C
$T_{C\text{-}MIN}$	0 °C

NOTE: Thermal specifications assume no attached heatsink is present.

2.3 Power Specifications

The ICH5 dissipates the Thermal Design Power value provided in Table 2.

Table 2. Intel® ICH5 Thermal Design Power Specification

Parameter	Value
TDP	2.4 W

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3 Thermal Metrology

The system designer must make temperature measurements to accurately determine the thermal performance of the system. Intel has established guidelines for proper techniques of measuring chipset component case temperatures.

3.1 Case Temperature Measurements

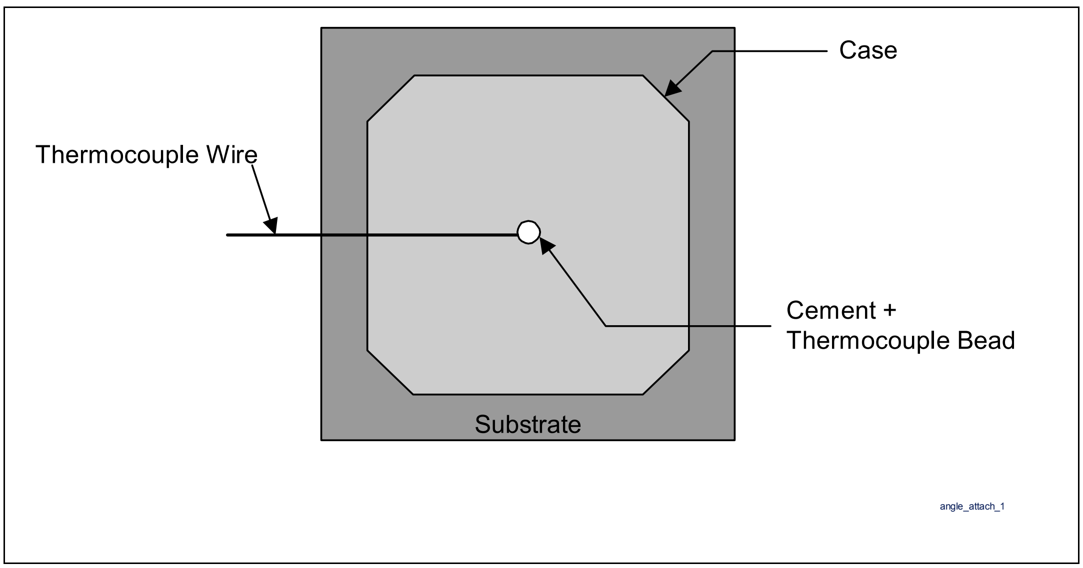
To ensure functionality and reliability, the chipset component is specified for proper operation when T_C is maintained at or below the maximum temperature listed in Table 1. The surface temperature at the geometric center of the die corresponds to T_C. Measuring T_C requires special care to ensure an accurate temperature measurement.

Temperature differences between the temperature of a surface and the surrounding local ambient air can introduce error in the measurements. The measurement errors could be due to a poor thermal contact between the thermocouple junction and the surface of the package, heat loss by radiation and/or convection, and/or conduction through thermocouple leads. To minimize these measurement errors, the following approach is recommended for thermocouple attach.

3.1.1 0° Angle Attach Methodology

Attach a 36 gauge or smaller calibrated K-type thermocouple bead or junction to the center of the top surface of the case using a high thermal conductivity cement. **It is critical that the thermocouple bead makes contact with the case** (see Figure 1).

Figure 1. 0° Angle Attach Methodology (top view, not to scale)



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4 Reference Thermal Solution

Based on a component local operating environment of natural convection with a maximum local-ambient temperature of 55 °C, the ICH5 does not require an attached heatsink to meet thermal specifications. The local-ambient conditions are based on a 35 °C external-ambient temperature at sea level, where external-ambient refers to the environment external to the system. For systems where the local-ambient temperature is severe (greater than 55 °C, natural convection), a component-level thermal solution or system thermal solution improvement may be required. Attaching a heatsink to the package case and/or improving airflow to the component may be potential solutions.

4.1 Environmental Reliability Requirements

If an attached heatsink is implemented due to a severe component local operating environment, the reliability requirements in Table 3 are recommended. Each motherboard, heatsink, and attach combination may vary the mechanical loading of the component. Validation test plans should be defined by the user based on anticipated use conditions and resulting reliability requirements.

Table 3. Reference Thermal Solution Environmental Reliability Requirements

Test[1]	Requirement	Pass/Fail Criteria[2]
Mechanical Shock	• Quantity: 3 drops for + and - directions in each of 3 perpendicular axes (i.e., total 18 drops). • Profile: 50 G trapezoidal waveform, 11 ms duration, 170 inches/sec minimum velocity change. • Setup: Mount sample board on test fixture.	Visual\Electrical Check
Random Vibration	• Duration: 10 min/axis, 3 axes • Frequency Range: 5 Hz to 500 Hz • Power Spectral Density (PSD) Profile: 3.13 g RMS	Visual/Electrical Check
Thermal Cycling	• -40 °C to +85 °C, 1000 cycles	Visual Check
Temperature Life	• 85 °C, 1000 hours total	Visual/Electrical Check
Unbiased Humidity	• 85 % relative humidity / 55 °C, 1000 hours	Visual Check
Power Cycling	• 7,500 on/off cycles with each cycle specified as 3 minutes on, 2 minutes off 70 °C	Visual Check

NOTES:
1. The above tests should be performed on a sample size of at least 12 assemblies from 3 different lots of material.
2. Additional Pass/Fail Criteria may be added at the discretion of the user.

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Appendix A: Mechanical Drawings

Figure 2 provides the package dimensions for the 82801EB ICH5.

Figure 2. Intel® ICH5 Component Package Drawing