Intel® 845E Chipset

Design Guide

Intel® 82845 Memory Controller Hub (MCH) Thermal and Mechanical Design Guidelines

May 2002

Document Number: 298653-001

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Revision History

Revision Number	Description	Date
-001	• Initial Release.	May 2002

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1 Introduction

As the complexity of computer systems increases, so do power dissipation requirements. Care must be taken to ensure that the additional power is 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 simplest and most cost-effective method is to improve the inherent system cooling characteristics of the MCH is 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.

The mechanical and thermal design guidelines for the 845E chipset are contained in two documents. This document describes the thermal and mechanical design guidelines for the 82845 MCH. For the ICH4, refer to the *Intel® 82801DB I/O Controller Hub 4 (ICH4) Thermal Design Guidelines* (document number 298651).

The thermal design guides in this document provide an understanding of the operating limits of the 82845 MCH and discusses a generic thermal solution. This document presents the conditions and requirements to properly design a cooling solution for systems that use the 82845 MCH. Properly designed solutions provide adequate cooling to maintain the MCH case temperature at or below thermal specification. 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 MCH case temperature at or below what is recommended in this document, a system designer can ensure the proper functionality, performance, and reliability of the component. Table 1 summarizes the specifications discussed in this design guide.

Table 1. Specification Summary

Package Dimensions	
MCH	37.5 mm x 37.5 mm x 2.54 mm
Handling Keep out on Substrate	
MCH	2 mm from edge of die
Max Allowable Die Pressure	
MCH	400 kPa (this corresponds to 50 lbf load on die)
Heatsink Volume Keep outs	
MCH Heatsink	X:37.5 mm, Y:37.5 mm, Z:40 mm
Operating Environment	
Maximum Temperature	55 °C
Minimum Airflow	50 lfm
Thermal Design Power (TDPtyp)	
MCH	5.8 W (533 MHz FSB, DDR 266 w/4 Rows)
MCH Maximum Case Temperature	
MCH	92 °C

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1.1 Definition of Terms

Term	Definition
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.
CFD	Computational Fluid Dynamics.
FC-BGA	Flip Chip Ball Grid Array. A package type defined by a plastic substrate where a die is mounted using an underfill C4 (Controlled Collapse Chip Connection) attach style. The primary electrical interface is an array of solder balls attached to the substrate opposite the die. Note that the device arrives at the customer with solder balls attached (see Figure 8).
Intel® ICH4	I/O Controller Hub. The chipset component that contains the primary PCI interface, LPC interface, USB, ATA-33, and other legacy functions.
EBGA	Mini Ball Grid Array. A smaller version of the BGA with a ball pitch of 1.00 mm.
MCH	Memory Controller Hub. The chipset component that contains the processor and memory interface.
OLGA	Organic Land Grid Array.
T_C	T_C is the case temperature as measured at the geometric center of the top of the package die.
$T_{C\text{-}MAX}$	$T_{C\text{-}MAX}$ is the maximum allowable temperature as measured at the geometric center of the top of the package die.
TDP	Thermal Design Power. Thermal solutions should be designed to dissipate this target power level. Thermal Design Power (typical) 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. This material is designed to fill surface voids between the die and heatsink surfaces in order to facilitate heat transfer.
lfm	Linear Feet per Minute. Units of mass flow for fluids
TRHS	Thermal Resistance of Heatsink.
TOP	Thermal Operating Point. The TOP is defined as the thermal resistance of the thermal interface material loaded at the design force of the clip and retention mechanism plus the thermal resistance of the heatsink at the specified airflow speed.

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2 Product Specifications

2.1 Package Description

2.1.1 Intel® 845E MCH Package Dimensions

The MCH is packaged in a 37.5 mm x 37.5 mm, 593 FC-BGA (see Appendix A).

2.2 Heatsink and Clip Mechanical Reference Design

The reference heatsink solution is a passive extruded aluminum heatsink with thermal and mechanical interfaces. It is attached using a clip frame and mechanical advantage lever. The clip frame is secured to the system board via four solder down anchors in four locations around the MCH.

The heatsink clip for the MCH is designed to be used in conjunction with the mechanical attach solution for the Intel® Pentium® 4 processor. The clip provides a mechanical preload applied to the heatsink and package via a mechanical advantage lever. This preload assures minimal bond line thickness and adds rigidity to the heatsink and package assembly. The clip is designed to prevent component damage and potential failures under environmental system loading.

2.2.1 Mechanical Keep-Outs

The mechanical keep-out restrictions are included in Appendix A. The component height restrictions are illustrated by a legend in the drawing. It is important to note that the keep-out and height restrictions differ slightly from the Intel 845 chipset keep-outs.

2.2.2 Heatsink Assembly

The heatsink assembly includes the heatsink (with TIM and mechanical interface gasket), the clip, and clip lever as shown in Figure 1. This clip attaches to solder down anchors located on the system board.

Figure 1. Heatsink Assembly: Heatsink, Clip Frame, Clip Lever

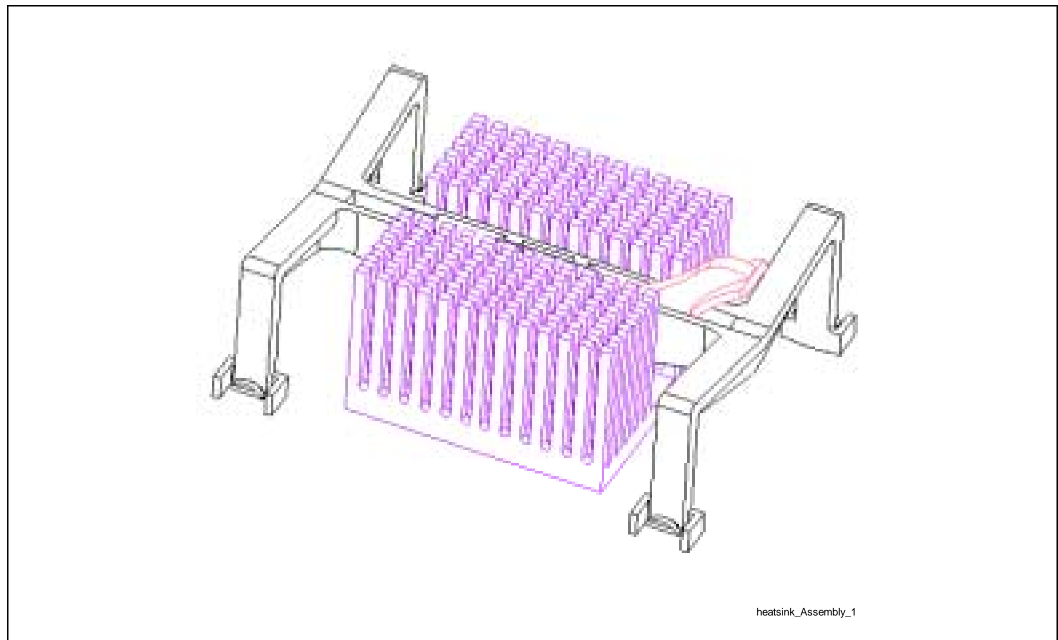
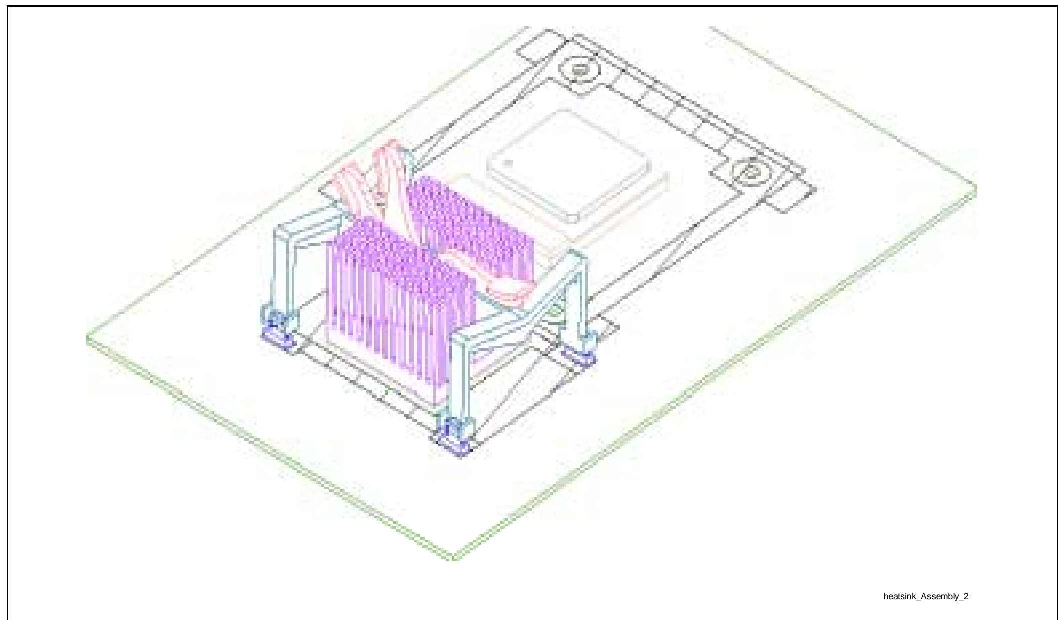


Figure 2. Heatsink Assembly Placement and Actuation



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2.3 Thermal and Mechanical Reliability

Recommendations for thermal mechanical reliability testing are shown in Table 2. These should be considered as general guidelines. The user, based on anticipated use conditions, should define validation-testing requirements.

Table 2. Reliability Validation

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	• -5 °C to +70 °C, 500 cycles	Visual 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.

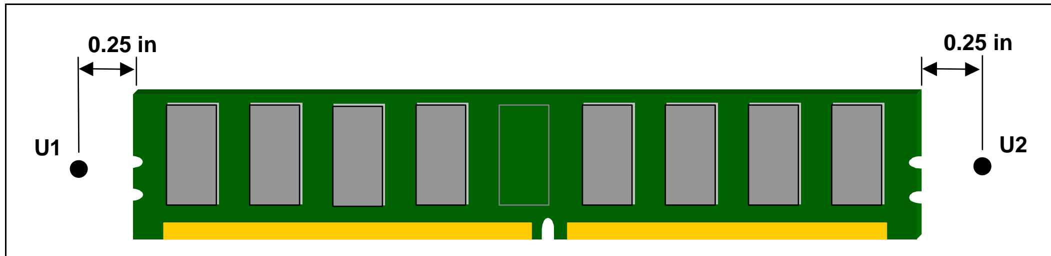
2.4 Thermal Specifications

2.4.1 External Ambient Conditions

To ensure proper operation and reliability of the MCH, an airflow speed of 50 lfm (linear feet per minute) must be present 1 inch in front of the heatsink air inlet side of the 845E chipset generic thermal solution that is attached to the MCH. Furthermore, the maximum allowable operating air temperature at the MCH heatsink must not exceed 55 °C. The thermal designer must carefully select the location to measure airflow to get a representative sampling. (Note that these environmental specifications are based on a 35°C system external temperature measured at 5000′)

The amount of airflow also directly impacts the BIOS settings required for the memory thermal management, which is controlled by the chipset. Memory thermal management needs to be set in the BIOS for systems with under 100 lfm airflow to the MCH and under 100 lfm airflow to the memory. To determine the memory airflow, Figure 3 shows the correct location for air speed probes in relation to the DIMM. The location of the probes (U1 and U2) should be elevated to the center of the DIMM, and 0.25" from the edges as shown. The average should be taken from the measurements at locations u1 and u2 shown below for determining the airspeed setting.

Figure 3. DIMM Airflow Measurement Location



2.4.2 Intel® 82845 MCH Maximum Case Temperature

To ensure proper operation and reliability of the MCH, the temperature must be at or below the values specified in Table 3. If the temperature of the component exceeds the maximum temperatures listed, system or component level thermal enhancements are required to dissipate the heat generated. Section 2.5 provides the temperature measurement metrology for case temperature measurements.

Table 3. MCH Maximum Case Temperature

Parameter	Maximum MCH Case Temperature
$T_{C\text{-}MAX}$	92 °C

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2.5 Temperature Measurement Metrology

To accurately assess junction temperature for an application or to determine if you are not exceeding a $T_{C\text{-}MAX}$ of 92 °C, it is necessary to have a good thermocouple attach. Intel has established guidelines for the proper techniques to be used when measuring the MCH case temperature. Section 2.6 contains information on running an application program that emulates anticipated maximum TDP. The flowchart in Figure 7 offers useful guidelines for thermal performance and evaluation.

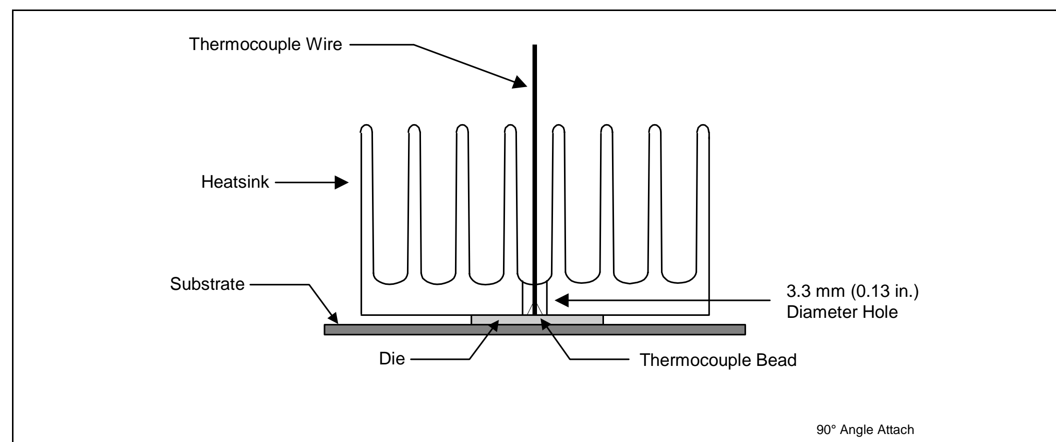
2.5.1 Case Temperature Measurements

To ensure functionality and reliability, the MCH is specified for proper operation when Tcase is maintained at or below its respective temperatures at 50 lfm for the MCH (see Table 3). The surface temperature at the geometric center of the die corresponds to the maximum Tcase or $T_{C\text{-}MAX}$.

2.5.2 90 Degree Angle Attach Methodology

1. Use 36 gauge or smaller K-type thermocouples.
2. Ensure that the thermocouples have been properly calibrated.
3. Attach the thermocouple bead or junction to the top surface of the die in the center using high thermal conductivity cement. **It is critical that the thermocouple bead makes contact with the die.**
4. The thermocouple should be attached at a 90-degree angle if there is no interference with the thermocouple attach location or leads (see Figure 4). This is the preferred method and is recommended or use with both bare packages as well as packages employing a thermal solution.
5. The hole size through the heatsink base to route the thermocouple wires out should be smaller than 3.3 mm (0.13 inches) in diameter.
6. Make sure there is no contact between the thermocouple cement and the heatsink base. This contact will affect the thermocouple reading.

Figure 4. 90 Degree Angle Attach Methodology (not to scale)



2.5.3 0 Degree Angle Attach Methodology

1. Mill a 3.3 mm (0.13 inches) diameter hole centered on bottom of the heatsink base (see Figure 5). The milled hole should be approximately 1.5 mm (0.06 inches) deep.
2. Mill a 1.3 mm (0.05 inches) wide slot, 0.5 mm (0.02 inches) deep, from the centered hole to one edge of the heatsink. The slot should be in the direction parallel to the heatsink fins (see Figure 5 and Figure 6).
3. Attach thermal interface material (TIM) to the bottom of the heatsink base.
4. Cut out portions of the TIM to make room for the thermocouple wire and bead. The cutouts should match the slot and hole milled into the heatsink base.
5. Attach a 36 gauge or smaller calibrated K-type thermocouple bead or junction to the center of the top surface of the die using a high thermal conductivity cement. During this step, make sure there is no contact between the thermocouple cement and the heatsink base because any contact will affect the thermocouple reading. **It is critical that the thermocouple bead makes contact with the die** (see Figure 5).
6. Attach heatsink assembly to the MCH and route the thermocouple wires out through the milled slot.

Figure 5. 0 Degree Angle Attach Heatsink Modifications (not to scale)

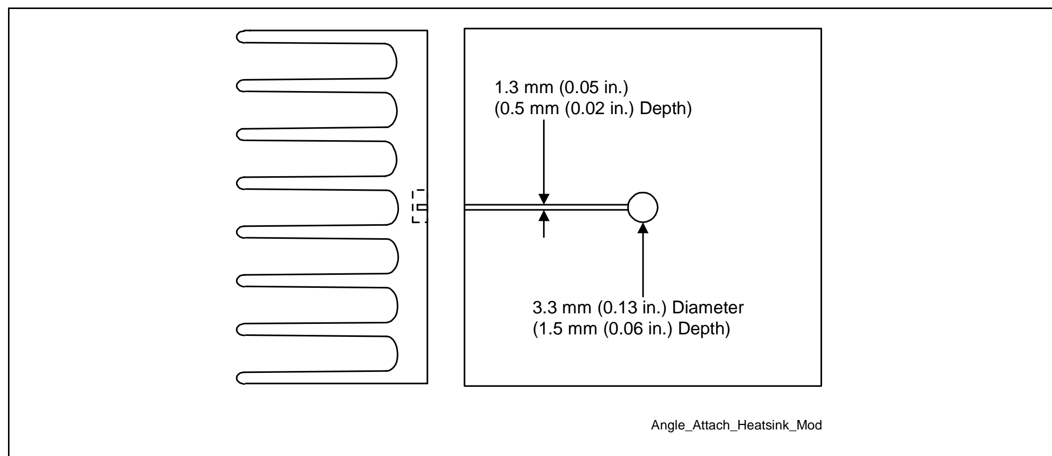
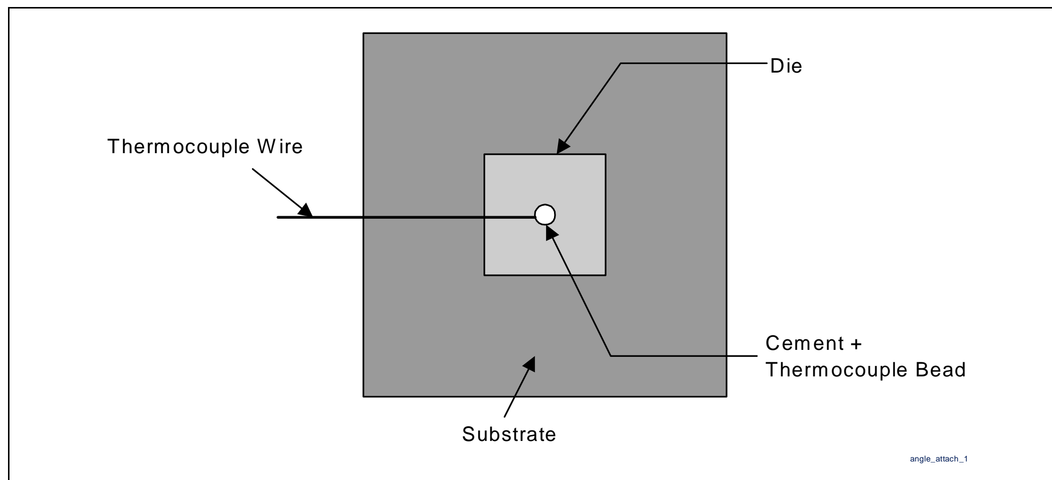


Figure 6. 0 Degree Angle Attach Methodology (not to scale)

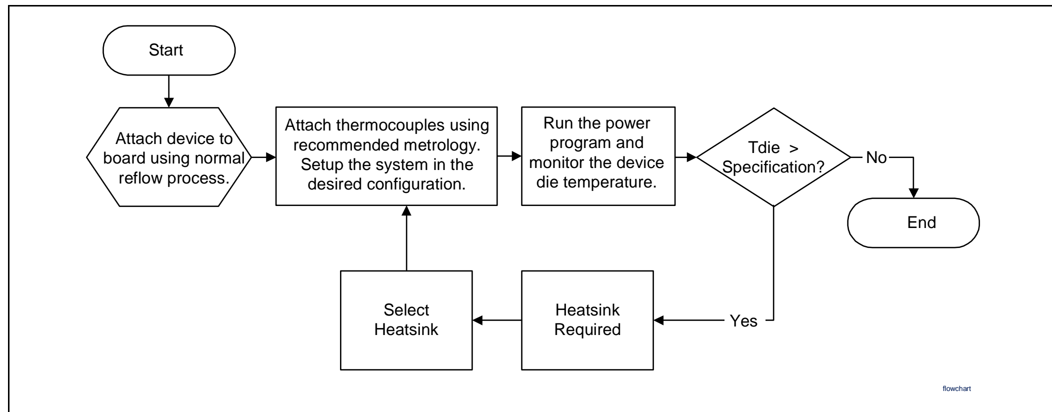


2.6 Power Dissipation Software

The power simulation software is a utility designed to dissipate the Thermal Design Power (TDP) on the MCH when used in conjunction with a Pentium 4 processor. The combination of the Intel Pentium 4 processor and the bandwidth capability of the MCH enable new levels of system performance. To assess the thermal performance of the 845E chipset generic thermal solution during “worst-case realistic application” conditions, Intel has developed a software utility that operates the chipset at near worst-case power dissipation.

The utility has been developed solely for testing customer thermal solutions at or near the thermal design power. Figure 7 shows a decision flowchart for determining thermal solution needs. Real future applications may exceed the thermal design power limit for transient time periods. For power supply current requirements under these transient conditions, refer to each component’s datasheet for the I_{CC} (Max Power Supply Current) specification. Contact your Intel Field Sales representative to obtain a copy of this software.

Figure 7. 0 Degree Thermal Solution Decision Flowchart for 0 °C



2.7 MCH Thermal Design Power

The 845E chipset power utility is designed to dissipate the TDPtyp power value through the MCH when a system is populated with the memory listed in Table 4. These values have been validated for the following configuration running the front side bus frequency at 533 MHz.

Table 4. MCH Thermal Design Power

TDPtyp (Watts)	System Configuration
5.8 W	533 MHz FSB, DDR 266 w/4 Rows

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3 Generic Thermal Solution

3.1 Generic Thermal Solution Performance

If the thermal designer is able to provide greater than 50 lfm at the air inlet side (upstream) of the heatsink, the case temperature of the MCH will decrease. Since the thermal resistance of the package and thermal interface material (TIM) remain constant for all upstream airflow speeds, this behavior is due to the decreased thermal resistance (°C/W) of the 845E chipset generic thermal solution's heatsink. Hence, if a thermal designer can provide greater than 50 lfm upstream of the heatsink, the junction temperature will be reduced. This reduction in junction temperature leads to greater component reliability.

3.2 Generic Thermal Solution TIM Description

A thermal interface material is used to provide improved conductivity between the die and heatsink. The reference thermal solution uses Chomerics T-710, 0.127 mm (0.005 inches) thick, 12.7 mm x 12.7 mm (0.5 inches x 0.5 inches).

3.2.1 The Effect of Pressure on TIM Performance

As mechanical pressure increases on the TIM, the thermal resistance of the TIM decreases. This phenomenon is due to the decrease of the Bond Line Thickness (BLT). The effect of pressure on the thermal resistance of the Chomerics T710 TIM is shown in Table 5. The heatsink clip (see Figure 1) provides enough pressure for the TIM to achieve a thermal conductivity of 0.9 W/m·K.

Table 5. Chomerics T710 TIM Performance (at 50 °C as a Function of Attach Pressure)

Pressure (psi)	Thermal Resistance (°C*In^2)/W
5	0.37
10	0.3
20	0.21
50	0.17

3.3 Generic Thermal Solution Thermal Operating Point

The Thermal Operating Point (TOP) is defined as the thermal resistance of the TIM at the design force of the clip and retention mechanism plus the thermal resistance of the heatsink at the specified airflow speed. The thermal resistance of the heatsink (TRHS) is given by the following equation:

$$TRHS = (T_{case} - T_{local_ambient}) / (\%\ TDP\ dissipated\ via\ heatsink)$$

Thermal simulation results show that as airflow increases upstream of the 845E chipset generic thermal solution, the percentage of TDP that leaves via the top of the package increases (see Table 6).

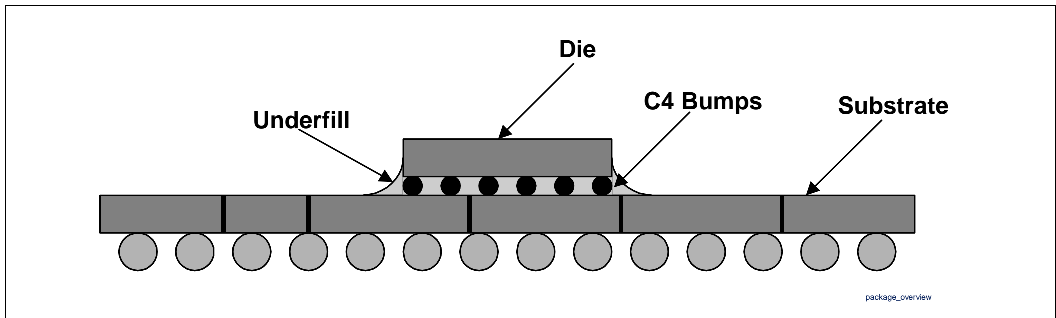
Table 6. TDP Dissipation for Various Airflow Speeds

Upstream Airflow Speed (lfm)	Percent of TDP Dissipated via Intel Thermal Solution	Percent of TDP Dissipated via the 4-Layer JEDEC Board
50	70%	30%
100	75%	25%
150	77%	23%

3.4 Generic Thermal Solution Simulation

A Computational Fluid Dynamics (CFD) model of the MCH has been developed for use with the commercially available thermal analysis tool "Flotherm" (version 2.1 or later). This model can be used to evaluate package thermal limits and cooling methods. Modeled MCH components are shown in Figure 8.

Figure 8. Intel® MCH Components Modeled



Contact your Intel Field Sales representative to order the thermal models and user's guides.

3.4.1 Flotherm Model Implementation in a System Level Analysis

When integrating the MCH model into a system level analysis, two important issues must be considered to ensure that the MCH CFD model correctly predicts thermal behavior. These issues are the proper mating of the model with the motherboard and the thermal solution. Proper mating requires the following:

- Ensure that the solder ball cuboid in the chipset model makes direct contact with the motherboard. Good modeling contact must be specified and the contact should be verified by closely zooming in on the interface between the solder ball cuboid and the motherboard.
- Ensure that the die cuboid in the chipset model is properly mated to the thermal solution. Model the thermal interface material by using a cuboid with the appropriate properties to account for the thermal resistance in the material and the surface contact. Either a non-collapsed or a collapsed cuboid may be used to model the thermal interface material as long as the specified properties of the cuboid remain the same.

System Model Grid

Make sure that a sufficient number of grid cells are used within and around the area of the package to capture sharp thermal gradients. Note that an increase in the number of grid cells may also add to the computation time of model.

3.4.3 Thermal Model Power Dissipation

Based on the system component configuration, use the TDPtyp power values shown in Table 4.

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4 Generic Thermal Attach / Mechanical Solution

The heatsink is affixed to the die with a mechanism advantage clip. The clip consists of a clip frame that interfaces to the motherboard through four through-hole mount anchors and an integral lever (see Figure 2). The clip and lever serve three main purposes: 1) Secure the heatsink in intimate contact with the die, 2) Ensure a thermally good bondline between the heatsink and die, and 3) Prevent damage at the package-to-motherboard solder joint during mechanical shock events

4.1 Heatsink Retention

The heatsink must maintain close contact with the die for the life of the system. The generic clip retention mechanism design holds the heatsink to the die through a single point contact at the center of the heatsink. This ensures that the clip load is centered on the die, thus preventing heatsink tilt that may be caused by unbalanced loading (see Figure 9). The clip frame also restrains heatsink lateral motion through tabs located between the heatsink fins (see Figure 10).

Figure 9. MCH Clip Assembly

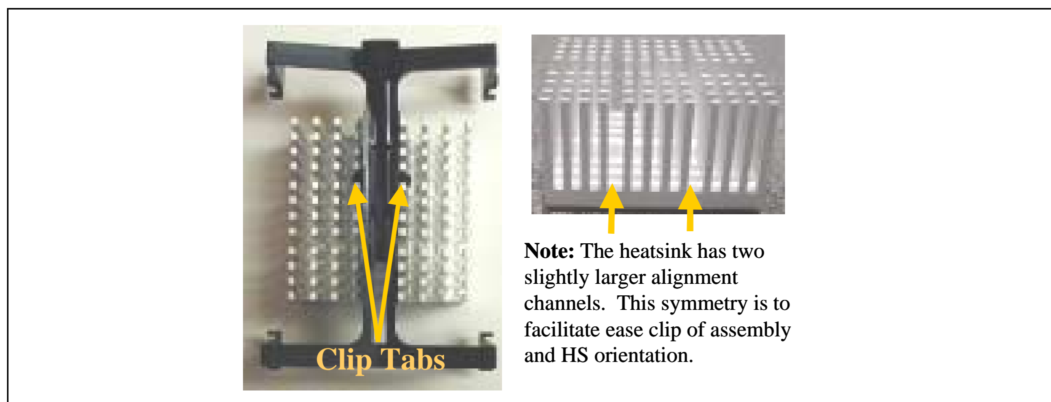
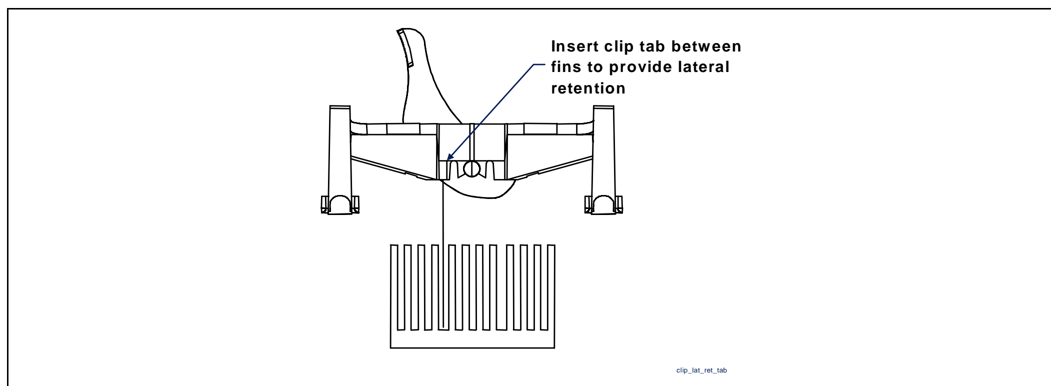


Figure 10. MCH Clip Lateral Retention Tab Feature



4.2 Thermal Bond Line

The thickness of the bond line between the heatsink and die is critical to thermal performance of the TIM. The bond line thickness is dependent on the pressure between the heatsink and the die. The clip retention mechanism is used to generate the pressure required to ensure thermal performance (see Table 5). The generic clip frame and lever design generates more than 50 psi pressure.

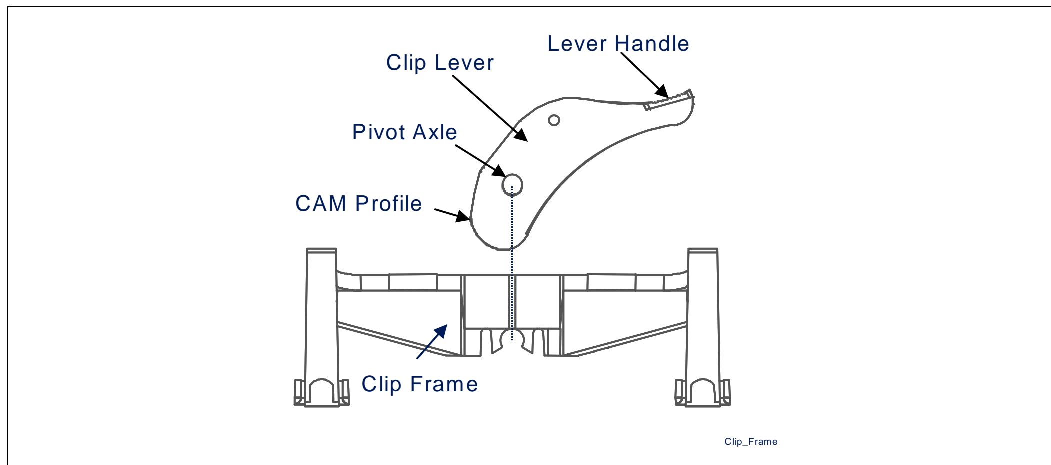
4.3 Solder Joint Protection

The solder joints between the package and the motherboard are susceptible to damage under mechanical shock conditions depending on the mass and proximity of the processor heatsink. Other elements (e.g., motherboard bending rigidity and the size and distribution of other mass components on the motherboard) can also affect solder joint susceptibility to damage.

The generic clip design uses mechanical preload on the package to protect the solder joint against damage under mechanical shock. The design features a rotating cam (see Figure 11) that generates substantial preload between the heatsink and package. The cam has a levered handle that provides a mechanical advantage during installation.

The preload serves to compress the solder ball array between the package and motherboard. The compression in the solder balls delays the onset of tensile load under critical shock conditions, and the magnitude of maximum tensile load is thereby reduced. In this manner, the critical solder balls are protected from tensile loading that may cause damage to the solder joint.

Figure 11. MCH Clip Frame and Lever



4.4 MCH Heatsink Drawings

Contact your field representative for additional information.

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5 Vendors

5.1 Heatsink Suppliers

Topic	Part	Intel Part Number	Supplier	Supplier Part Number
Extruded Heatsinks	Intel 82845 MCH Pin Fin	A54515-001	Foxconn	
Interface Materials	Intel 82845 MCH TIM (T-710)		Chomerics	69-12-22066-T710
	Intel 82845 MCH Mechanical (Poron)	A61203-001	Boyd	
Attach Hardware	Intel 82845 MCH Clip Frame	A65066-001	Foxconn	
	Intel 82845 MCH Clip Lever	A67031-001	Foxconn	
	Solder-Down Anchor	A13494-005	Foxconn	HB96030-DW
Enabling Assembly	Intel 82845 MCH Enabling Assembly Includes: Heatsink, thermal interface material, mechanical interface material, Clip frame, and Clip lever	A67625-001	Foxconn	PHC029C02012

Some suppliers may be able to provide pre-assembled kits. Contact individual suppliers for information.

Supplier Contact Information

Boyd Corporation http://www.boydcorp.com

Chomerics, Inc. http://www.chomerics.com

Foxconn Electronics, Inc. http://www.foxconn.com

Note: These vendorsare listed by Intel as a convenience to Intel's general customer base, but Intel does not make any representations or warranties whatsoever regarding quality, reliability, functionality, or compatibility of these devices. This list and/or these devices may be subject to change without notice.

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Appendix A: Package Dimensions

This appendix provides package dimensions and keep-out zone requirements for the 82845 MCH.

Figure 12. Intel® 82845 MCH FC-BGA Package Dimensions (Top and Side View)

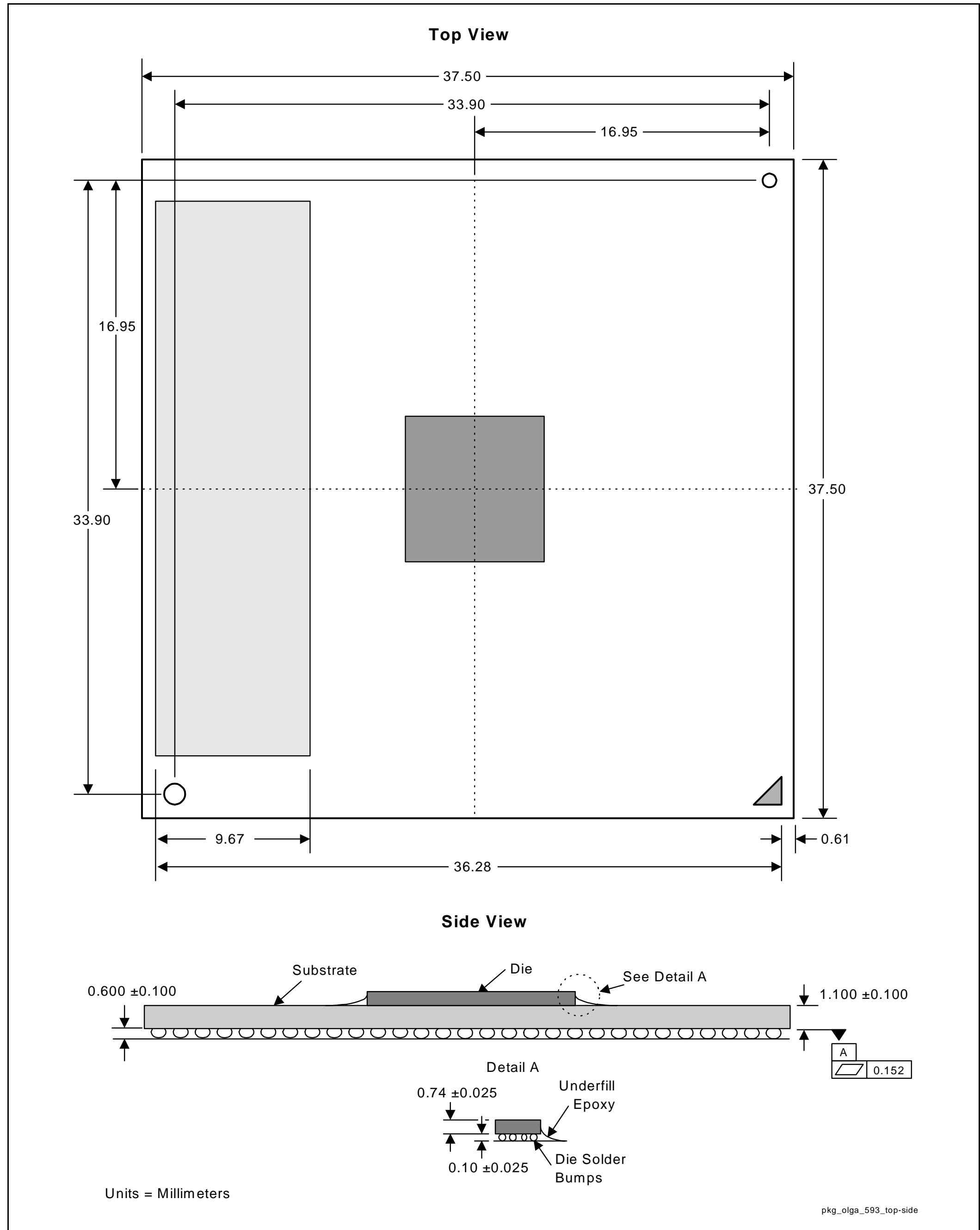

Figure 13. Intel® 82845 MCH FC-BGA Package Dimensions (Bottom View)

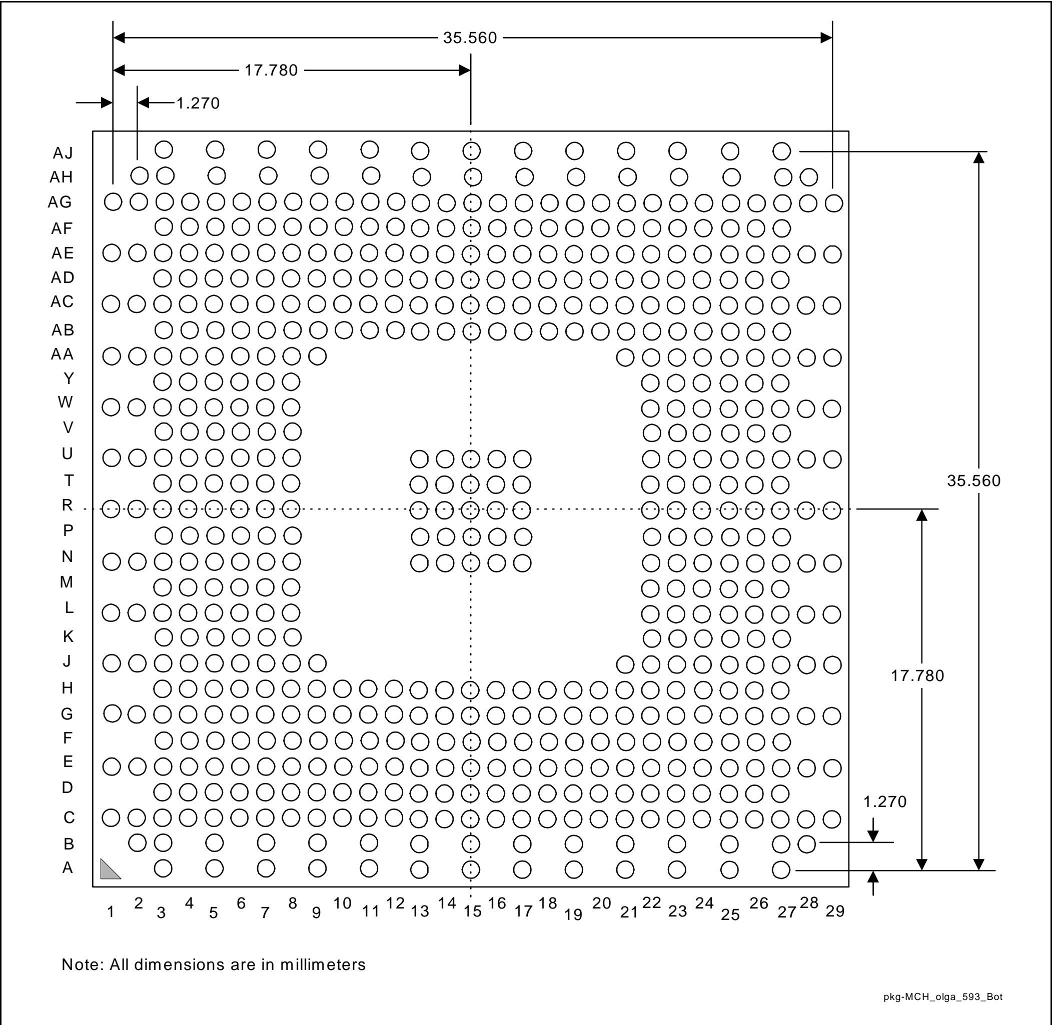

Figure 14. MCH Keep-Out Restriction