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Intel® E7500 Chipset

Design Guide

E7500 Memory Controller Hub (MCH) Thermal and Mechanical Design Guidelines

February 2002

Document Number: 298647-001

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Revision History

Revision Number	Description	Date
-001	Initial Release.	February 2002

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1 *Introduction*

As the complexity of computer systems increases, so do the 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 temperatures of all components in a system are 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 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 goal of this document is to provide an understanding of the operating limits of the Intel® E7500 chipset MCH and describe a reference thermal solution. Properly designed solutions provide adequate cooling to maintain the MCH die temperatures within thermal specifications. This is accomplished by providing a low local-ambient temperature, ensuring adequate local airflow, and minimizing the die to local-ambient thermal resistance. By maintaining the MCH die temperature within the range recommended in this document, the system designer can ensure the proper functionality, performance, and reliability of the chipset.

This document addresses thermal design and specifications for the MCH component only. For thermal design information on other chipset components, refer to the respective component datasheet. For the P64H2, refer to the *Intel® PCI/PCI-X 64-bit Hub 2 (P64H2) Thermal and Mechanical Design Guidelines.*

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1.1   Design Flow

To develop a reliable, cost-effective thermal solution, several tools have been provided to the system designer. Figure 1 illustrates the design process implicit to this document and the tools appropriate for each step.

Figure 1. Thermal Design Process

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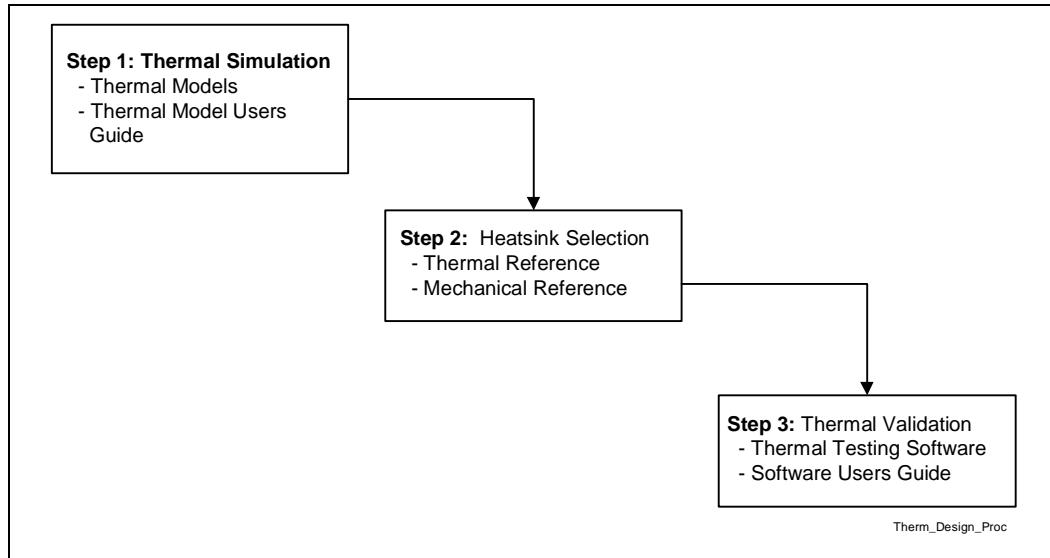
1.2 Definition of Terms

Term	Definition
BGA	Ball Grid Array. A package type defined by a resin-fiber substrate, onto which 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.
ICH3-S	I/O Controller Hub. The chipset component that contains the primary PCI interface, LPC interface, USB, ATA-33, and other legacy functions.
MBGA	Mini Ball Grid Array. A version of the BGA with a smaller ball pitch.
MCH	Memory Controller Hub. The chipset component that contains the processor interface and the memory interface.
FC-BGA	Flip Chip Ball Grid Array. A packaging technology used for the MCH.
P64H2	Bus Controller Hub. The chipset component that interfaces the PCI-X buses.
$T_{case-nhs}$	The maximum package case temperature without any package thermal solution. This temperature is measured at the geometric center of the top of the package case.
$T_{die-nhs}$	The maximum die temperature without any package thermal solution. This temperature is measured at the geometric center of the top of the package die.
T_{die-hs}	The maximum die temperature with the reference thermal solution attached. This temperature is 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.

1.3   Reference Documents

Document	Document Number
Intel® Xeon™ Processor Thermal Design Guidelines http://www.intel.com/design/Xeon/guides/298348.htm	298348
Intel® PCI/PCI-X 64-bit Hub 2 (P64H2) Thermal and Mechanical Design Guidelines	298648
Intel® Xeon™ Processor with 512 KB L2 Cache and Intel® E7500 Chipset Platform Design Guide	298649
Intel® E7500 Chipset Datasheet: E7500 Memory Controller Hub (MCH)	290730
Intel® 82801CA I/O Controller Hub 3 (ICH3-S) Datasheet	290733
Intel® 82870P2 PCI/PCI-X 64-bit Hub 2 (P64H2) Datasheet	290732
BGA/OLGA Assembly Development Guide	Note 1
Thermal Design Suggestions for various form factors http://www.formfactors.org	

NOTES:
1. Contact your Intel Field Sales representative.

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2 Packaging Technology

The E7500 chipset consists of three individual components: E7500 MCH, 82870P2 P64H2, and 82801CA ICH3-S. The E7500 MCH utilizes a 42.5 mm, 6-layer FC-BGA package shown in Figure 3 and Figure 2. For information on the P64H2 package, refer to the *Intel® 82870P2 PCI/PCI-X 64-bit Hub 2 (P64H2) Thermal and Mechanical Design Guidelines* and the *Intel® 82870P2 PCI/PCI-X 64-bit Hub 2 (P64H2) Datasheet*. For information on the ICH3-S package, refer to the *Intel® 82801CA I/O Controller Hub 3 (ICH3-S) Datasheet*.

Figure 2. Intel® E7500 MCH Package Dimensions (Side View)
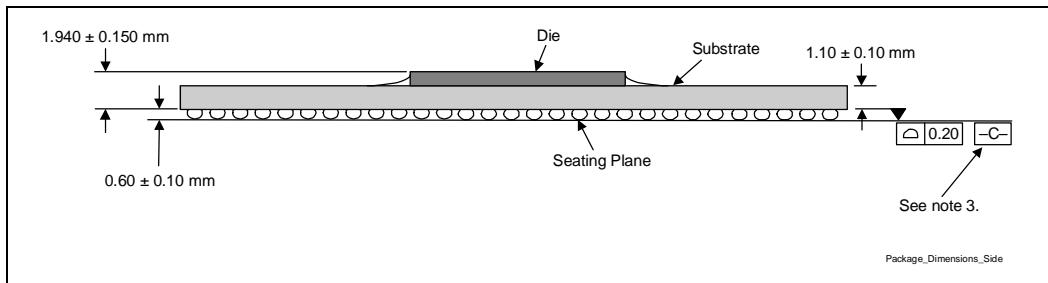
NOTES:
1. All dimensions are in millimeters.
2. Substrate thickness and package overall height are thicker than standard 492-L PBGA.
3. Primary datum –C– and seating plane are defined by the spherical crowns of the solder balls.
4. All dimensions and tolerances conform to ANSI Y14.5M–1982.

Figure 3. Intel® E7500 MCH Package Dimensions (Top View)
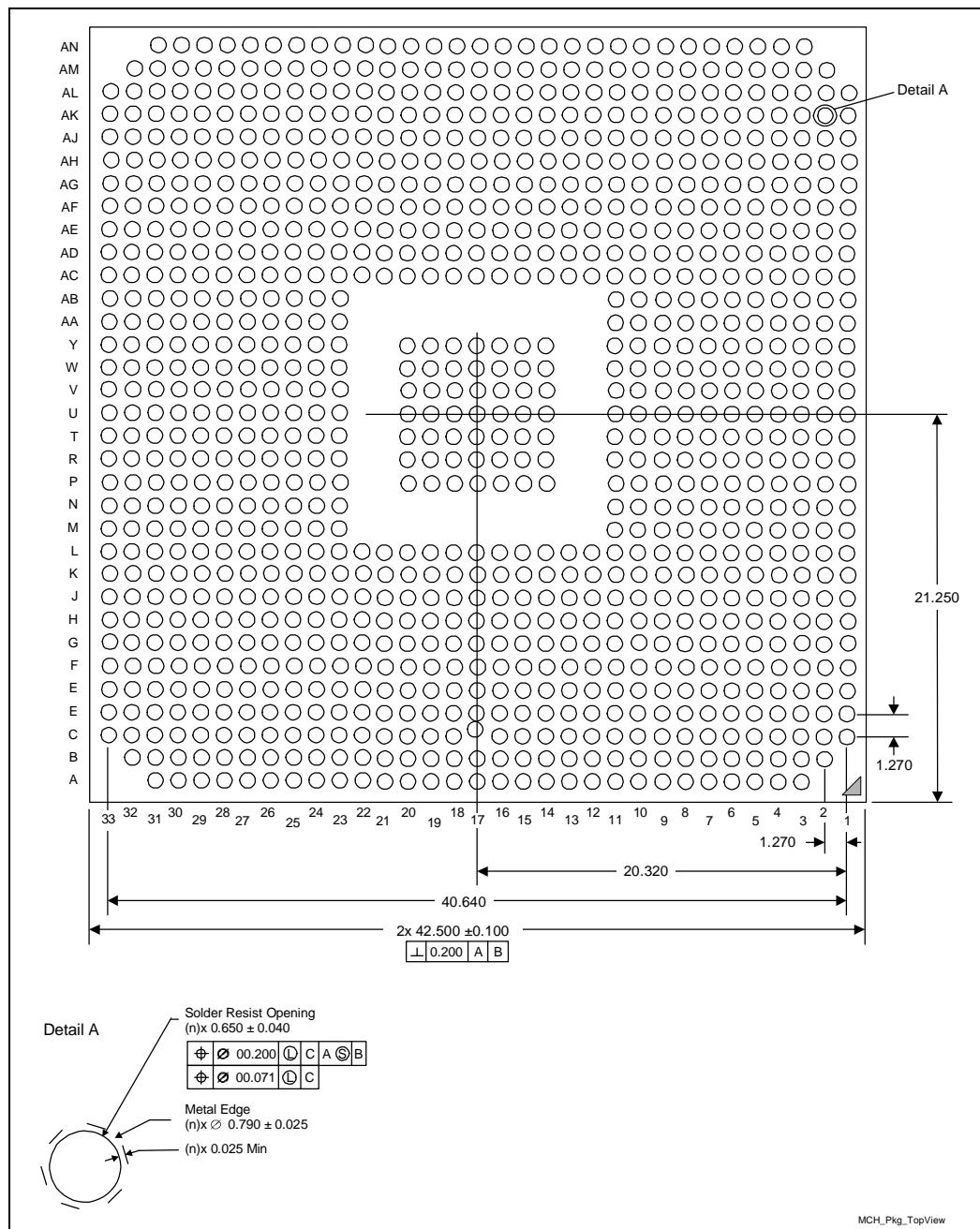
NOTES:
1. All dimensions are in millimeters.
2. All dimensions and tolerances conform to ANSI Y14.5M–1982.

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3   *Thermal Simulation*

Intel provides thermal simulation models of the MCH and associated user's guides to aid system designers in simulating, analyzing, and optimizing their thermal solutions in an integrated system-level environment. The models are for use with the commercially available Computational Fluid Dynamics (CFD)-based thermal analysis tool "FLOTHERM*" (version 3.1 or higher) by Flomerics* Inc. Contact your Intel Field Sales representative to order the thermal models and user's guides.

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4 *Thermal Specifications*

4.1 Power

See Table 1 for TDP specifications for the E7500 MCH. FC-BGA packages have poor heat transfer capability into the board and have minimal thermal capability without thermal solutions. Intel recommends that system designers plan for one or more heatsinks when using the E7500 chipset.

4.2 Die Temperature

To ensure proper operation and reliability of the MCH, the die temperatures must be at or below the values specified for the MCH in Table 1. System or component level thermal solutions are required to maintain die temperatures below the maximum temperature specifications. Refer to Chapter 5 for guidelines on accurately measuring package die temperatures.

Table 1. Intel® E7500 MCH Thermal Specifications

Parameter	Maximum
T_{die-hs}	102 °C
TDP	9.0 W

NOTE: T_{die-hs} is defined as the maximum die temperature with the reference thermal solution attached.

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5   *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 the MCH die temperature. Section 5.1 provides guidelines on how to accurately measure the MCH die temperatures. Section 5.2 contains information on running an application program that will emulate anticipated maximum thermal design power. The flowchart in Figure 7 offers useful guidelines for thermal performance and evaluation.

## 5.1   Die Temperature Measurements

To ensure functionality and reliability, the MCH is specified for proper operation when T_{die} is maintained at or below their respective maximum temperatures listed in Table 1. The surface temperature at the geometric center of the die corresponds to T_{die}. Measuring T_{die} 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, conduction through thermocouple leads, or contact between the thermocouple cement and the heatsink base (if a heatsink is used). To minimize these measurement errors, the following approaches are recommended for thermocouple attach.

5.1.1   90° Angle Attach Methodology

1. Use 36 gauge or smaller diameter K-type thermocouples.

2. Ensure that the thermocouple has 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° angle if no interference exists between the thermocouple wire and retention mechanism (see Figure 4). This is the preferred method and is recommended for 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 no larger than 3.3 mm (0.13 in.) in diameter.

6. Make sure no contact exists between the thermocouple cement and heatsink base. This contact will affect the thermocouple reading.

Figure 4. 90° Angle Attach Methodology
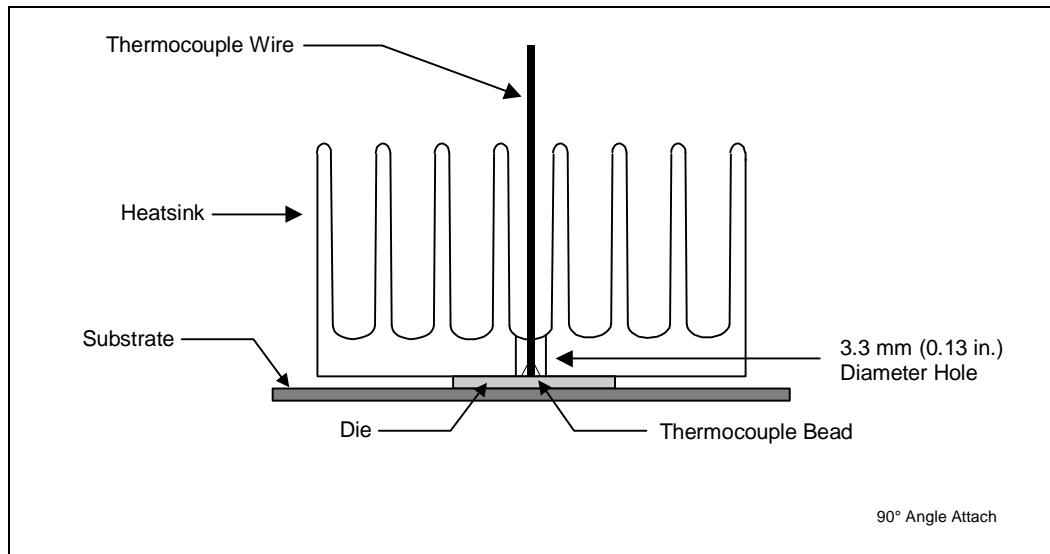
NOTE: Not to scale.

5.1.2   0° Angle Attach Methodology

1. Mill a 3.3 mm (0.13 in.) diameter hole centered on bottom of the heatsink base. The milled hole should be approximately 1.5 mm (0.06 in.) deep.

2. Mill a 1.3 mm (0.05 in.) wide slot, 0.5 mm (0.02 in.) 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 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 high thermal conductivity cement. During this step, make sure no contact is present 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 thermocouple wires out through the milled slot.

Figure 5. 0° Angle Attach Methodology (Top View)
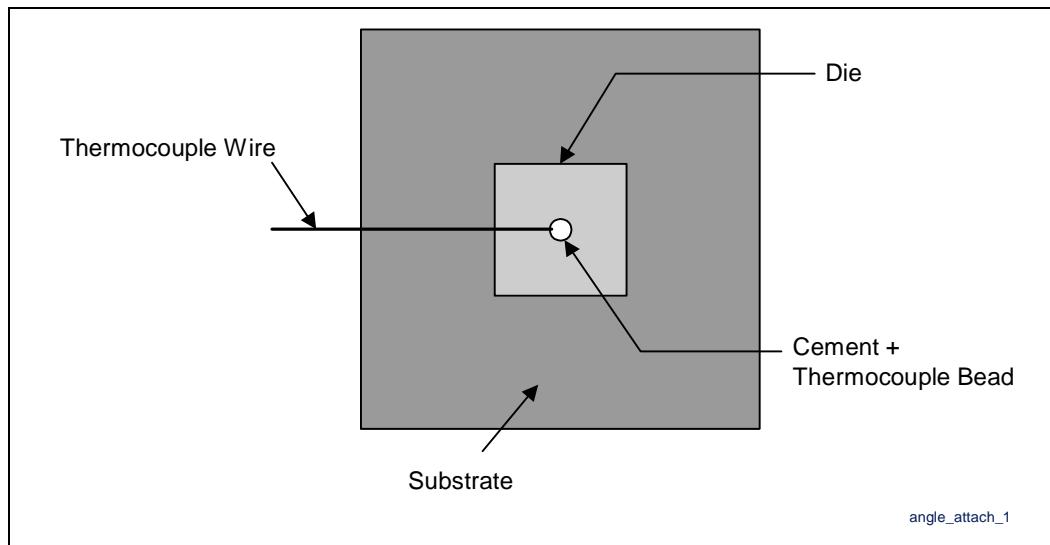
NOTE: Not to scale.

Figure 6. 0° Angle Attach Heatsink Modifications
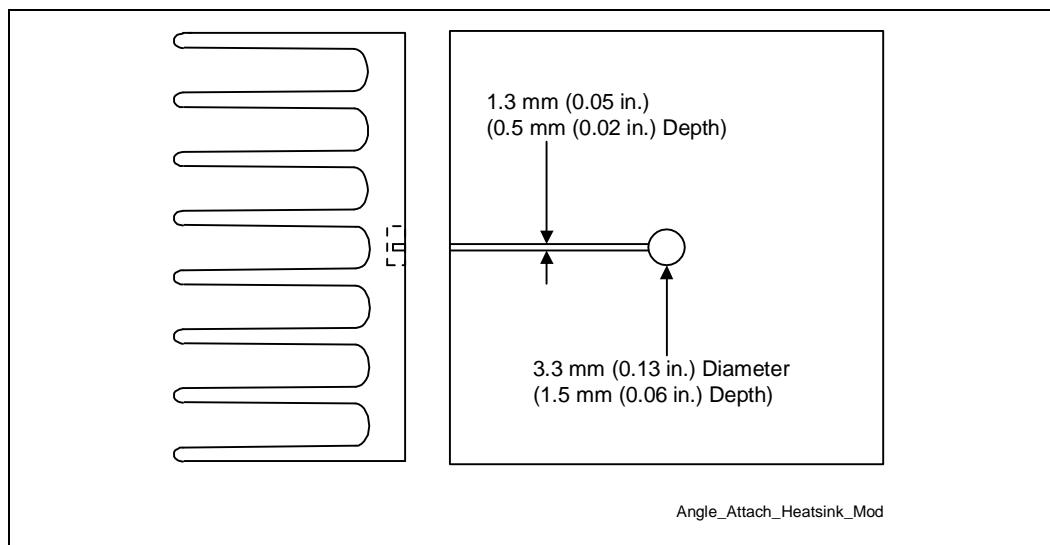
NOTE: Not to scale.

5.2 Power Simulation Software

The power simulation software is a utility designed to dissipate the thermal design power on a MCH when used in conjunction with an Intel® Xeon™ processor with 512-KB L2 cache. The combination of the Intel® Xeon™ processor with 512-KB L2 cache and the higher bandwidth capability of the E7500 chipset enables new levels of system performance. To assess the thermal performance of an MCH thermal solution under "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 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. Thermal Solution Decision Flowchart
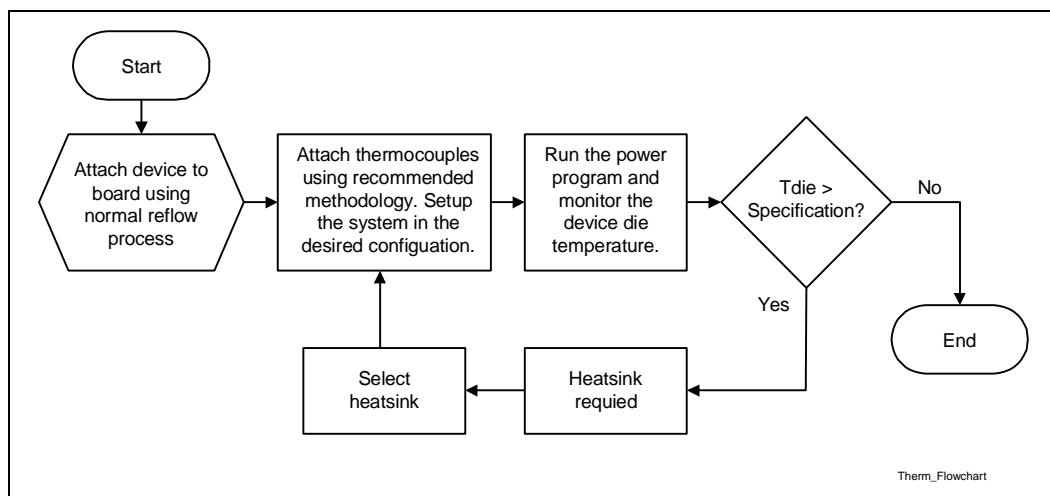
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6   *Reference Thermal Solutions*

Intel has developed a reference thermal solution designed to meet the cooling needs of the MCH at worst-case conditions. This chapter describes the overall requirements for the reference thermal solution, including critical-to-function dimensions, operating environment, and validation criteria. Other chipset components may or may not need thermal solutions, depending on specific system local-ambient operating conditions. For information on the P64H2 thermal solutions, refer to the *Intel® 82870P2 PCI/PCI-X 64-bit Hub 2 (P64H2) Thermal and Mechanical Design Guidelines*.

6.1   Operating Environment

The reference thermal solution was designed assuming a maximum local-ambient temperature of 50°C. The minimum recommended airflow velocity at the heatsink is 200 lfm (linear feet per minute). The approaching airflow temperature is assumed to be equal to the local-ambient temperature. The thermal designer must carefully select the location to measure airflow to obtain an accurate estimate. These local-ambient conditions are based on a 35 °C external-ambient temperature at sea level. (External-ambient refers to the environment external to the system.)

6.2   Mechanical Design Envelope

Though each design may have unique mechanical volume and height restrictions or implementation requirements, the height, width, and depth constraints typically placed on the E7500 MCH thermal solution is shown in Figure 8.

When using heatsinks that extend beyond the MCH reference heatsink envelope shown in Figure 8, any motherboard components placed between the heatsink and motherboard cannot exceed 2.286 mm (0.090 in.) in height.

Figure 8. Reference Heatsink Volumetric Envelope for the MCH

40 mm (1.6
(Tall

28 mm (1.1
(Short

Keep-out
Above
Motherboa

Motherboa

MCH

42.5 mm (1.67

42.5
(1.67

42.5 mm (1.67

Heatsink_Volumetric_Envelope

NOTE: Not to scale.

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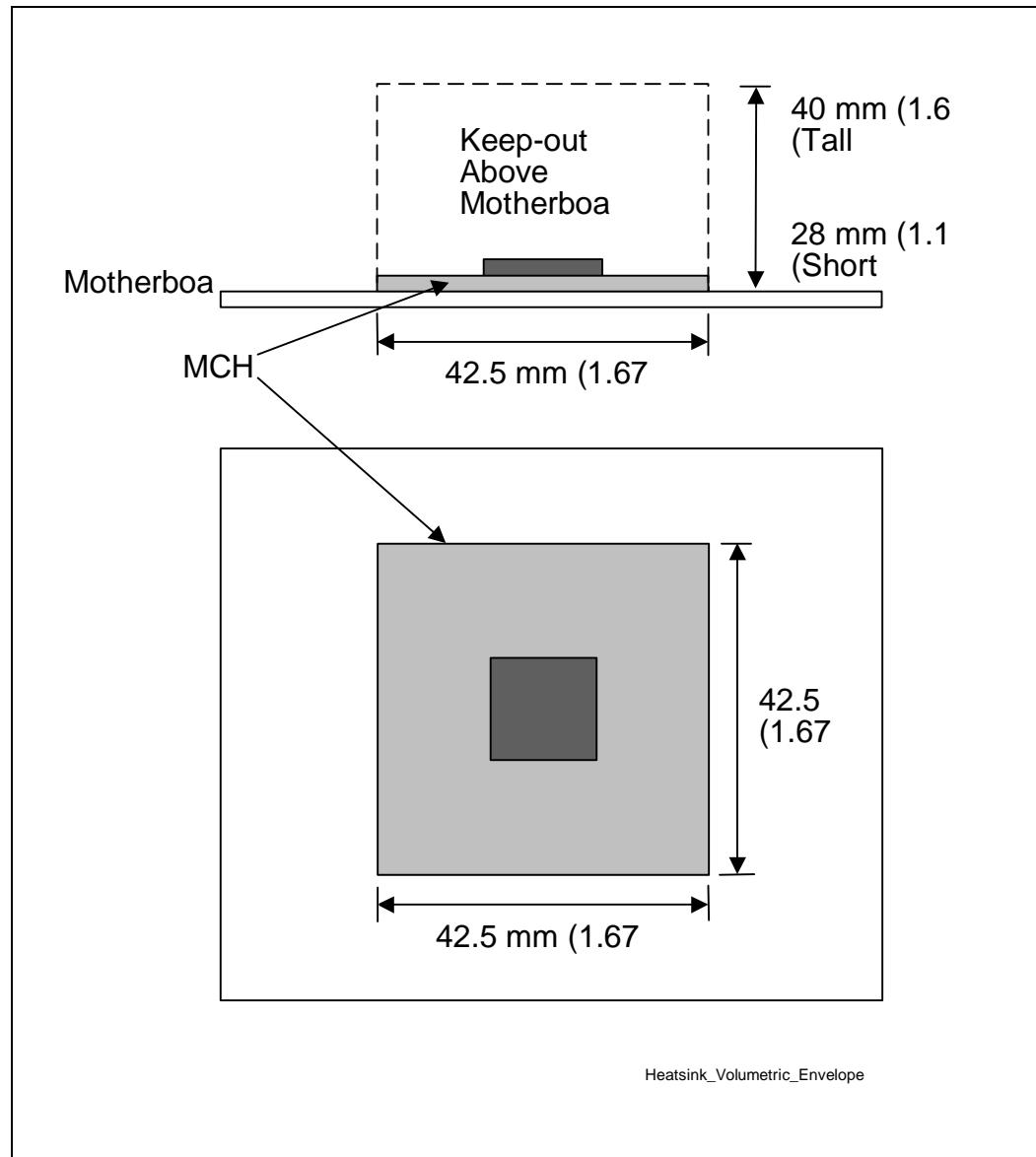
6.3 Thermal Solution Assembly

The reference thermal solution is a passive extruded heatsink with thermal and mechanical interfaces. It is attached using a clip with each end hooked through an anchor soldered to the board. Figure 9 shows the reference thermal solution assembly and associated components.

Figure 9 and Figure 10 show alternate views of the reference solution. Full mechanical drawings of the thermal solution assembly and the heatsink clip are provided in Appendix B.

Appendix A contains vendor information for each thermal solution component.

Figure 9. Reference Thermal Solution Assembly

ref_therm_solution_assy
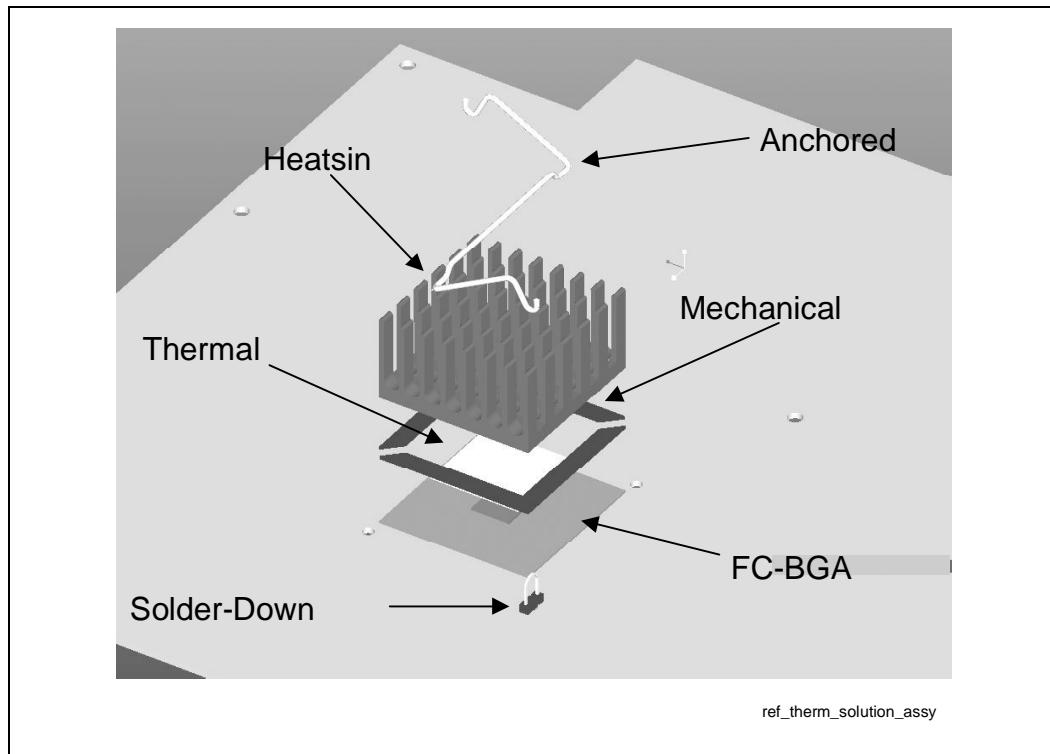
Figure 10. Reference Thermal Solution Assembly (Side View)
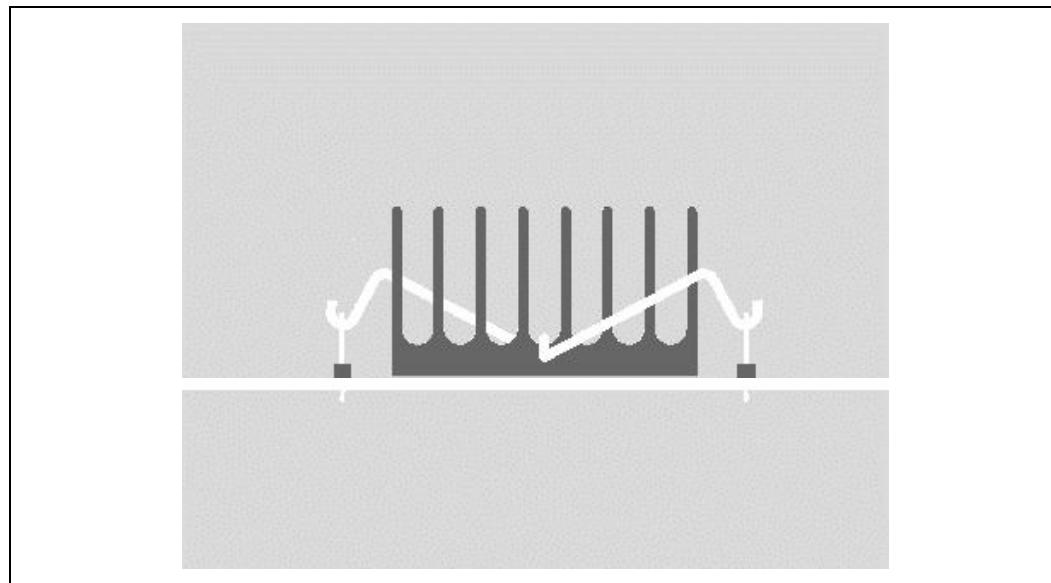
Figure 11. Reference Thermal Solution (Top View)

Ref_Thermal_Solution

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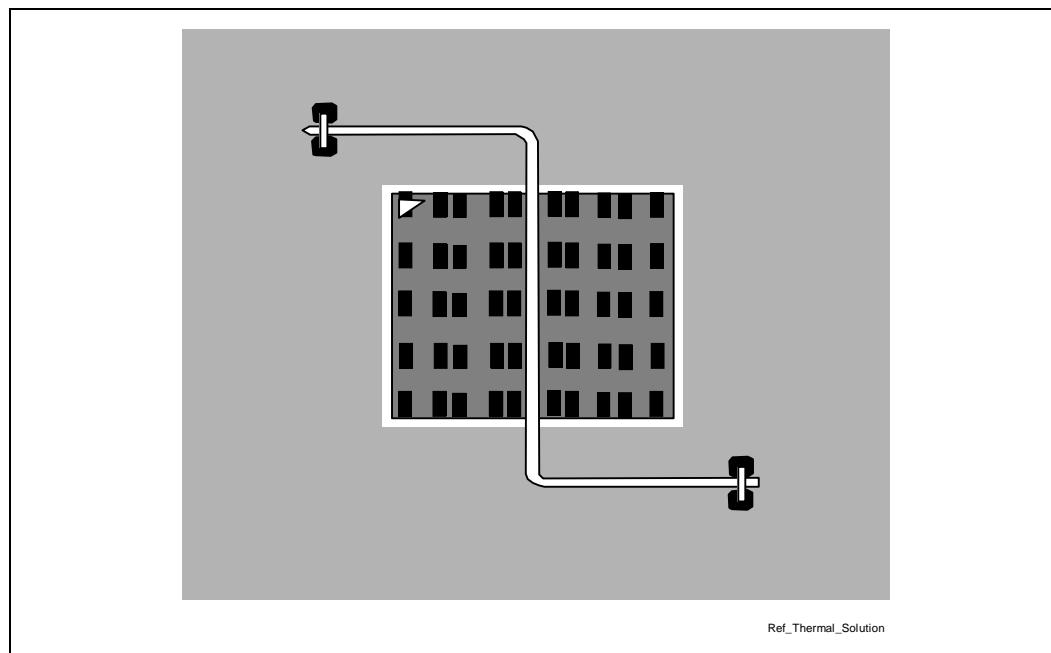
6.3.1   Heatsink Orientations

To enhance the efficiency of the reference thermal solution, it is important for the designer to orient the fins properly with respect to the mean airflow direction. Simulation and experimental evidence have shown that the MCH heatsink thermal performance is enhanced when the fins are aligned with the mean airflow direction (Figure 12). Aligning the heatsink 45° relative to the airflow is acceptable but delivers reduced thermal performance.

Figure 12. Preferred Heatsink Orientation
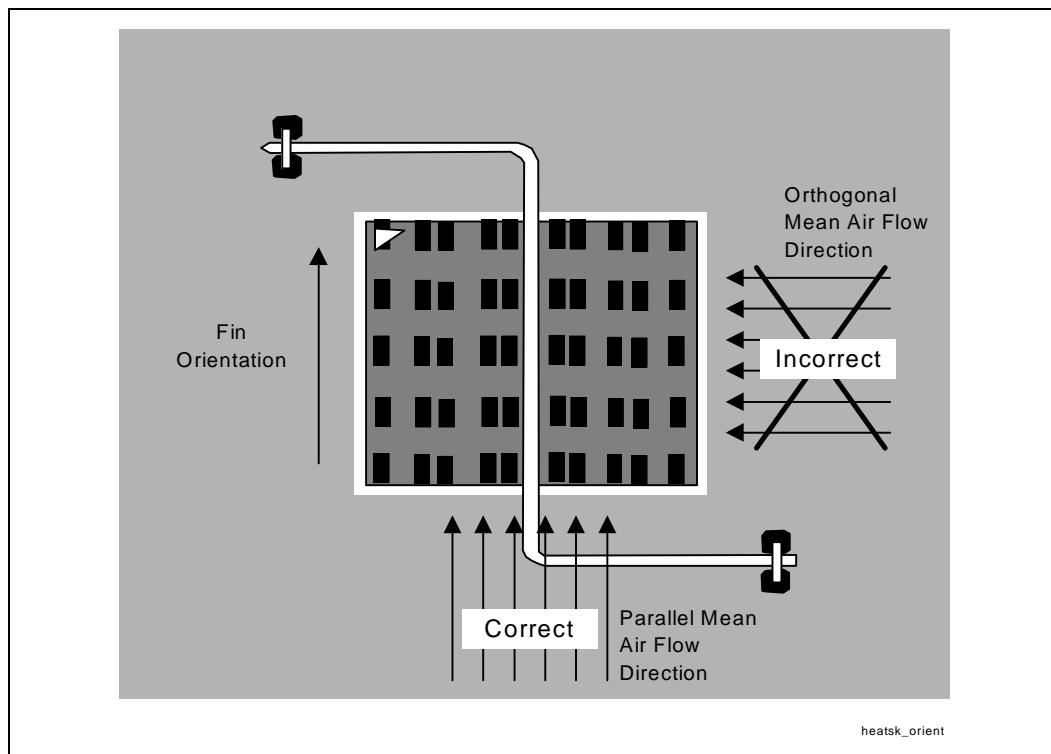
6.3.2 Extruded Heatsink Profiles

The E7500 chipset reference thermal solution uses an extruded heatsink for cooling the MCH. Figure 13 shows the heatsink profile. This document does not provide tolerance information. Check with your heatsink supplier for specific tolerances. Appendix A lists suppliers for the extruded heatsink. Other heatsinks with similar dimensions and increased thermal performance may be available, including the tall heatsink shown in Figure 14. Contact your heatsink supplier for information on alternate heatsinks.

Figure 13. Extruded Heatsink Profile

3.05 mm (0.120 in.)

23.01 mm (0.906 in.)

42.34 mm (1.67 in.)

Extr_Heasink_Profile
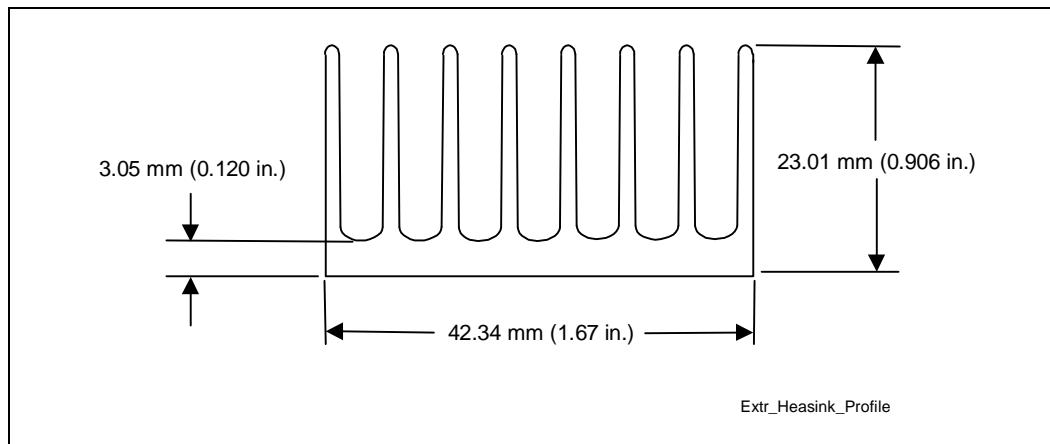
NOTE: Not to scale.

Figure 14. Alternate Tall Heatsink Profile

3.81 mm (0.150 in.)

35.00 mm (1.38 in.)

42.34 mm (1.67 in.)

Alt_Extr_Heatsink_Profile
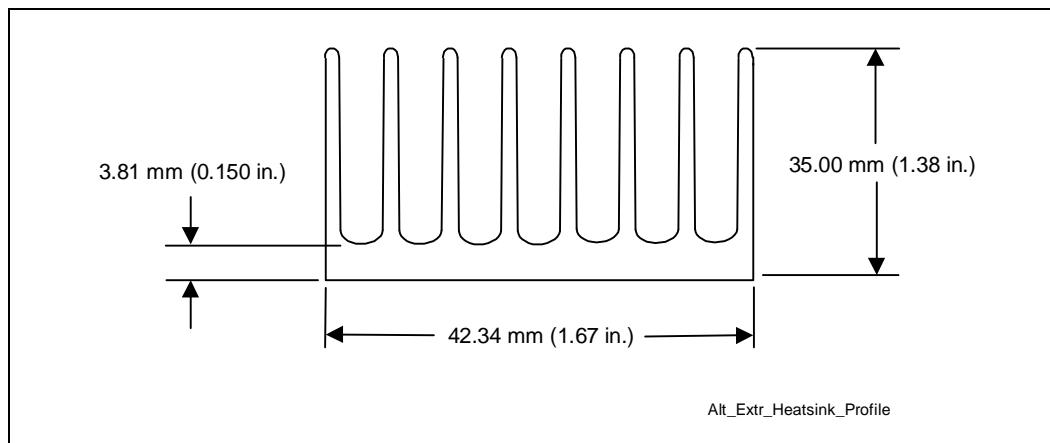
NOTE: Not to scale.

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6.3.3   Mechanical Interface Material

Intel recommends the use of a mechanical interface material to avoid cracking of the exposed die under loading. The interface material reduces mechanical loads experienced by the die. The reference thermal solution uses a picture frame gasket of 0.813 mm (0.032 in.) thick Poron* foam. The foam gasket is a two-piece design with diagonal cuts at two corners as shown in Figure 15. A one-piece gasket design may be used instead without any impact to mechanical performance.

Figure 15. Heatsink Mechanical Gasket, Optional Two-Piece

42.34 mm (1.667 in.)

42.34 mm (1.667 in.)

33.20 mm (1.307 in.)

33.20 mm (1.307 in.)

0.81 mm (0.032 in.)

Heatsink_Gasket
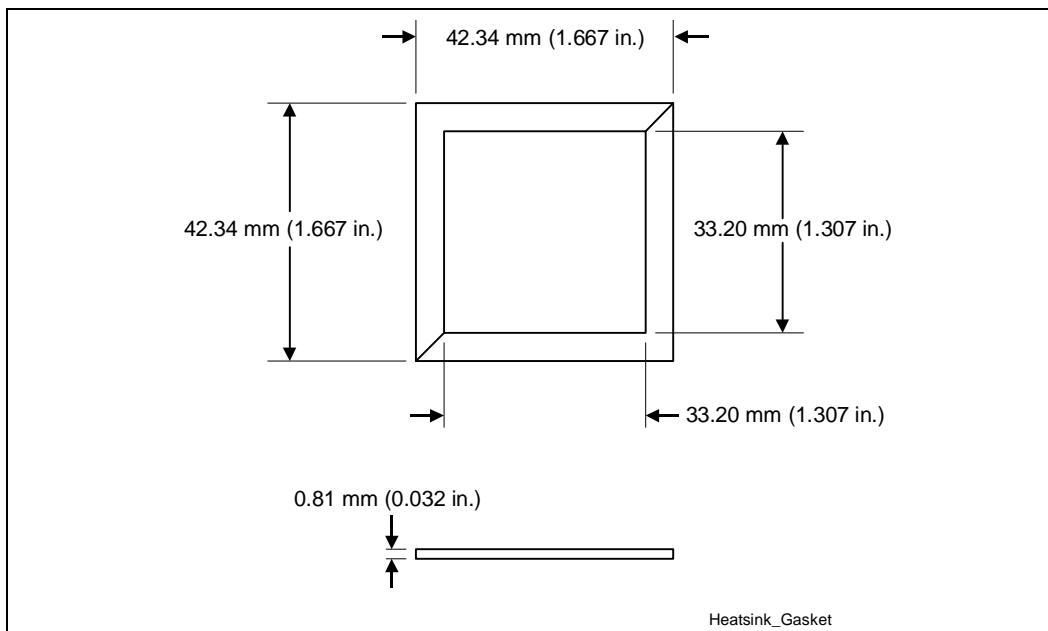
NOTE: Not to scale.

6.3.4   Thermal Interface Material

A thermal interface material provides improved conductivity between the die and heatsink. The reference thermal solution uses Chomerics* T-710, 0.127 mm (0.005 in.) thick, 25.4 mm x 25.4 mm (1.0 in. x 1.0 in.) square.

6.3.5   Heatsink Clip

The reference solution uses a wire clip with hooked ends. The hooks attach to wire anchors to fasten the clip to the board. See Figure 19 in Appendix B for a mechanical drawing of the clip.

6.3.6   Clip Retention Anchors

For E7500 chipset-based platforms that have very limited board space, a clip retention anchor has been developed to minimize the impact of clip retention on the board. It is based on a standard three-pin jumper and is soldered to the board like any common through-hole header. A new anchor design is available with 45° bent leads to increase the anchor attach reliability over time. See Appendix A for the part number and supplier information.

6.3.7   Board Level Component Keep-out Dimensions

The locations of hole patterns and keep-out zones for the reference thermal solution are shown in Figure 16 and Figure 17.

Figure 16. Heatsink Retention Mechanism Layout

NOTES:
1. Dimensions are in inches.
2. Not to scale.

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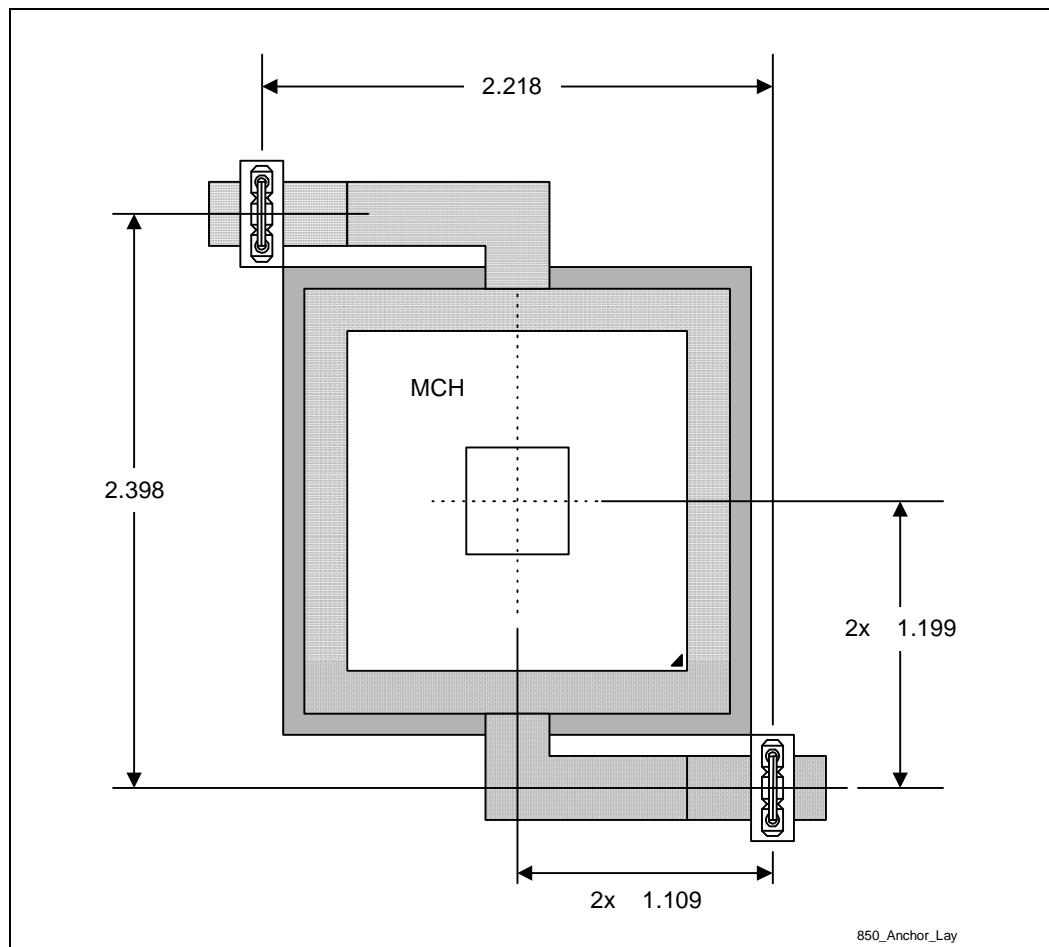
Figure 17. Retention Mechanism Component Keep-out Zones

NOTES:
1. Dimensions are in inches.
2. Not to scale.

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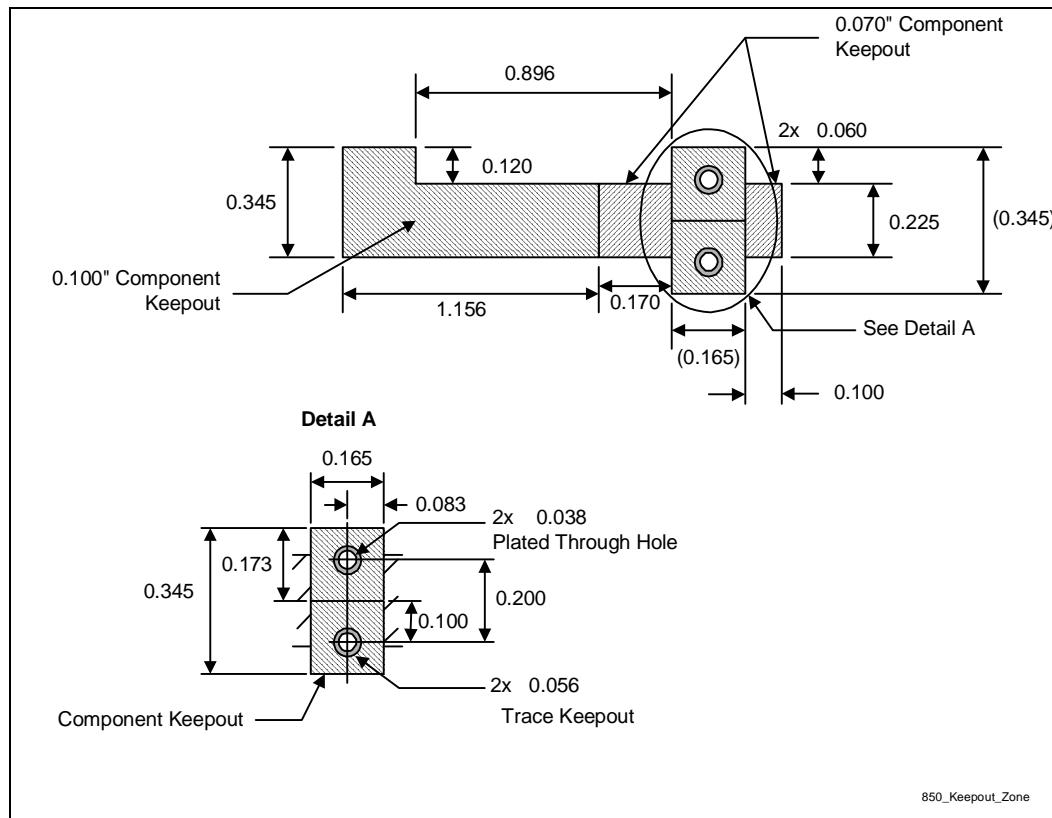
6.4   Reliability Requirements

Each motherboard, heatsink and attach combination may vary the mechanical loading of the component. The user should carefully evaluate the reliability of the completed assembly prior to use in high volume. Some general recommendations are shown in Table 2.

Table 2. Reliability Requirements

Test	Requirement	Pass/Fail Criteria
Mechanical Shock	50 g, board level, 11 msec, 3 shocks/axis	Visual Check and Electrical Functional Test
Random Vibration	7.3 g, board level, 45 min/axis, 50 Hz to 2000 Hz	Visual Check and Electrical Functional Test
Temperature Life	85 °C, 2000 hours total, checkpoints at 168, 500, 1000, and 2000 hours	Visual Check
Thermal Cycling	-5 °C to +70 °C, 500 cycles	Visual Check
Humidity	85% relative humidity, 55 °C, 1000 hours	Visual Check

NOTES:

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

Appendix A: Thermal Solution Component Suppliers

Table 3. Complete Thermal Solution Kits

Part	Intel Part Number	Supplier	Contact Information
Pin Fin Heatsink Kit (31gm, 42 x 42 x 23 mm)	A69225-001	CCI	Dr. Dah-Chyi (DC) Kuo 886-2-2995-2666, x131 kuo@ccic.com.tw
		Foxconn	Bob Hall (503) 693-3509, x235 bhall@foxconn.com
Alternate Pin Fin Heatsink Kit (43gm, 42 x 42 x 35 mm)	A69225-002	CCI	Dr. Dah-Chyi (DC) Kuo 886-2-2995-2666, x131 kuo@ccic.com.tw
		Foxconn	Bob Hall (503) 693-3509, x235 bhall@foxconn.com

Table 4. Extruded Heatsinks

Part	Intel Part Number	Supplier	Contact Information
Pin Fin Heatsink Kit (31gm, 42 x 42 x 23 mm)	A20930-001	CCI	Dr. Dah-Chyi (DC) Kuo 886-2-2995-2666, x131 kuo@ccic.com.tw
		Foxconn	Bob Hall (503) 693-3509, x235 bhall@foxconn.com
Alternate Pin Fin Heatsink Kit (43gm, 42 x 42 x 35 mm)	A13506-001	CCI	Dr. Dah-Chyi (DC) Kuo 886-2-2995-2666, x131 kuo@ccic.com.tw
		Foxconn	Bob Hall (503) 693-3509, x235 bhall@foxconn.com

Table 5. Interface Materials

Part	Intel Part Number	Supplier (Part Number)	Contact Information
Thermal Interface (T-710)	—	Chomerics (69-12-22315-T710)	Todd Sousa (360) 891-2018 tsousa@parker.com
Mechanical Interface (Poron*)	A69141-001	Boyd	Rhoda Kennedy (503) 972-3170

Table 6. Attach Hardware

Part	Intel Part Number	Supplier	Contact Information
Heatsink Attach Clip	A69230-001	CCI	Dr. Dah-Chyi (DC) Kuo 886-2-2995-2666, x131 kuo@ccic.com.tw
		Foxconn	Bob Hall (503) 693-3509, x235 bhall@foxconn.com
Solder-Down Anchor	A13494-005	Foxconn	Julia Jiang (408) 919-6178 juliaj@foxconn.com

Note: The enabled components may not be currently available from all suppliers. Contact the supplier directly to verify time of component availability.

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Appendix B: Mechanical Drawings

This appendix contains the following drawings:

- MCH Heatsink Assembly

- MCH Heatsink Clip

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Figure 18. MCH Heatsink Assembly

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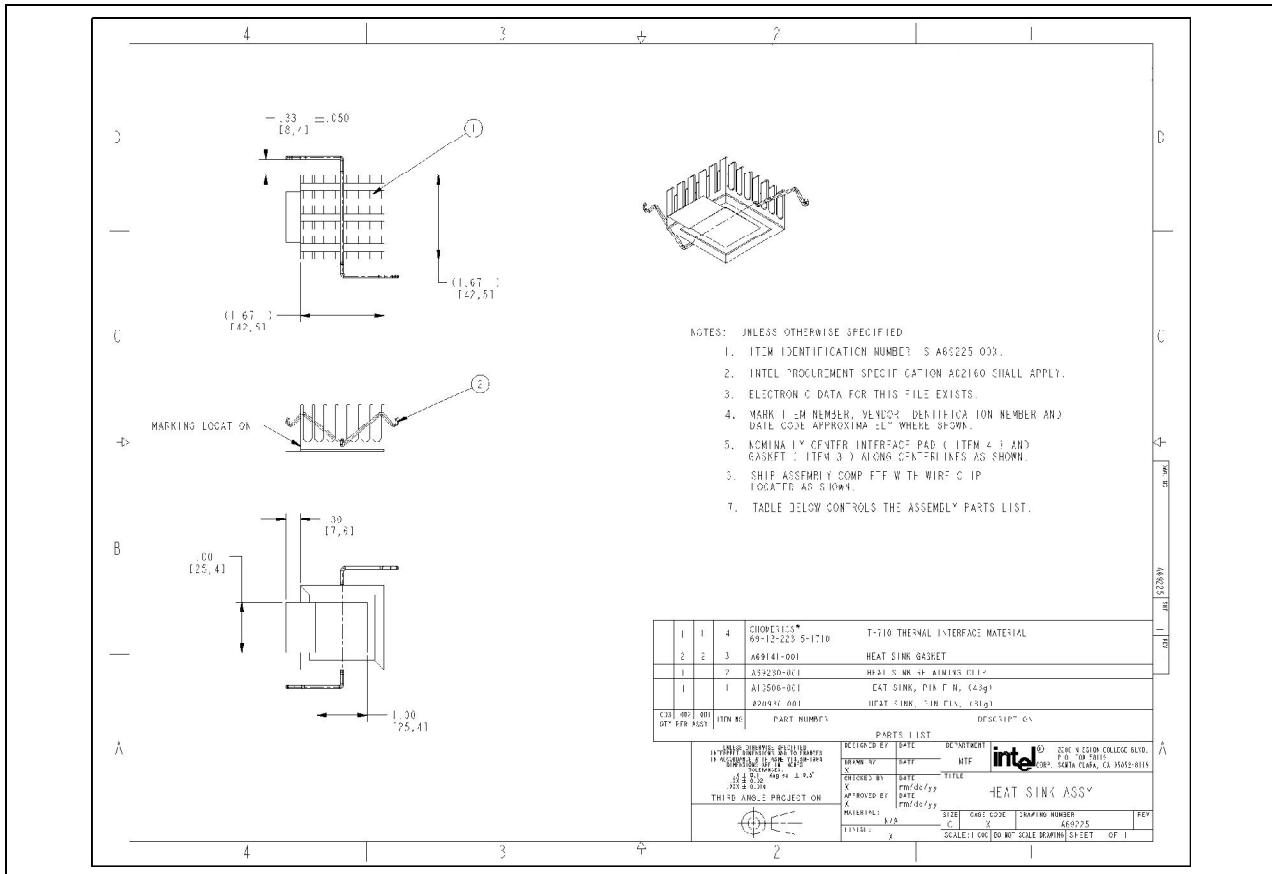
Figure 19. MCH Heatsink Clip