Intel® 875P Chipset

Thermal/Mechanical Design Guidelines

For the Intel® 82875P Memory Controller Hub (MCH)

April 2004

Document Number: 252528-003

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Revision History

Revision Number	Description	Date
-001	• Initial Release	April 2003
-002	• Added processor support to the 875P chipset for the Intel® Pentium® 4 processor Extreme Edition supporting Hyper-Threading Technology and the Intel® Pentium® 4 processor on 90 nm process.	February 2004
-003	• Re-titled from "Thermal Design Guide" to "Thermal/Mechanical Design Guidelines" due to additional package information added. • Updated definition for thermal design power in Section **Error! Reference source not found.** • Added BGA pre-SMT vs. post-SMT height information in Section 2. • Added package mechanical requirements in Section 2.1. • Updated thermal specification in Table 3. • Removal of all references to the I-Beam heatsink reference thermal solution due to long term reliability concern. • Removal of the torsional clip heatsink reference solution due to solder joint reliability concern in a non-direct chassis attach motherboard environment • Updated heatsink volumetric envelope information for both remaining reference thermal solutions.	April 2004

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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. Typical methods to improve heat dissipation include selective use of ducting, and/or passive heatsinks.

The goals of this document are to:

- Outline the thermal and Mechanical operating limits and specifications for the Intel® 875P chipset memory controller hub (82875P MCH).
- Describe a reference thermal solution that meets the specification of the Intel® 875P chipset memory controller hub (82875P MCH).

Properly designed thermal solutions provide adequate cooling to maintain the MCH die temperatures at or below 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 at or below the specified limits, a system designer can ensure the proper functionality, performance, and reliability of the chipset. Operation outside the functional limits can degrade system performance and may cause permanent changes in the operating characteristics of the component.

The simplest and most cost effective method to improve the inherent system cooling characteristics 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.

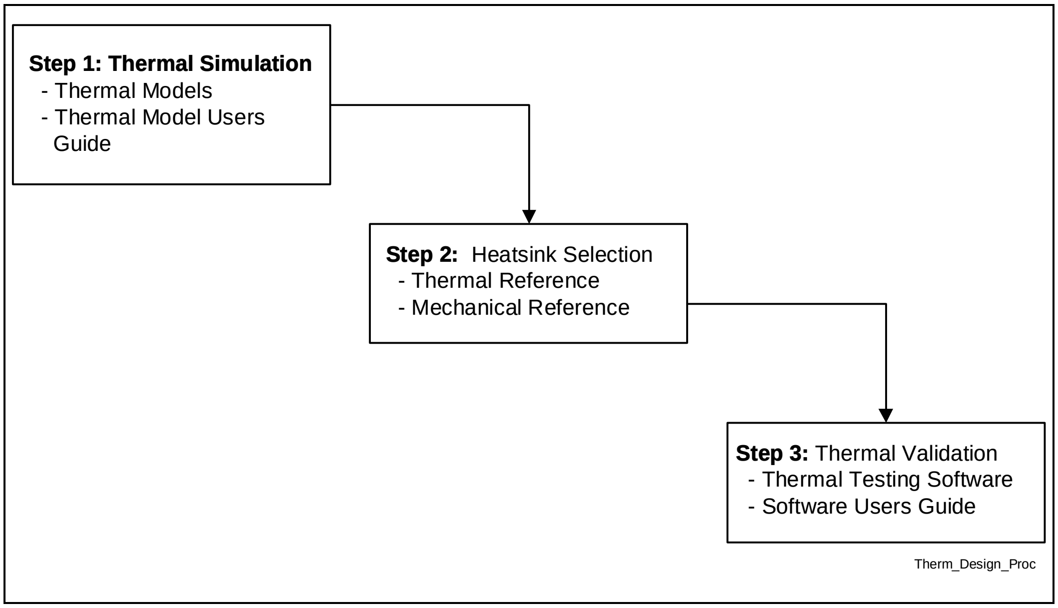
This document addresses thermal design specifications for the 82875P MCH component only. For thermal design information on other chipset components, refer to the respective component datasheet. For the ICH5/ICH5R, refer to the *Intel® 82801EB I/O Controller Hub 5 (ICH5) and Intel® 82801ER I/O Controller Hub 5R (ICH5R) Thermal Design Guide.*

Note: Unless otherwise specified, the term “MCH” refers to the 875P Chipset MCH.

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



1.2 Definition of Terms

Table 1. Terms and Definitions

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.
ICH5	I/O controller hub. The chipset component that contains the primary PCI interface, LPC interface, USB, SATA, and other legacy functions.
MCH	Memory Controller Hub. The chipset component that contains the processor interface and the memory interface.
T_{case_max}	Maximum die temperature allows. This temperature is measured at the geometric center of the top of the package die.
T_{case_min}	Minimum die temperature allows. 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. TDP is not the maximum power that the chipset can dissipate.

1.3 Reference Documents

Table 2. Reference Documents

Document	Document Number / Location
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: Intel® 82875P Memory Controller Hub (MCH) Datasheet	http://developer.intel.com/design/chipsets/datashts/252525.htm
Intel® 875P Chipset Platform Design Guide	http://developer.intel.com/design/chipsets/designex/252527.htm
BGA/OLGA Assembly Development Guide	Note 1
Thermal Design Suggestions for various form factors	http://www.formfactors.org

NOTES:
Contact your Intel Field Sales representative.

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2 Packaging Technology

The 875P chipset consists of two individual components: the 82875P MCH is used for the host bridge, and either the 82801EB ICH5 or 82801ER ICH5R is used for the I/O controller hub. The 82875P MCH component uses a 42.5 mm, 8-layer FC-BGA package (see Figure 2, Figure 3, and Figure 4). For information on the ICH5/ICH5R package, refer to the *Intel® 82801EB I/O Controller Hub 5 (ICH5) and Intel® 82801ER I/O Controller Hub 5 R (ICH5R) Thermal Design Guide.*

Figure 2. Intel® 82875P MCH Package Dimensions (Top View)

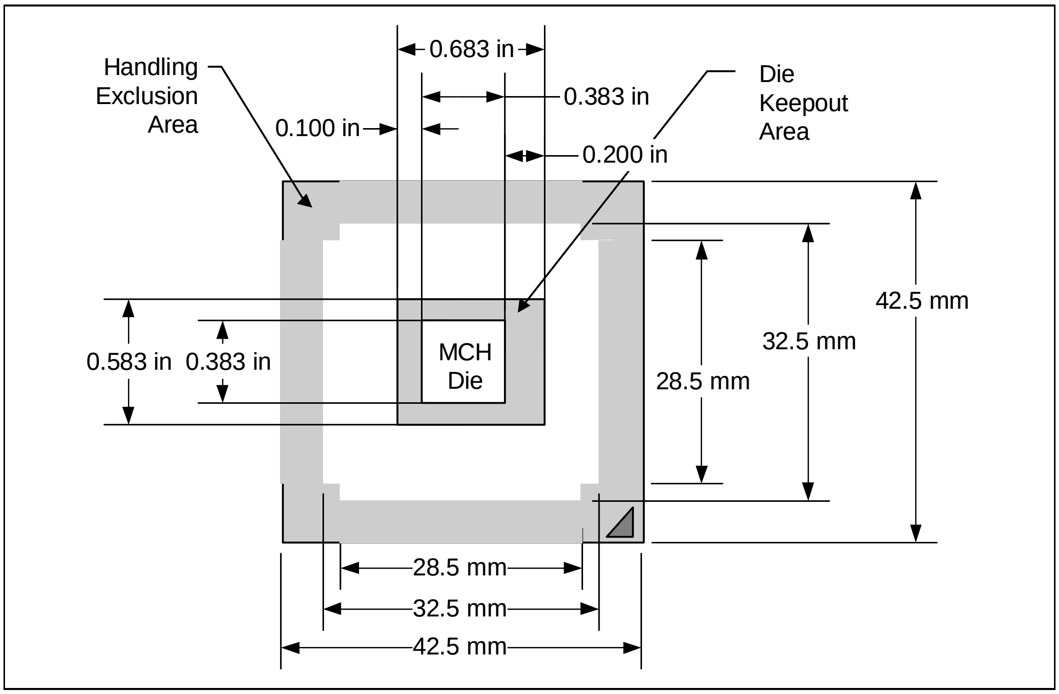


Figure 3. Intel® 82875P MCH Package Dimensions (Side View)

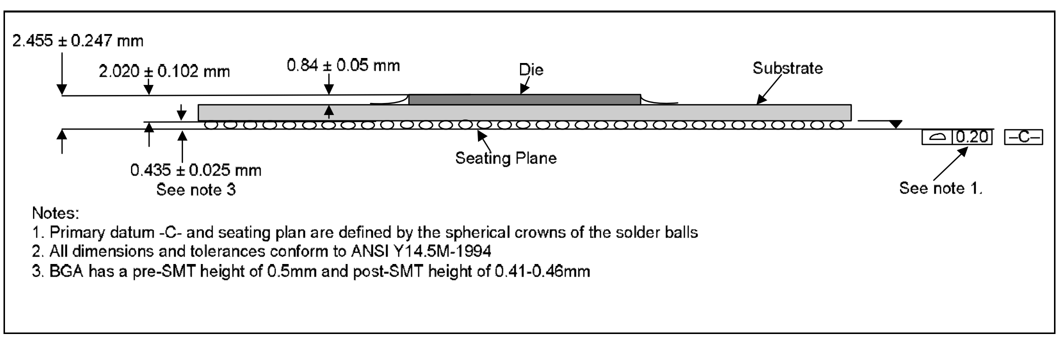
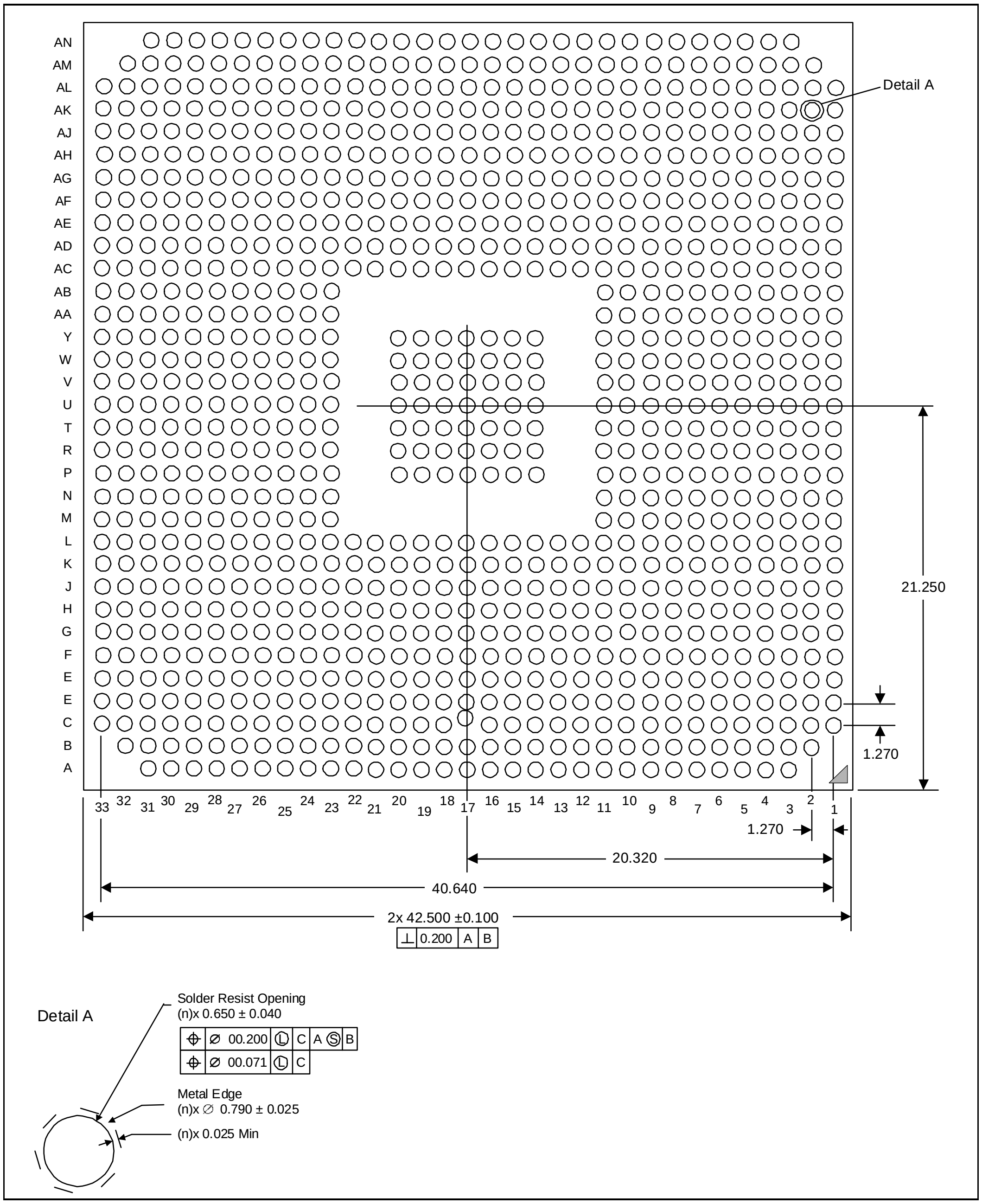


Figure 4. Intel® 82875P MCH Package Dimensions (Bottom View)



NOTES:

All dimensions are in millimeters.

All dimensions and tolerances conform to ANSI Y14.5M–1994.

2.1 Package Mechanical Requirements

The Intel® 82875P Memory Controller Hub (MCH) package has an exposed bare die which has mechanical load limits that should not be exceeded during heatsink installation, mechanical stress testing, and/or standard shipping conditions. The package is capable of sustaining a maximum static normal load of 15-lbf. The package is NOT capable of sustaining a dynamic or static compressive load applied to any edge of the bare die.

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3 Thermal Simulation

Intel provides thermal simulation models of the 82875P 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 guides.

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4 Thermal Specifications

4.1 Case Temperature and Thermal Design Power

See Table 3 for TDP specifications for the 82875P 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 a heatsink when using the 875P 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 in Table 3. System and/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 3. Intel® 82875P MCH Thermal Specifications

Parameter	Value
T_{case_max}	99 °C
T_{case_min}	0 °C
$TDP\_{dual\ channel}$	10.1 W
$TDP\_{single\ channel}$	10 W

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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 82875P MCH die temperature. Section 5.1 provides guidelines on how to accurately measure the 82875P 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 guidelines for thermal performance and evaluation.

5.1 Die Temperature Measurements

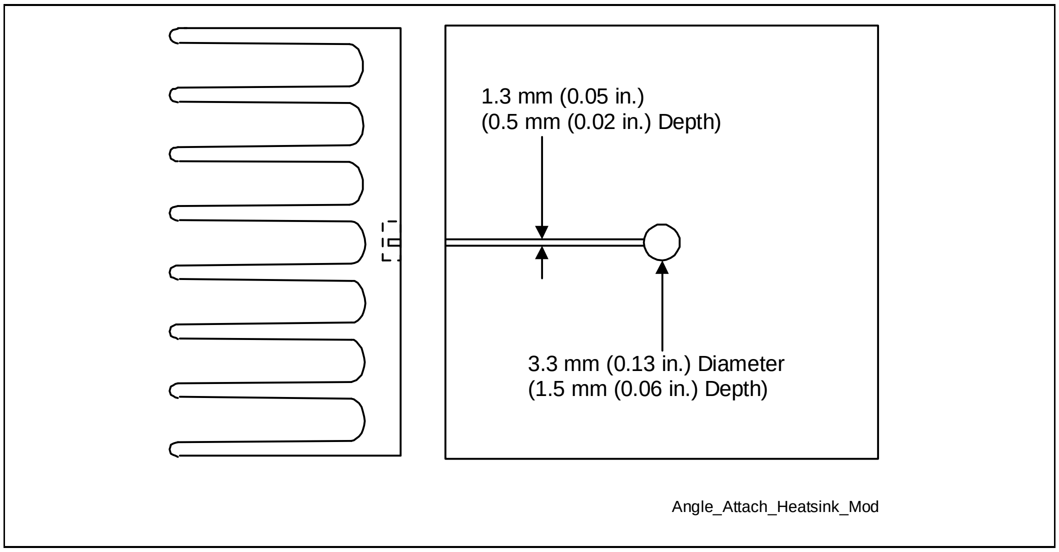
To ensure functionality and reliability, the T_{case} of the MCH must be maintained at or below the maximum temperatures specification as noted in Table 3. The surface temperature at the geometric center of the die corresponds to T_{case}. Measuring T_{case} requires special care to ensure an accurate temperature measurement.

Temperature differences between the temperature of a surface and the surrounding local ambient air can introduce errors 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, and/or contact between the thermocouple cement and the heatsink base (if a heatsink is used). For maximum measurement accuracy, only the 0° thermocouple attach approach is recommended for thermocouple attach.

5.1.1 0° Angle Attach Methodology

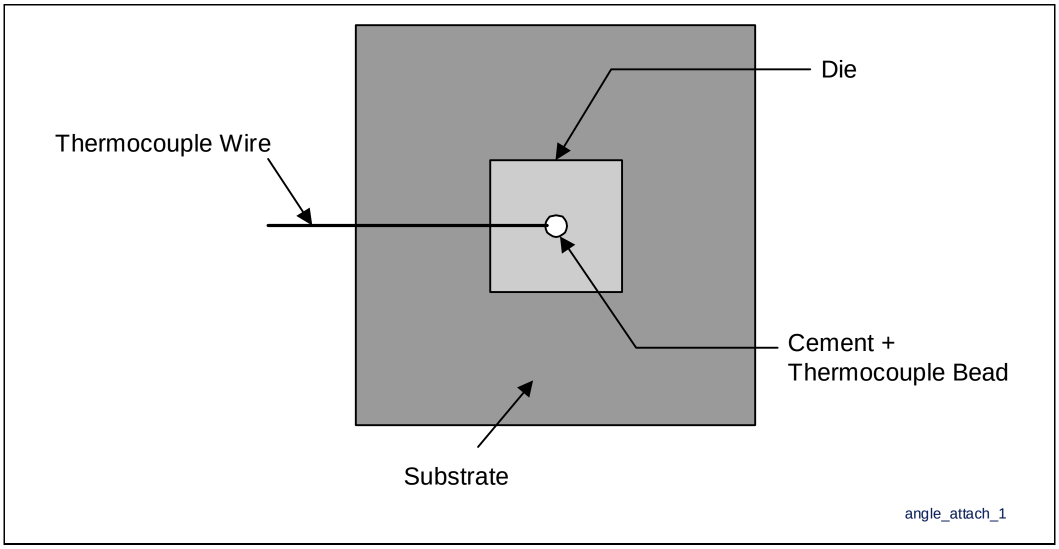
1. Mill a 3.3 mm (0.13 in.) diameter and 1.5 mm (0.06 in.) deep hole centered on bottom of the heatsink base.
2. Mill a 1.3 mm (0.05 in.) wide and 0.5 mm (0.02 in.) deep slot, from the centered hole to one edge of the heatsink. The slot should be in the direction parallel to the heatsink fins (see Figure 5).
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 6).
6. Attach heatsink assembly to the MCH and route thermocouple wire out through the milled slot.

Figure 5. 0° Angle Attach Heatsink Modifications



NOTE: Not to scale.

Figure 6. 0° Angle Attach Methodology (Top View)



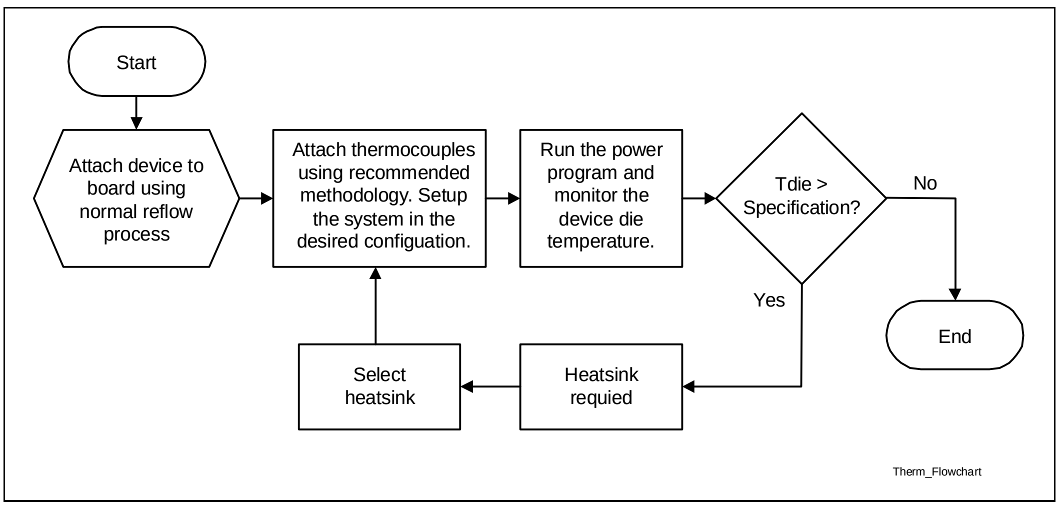
NOTE: Not to scale.

5.2 Power Simulation Software

The power simulation software is a utility designed to dissipate the thermal design power on the MCH when used in conjunction with the Intel® Pentium® 4 processor with 512-KB L2 cache on 0.13 micron process, the Intel® Pentium® 4 processor Extreme Edition supporting Hyper-Threading Technology, and the Intel® Pentium® 4 processor on 90 nm process. The combination of the above mentioned processor(s) and the higher bandwidth capability of the 875P chipset enables new levels of system performance. To assess the thermal performance of the MCH thermal solution under "worst-case realistic application" conditions, Intel has developed a software utility that operates the chipset at near worst-case thermal 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, please 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 Solution

Intel has developed a reference thermal solution designed to meet the cooling needs of the MCH under worst-case conditions. This chapter describes the overall requirements for the Wave Solder Heatsink (WSHS) reference thermal solution including critical-to-function dimensions, operating environment, and validation criteria. Other chipset components may or may not need attached thermal solutions, depending on your specific system local-ambient operating conditions. For information on the ICH5, refer to thermal specification in the *Intel® 82801EB I/O Controller Hub 5 (ICH5) and Intel® 82801ER I/O Controller Hub 5 R (ICH5R) Thermal Design Guide.*

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 150 linear feet per minute (lfm). 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

While each design may have unique mechanical volume and height restrictions or implementation requirements, the height, width, and depth constraints typically placed on the MCH thermal solution are 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.

6.3 Board-Level Component Keepout Dimensions

The location of hole patterns and keepout zones for the reference thermal solution are shown in Figure 9.

Figure 8. Wave Solder Heatsink Volumetric Envelope for the MCH

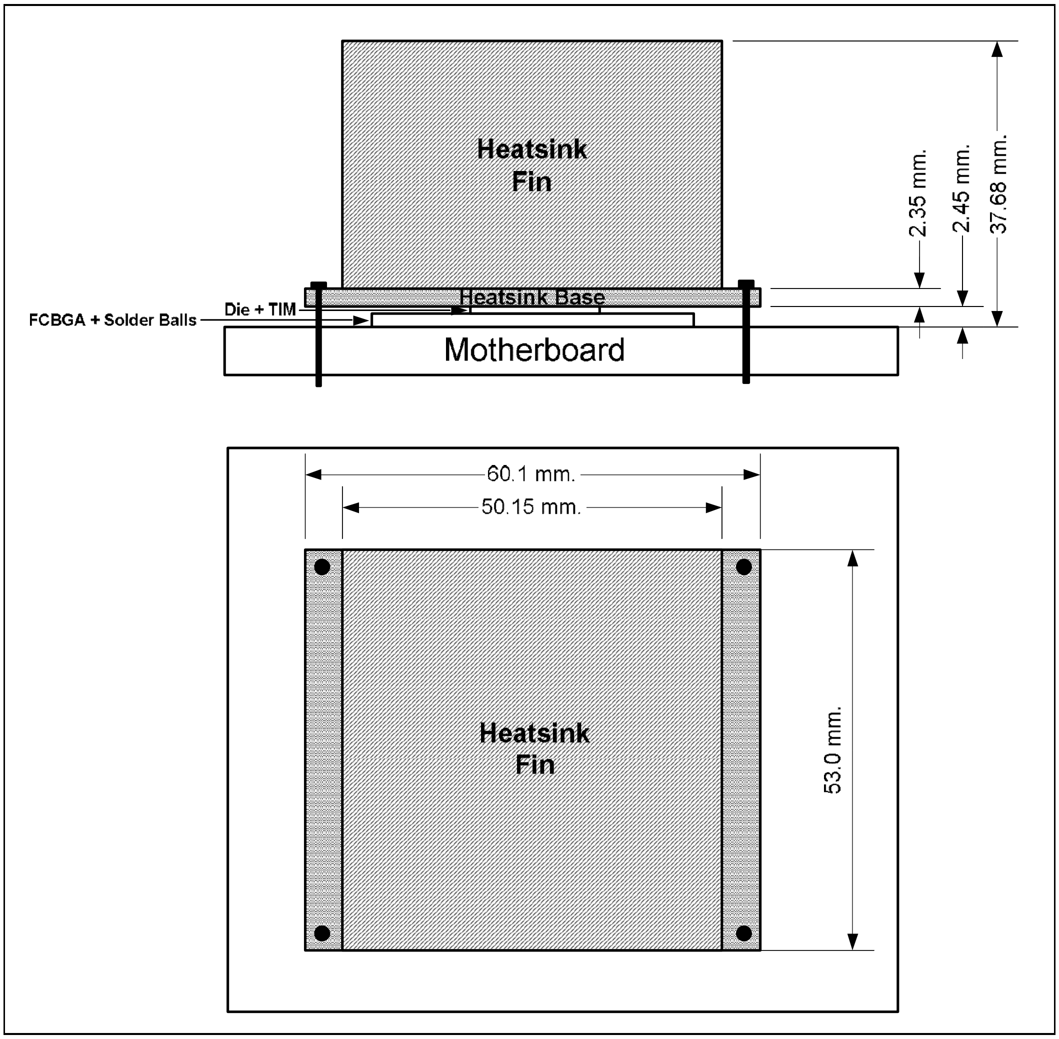
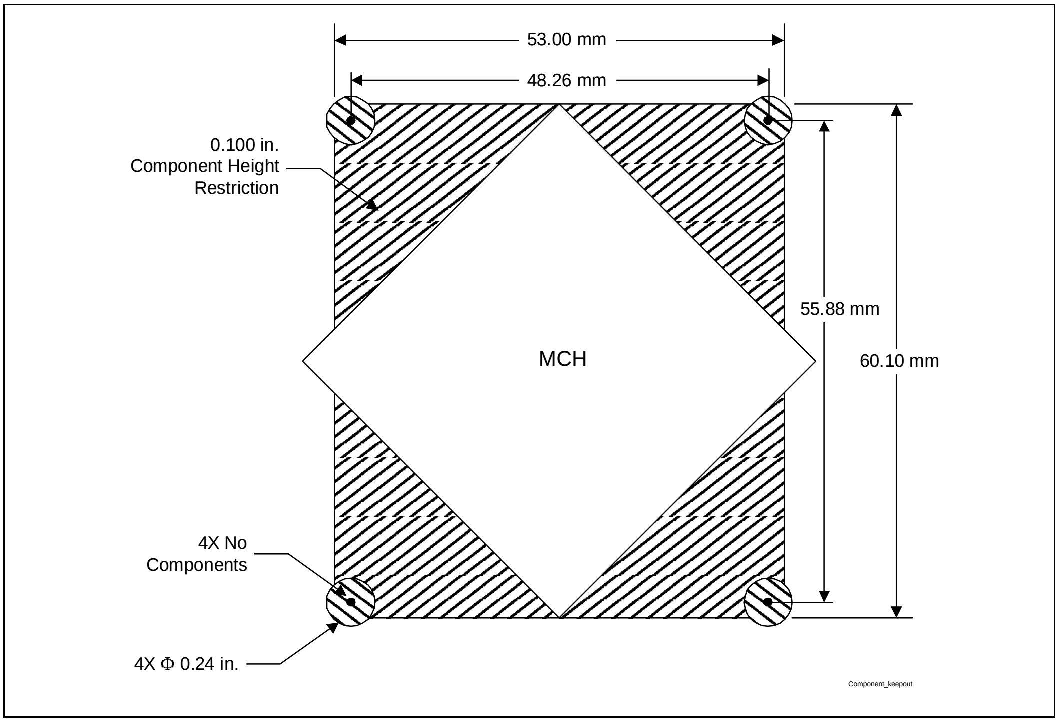


Figure 9. Wave Solder Heatsink Board Component Keepout

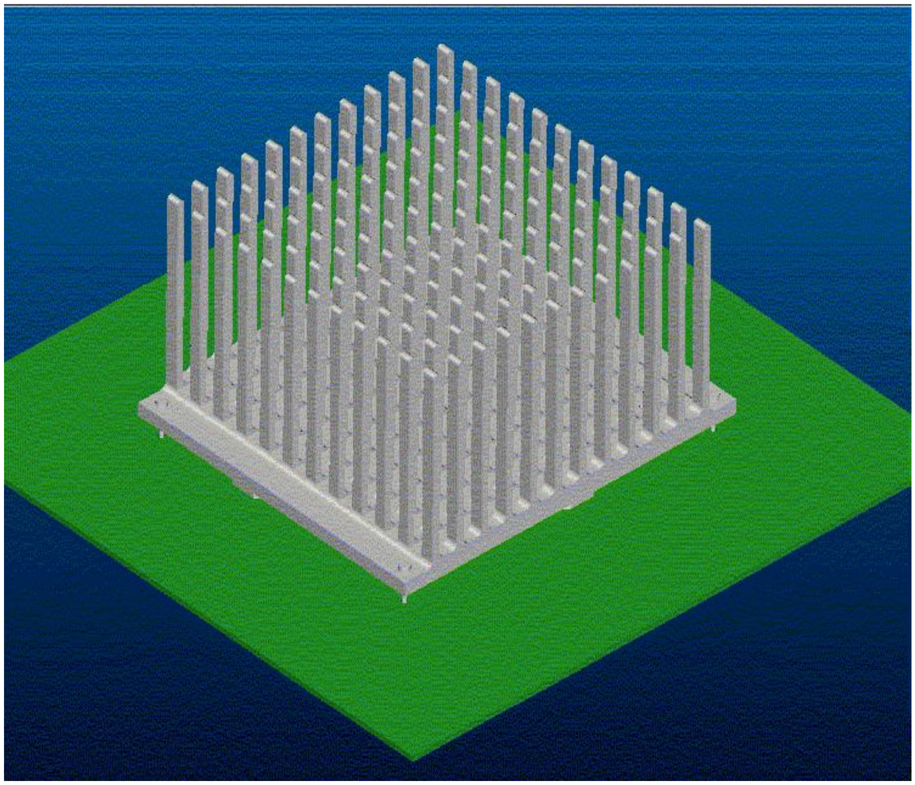


6.4 Wave Solder Heatsink Thermal Solution Assembly

The reference thermal solution consists of a passively cooled Wave Solder Heatsink (WSHS). The heatsink is comprised of an extruded aluminum heatsink with four mounting pins pressed into each corner of the heatsink base. A thermal interface material (Chomerics T-710*) is pre-applied to the heatsink bottom over an area in contact with the package die. A 45° diagonal cut is performed on the heatsink base to create rails to reduce the possibility of tilt when assembling the WSHS. Since the rails are oriented at 45° relative to the heatsink edges, the WSHS is only compatible with a MCH rotated 45° relative to the motherboard. Note that the rails do not touch the package substrate in the nominal position. The WSHS is shown in the installed configuration in Figure 10 (the MCH cannot be seen in this view as it is hidden by the WSHS base).

Full mechanical drawings of the thermal solution assembly and the mounting pins are provided in Appendix B. Appendix A contains vendor information for each thermal solution component.

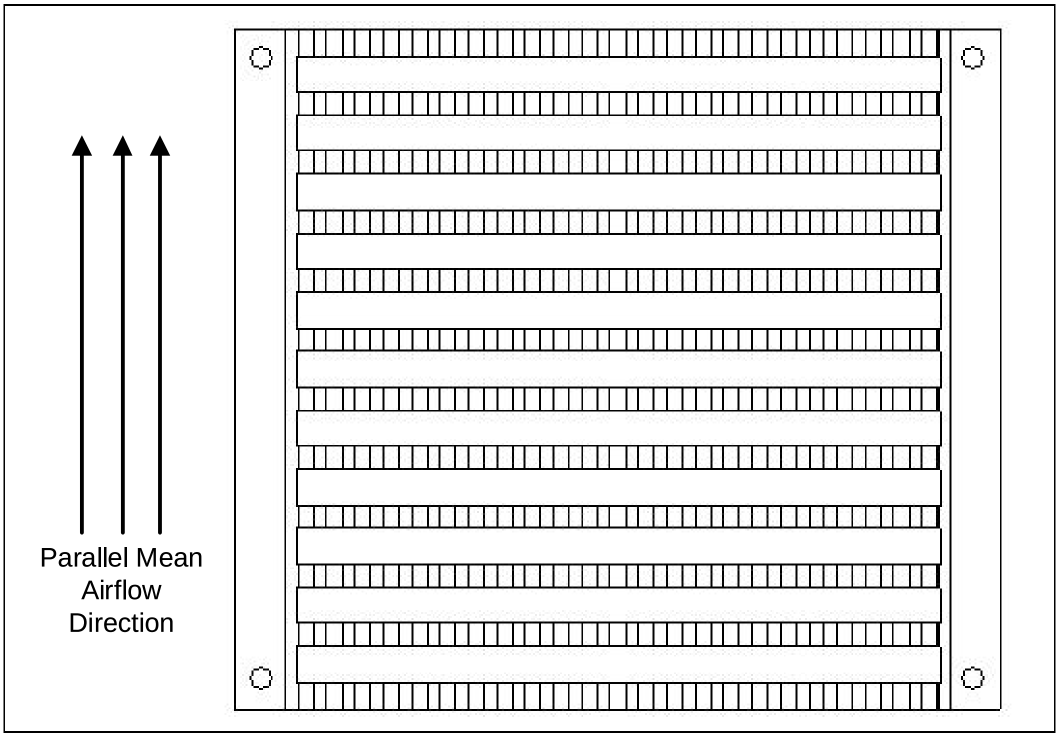
Figure 10. Wave Solder Heatsink Assembly



6.4.1 Heatsink Orientation

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 (see Figure 11).

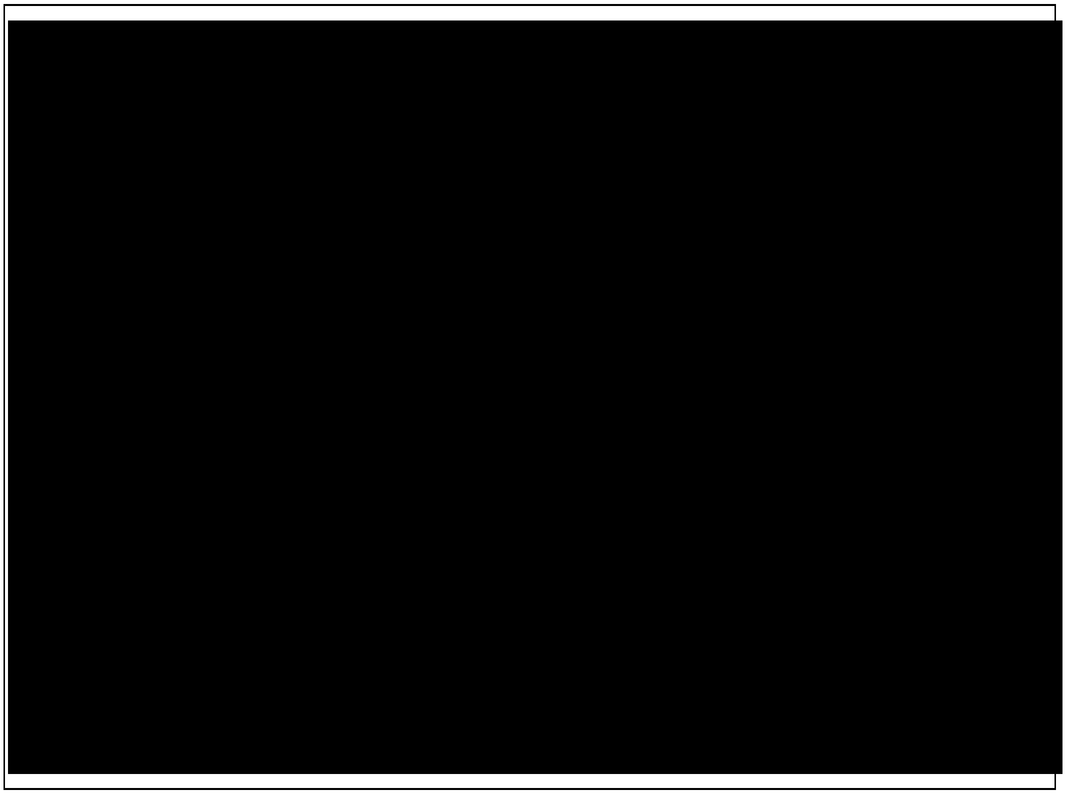
Figure 11. Preferred Heatsink Orientation



6.4.2 Extruded Heatsink Profiles

The reference thermal solution uses an extruded heatsink for cooling the MCH. Figure 12 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. Contact your heatsink supplier for information on alternate heatsinks.

Figure 12. Wave Solder Heatsink Extrusion Profile



6.4.3 Mechanical Interface Material

There is no mechanical interface material associated with this reference solution.

6.4.4 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, 19 mm x 19 mm (0.75 in. x 0.75 in.) square.

6.4.5 Heatsink Clip

There is no heatsink clip associated with this reference solution.

6.4.6 Clip Retention Anchors

There is no clip retention anchors associated with this reference solution.

6.5 Reliability Guidelines

Each motherboard, heatsink and attach combination may vary the mechanical loading of the component. Based on the end user environment, the user should define the appropriate reliability test criteria and carefully evaluate the completed assembly prior to use in high volume. Some general recommendations are shown in Table 4.

Table 4. Reliability Guidelines

Test (1)	Requirement	Pass/Fail Criteria (2)
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:

It is recommended that the above tests be performed on a sample size of at least twelve assemblies from three lots of material.

Additional pass/fail criteria may be added at the discretion of the user.

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Appendix A Thermal Solution Component Suppliers

Note: These vendors and devices are 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.

Table 5. Wave Solder Heatsink Thermal Solution

<table>
<tr><th>Part</th><th>Intel Part Number</th><th>Supplier
(Part Number)</th><th>Contact Information</th></tr>
<tr><td rowspan="2">Heatsink Assembly includes:
• Pin Fin Heatsink
• Solder Pin
• Thermal Interface Material</td><td rowspan="2">C19491-001</td><td>CCI/ACK</td><td>Harry Lin (USA)
714-739-5797
hlinack@aol.com
Monica Chih (Taiwan)
866-2-29952666, x131
monica_chih@ccic.com.tw</td></tr>
<tr><td>Foxconn</td><td>Kevin Tao (USA)
714-626-1278
kevintao@foxconn.com
Cheow-Kooi Lee (Taiwan)
604-6122122
leeck@foxconn.com</td></tr>
<tr><td rowspan="2">Pin Fin Heatsink
(No Solder Pin)</td><td rowspan="2">C19490-001</td><td>CCI/ACK</td><td>Harry Lin (USA)
714-739-5797
hlinack@aol.com
Monica Chih (Taiwan)
866-2-29952666, x131
monica_chih@ccic.com.tw</td></tr>
<tr><td>Foxconn</td><td>Kevin Tao (USA)
714-626-1278
kevintao@foxconn.com
Cheow-Kooi Lee (Taiwan)
604-6122122
leeck@foxconn.com</td></tr>
<tr><td>Thermal Interface
(T-710)</td><td>–</td><td>Chomerics
(69-12-22350-T710)</td><td>Todd Sousa (USA)
360-606-8171
tsousa@parker.com</td></tr>
</table>

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Appendix B Mechanical Drawings

This appendix contains the following drawings:

- Wave Solder Heatsink Assembly
- Wave Solder Heatsink Drawing
- Wave Solder Heatsink Mounting Pin

Figure 13. MCH Wave Solder Heatsink Assembly Drawing

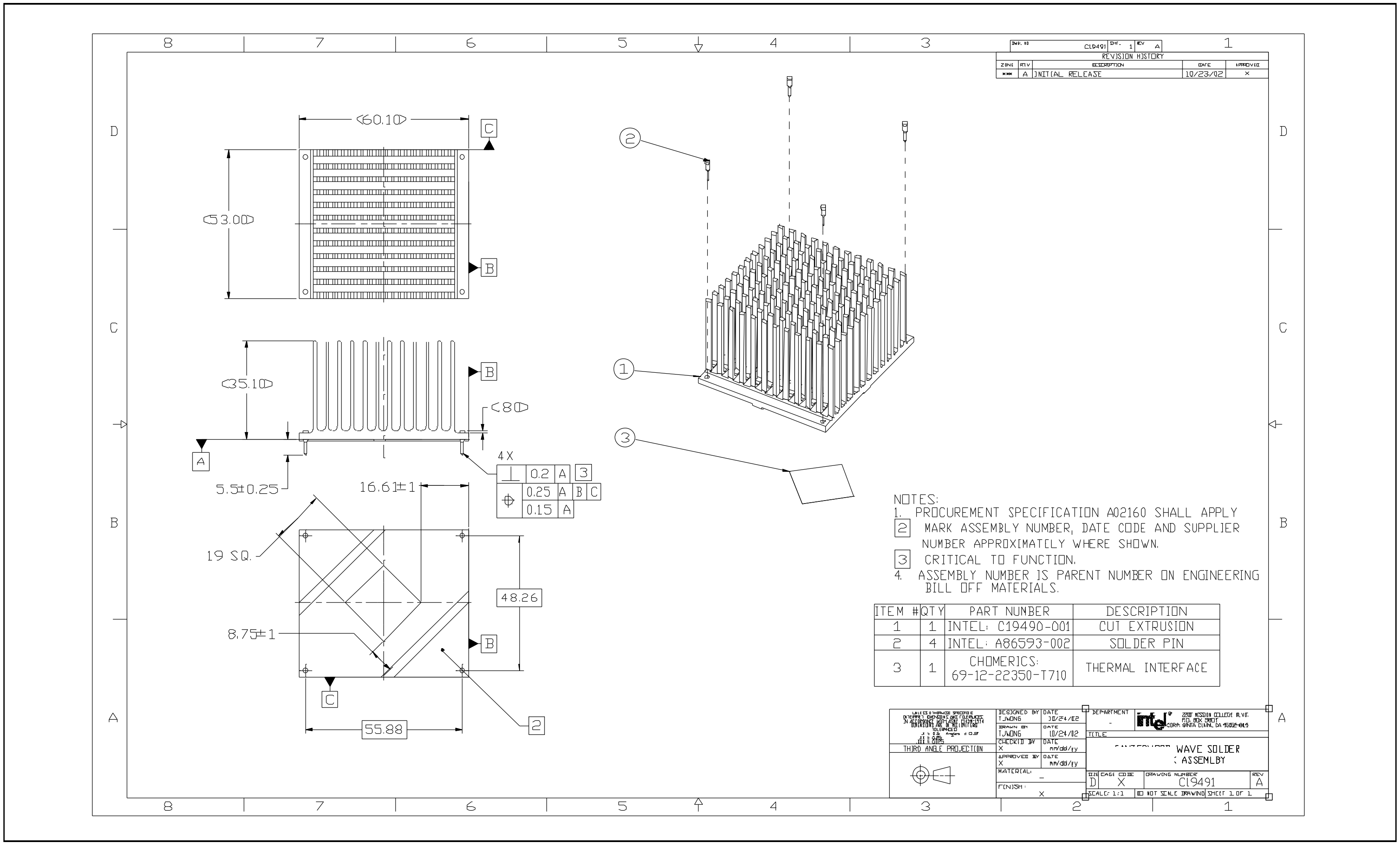


Figure 14. MCH Wave Solder Heatsink Drawing

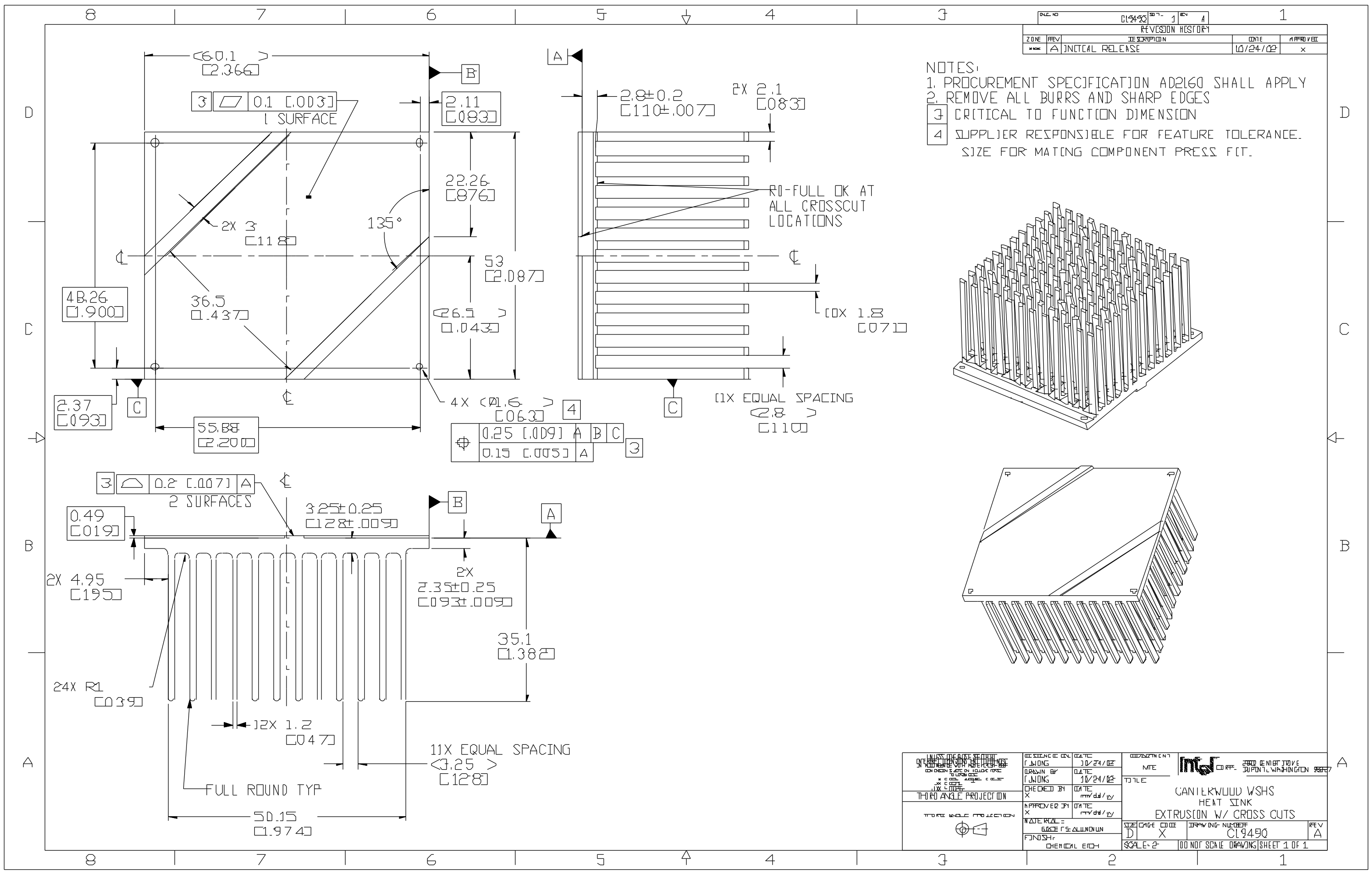
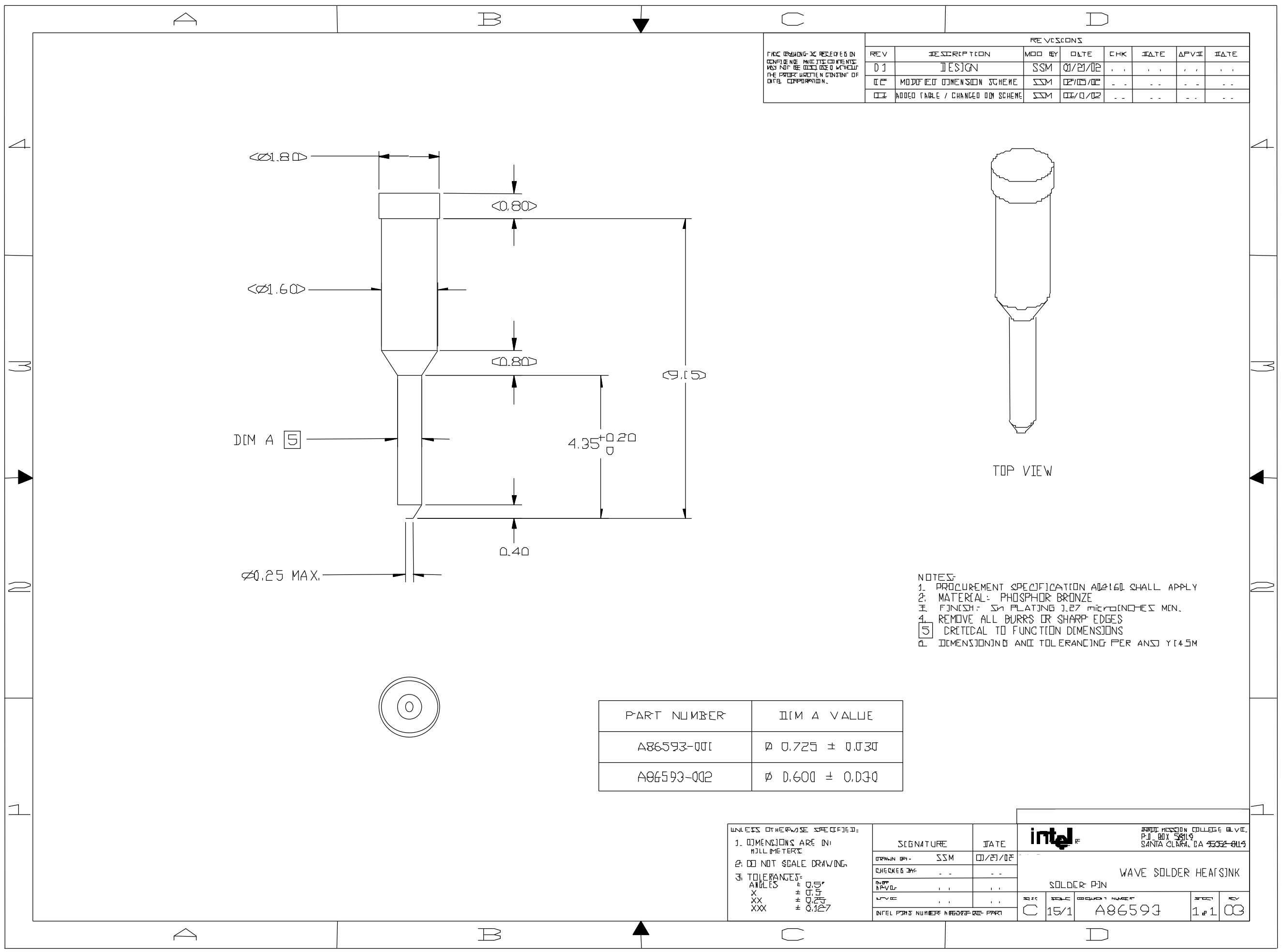


Figure 15. MCH Wave Solder Heatsink Mounting Pin Drawing



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