



Intel[®] 850 Chipset: Thermal Considerations

Application Note (AP-720)

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Revision History

Rev. Date	Doc. Ref. No.	Rev. No.	Description
November 2000	292268	-0011	Initial Release.
January 2001	292268	-002	<ul style="list-style-type: none">• Updated Table 1 and Table 2.• Updated Section 2.3, "Operating Environmental Conditions".• Added Section 3.2.1, "Heat Sink Orientation".• Updated Section 3.2.4, "Mechanical Interface Material".• Updated Table 3, "Reliability Validation".• Updated Table 4, "Specification Summary".• Updated Appendix A, "Heat Sink and Attach Suppliers".



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1. Introduction

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® 850 chipset and discuss a generic thermal solution.

1.1. Definition of Terms

Term	Description
OLGA	Organic Land Grid Array. A package type defined by a resin-fiber substrate that 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.
Lands	The pads on the PCB where the BGA Balls are soldered.
TDP	Thermal Design Power. This is the target power that the thermal solution should dissipate.

1.2. Reference Documents and Information Sources

Document Name or Information Source	Available From or Document Number
Intel® 82801BA I/O Controller Hub 2 (ICH2) and Intel® 82801BAM I/O Controller Hub 2 Mobile (ICH2-M) Datasheet	http://developer.intel.com/design/chipsets/datashts/290687.htm
Intel® 850 Chipset: 82850 Memory Controller Hub (MCH), Datasheet	http://developer.intel.com/design/chipsets/datashts/290691.htm
Intel® Pentium® 4 Processor / Intel® 850 Chipset Platform, Design Guide	http://developer.intel.com/design/chipsets/designex/298245.htm
Integrated Circuit Thermal Measurement Method-Electrical Test Method	EIA/JESD51-1
Integrated Circuits Thermal Test Method Environmental Conditions – Natural Convection (Still Air)	EIA/JESD51-2
Platform Development Support Web Site: Support for development of ATX, FlexATX, microATX, and NLX form factor specifications	http://www.teleport.com/~ffsuppr/
WTX Specification	http://www.wtx.org

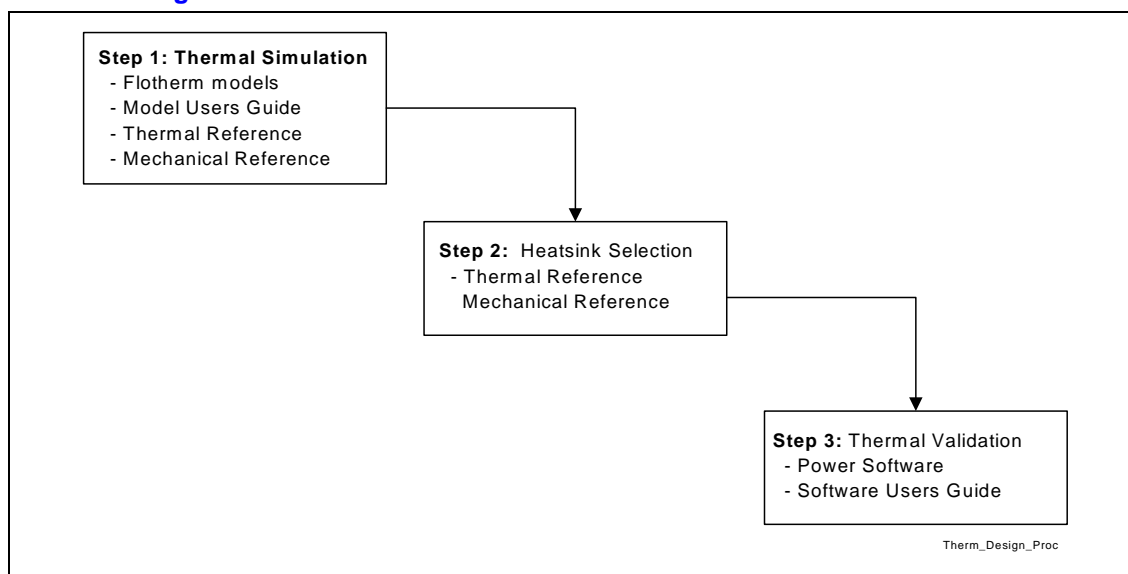


Document Name or Information Source	Available From or Document Number
Intel® 850 Thermal User's Guide, Rev 0.1	Contact your local Intel sales office or your distributor to obtain the latest specifications.
Intel® 850 Power Utility User's Guide	Contact your local Intel sales office or your distributor to obtain the latest specifications.
BGA/OLGA Development Guide	Contact your local Intel sales office or your distributor to obtain the latest specifications.

1.3. Design Flow

To develop a reliable, cost-effective thermal solution, several tools are available to the system designer. The figure below illustrates the design process implicit to this document and the tools appropriate for each step.

Figure 1. Thermal Design Process



1.4. Thermal Simulation

Simulation models of the Intel® 850 chipset and an associated user guide are provided to aid system designers in simulating, analyzing and optimizing their thermal solutions in an integrated system-level environment. The models have been created for use with the commercially available Computational Fluid Dynamics (CFD)-based thermal analysis tool “FLOTHERM*” (version 2.1 or higher) by Flomerics* Inc. Section 1.2 lists the source of the models and user guide.

2. Thermal Reference

2.1. Power

The Thermal Design Power (TDP) for each component can be found in their respective datasheet. Refer to the appropriate section to verify the respective thermal specifications for the Intel® 850 chipset. OLGA packages without thermal enhancement poorly utilize heat transfer into the board and have minimal thermal capability. It is recommended to plan for a heat sink when using the Intel® 850 chipset.

2.2. Die Temperature

To ensure proper operation and reliability of the Intel® 850 chipsets, the die temperature must be at or below the values specified in the tables below. If the die temperature exceeds the maximum temperatures listed, system or component level thermal enhancements will be required to dissipate the heat generated.

Table 1. 82850 MCH Thermal Absolute Maximum Rating

Parameter	Maximum
T _{die-nhs} (Note 1)	105°C
T _{die-hs} (Note 2)	85°C

Table 2. Thermal Absolute Maximum Rating

Parameter	Maximum
T _{case-nhs} (Note 3)	109°C

NOTES: For Table 1 and Table 2.

1. T_{die-nhs} is defined as the maximum die temperature without any thermal enhancement to the package.
2. T_{die-hs} and T_{case-hs} are defined as the maximum die temperature with the generic thermal solution attached (see Section 2.3).
3. T_{case-nhs} is defined as the maximum package case temperature without any thermal enhancement to the package.

2.3. Operating Environmental Conditions

To ensure proper operation and reliability of the Intel® 850 chipset generic thermal solution, the maximum allowable operating temperature is 50°C. The minimum recommended airflow over the package is 150 LFM (linear feet per minute). The thermal designer must carefully select the location to measure airflow to get a representative sampling.

Note: These environmental specifications are based on a 35 °C, 5000” system ambient temperature and altitude conditions.



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3. Mechanical Reference

3.1. Package Dimensions

The 82850 MCH is packaged in a 31x35 mm, 6-layer OLGA. The 82801BA ICH2 is packaged in a 23 mm, 4-layer MBGA. For the MCH and ICH2 package dimensions, refer to their respective component datasheets.

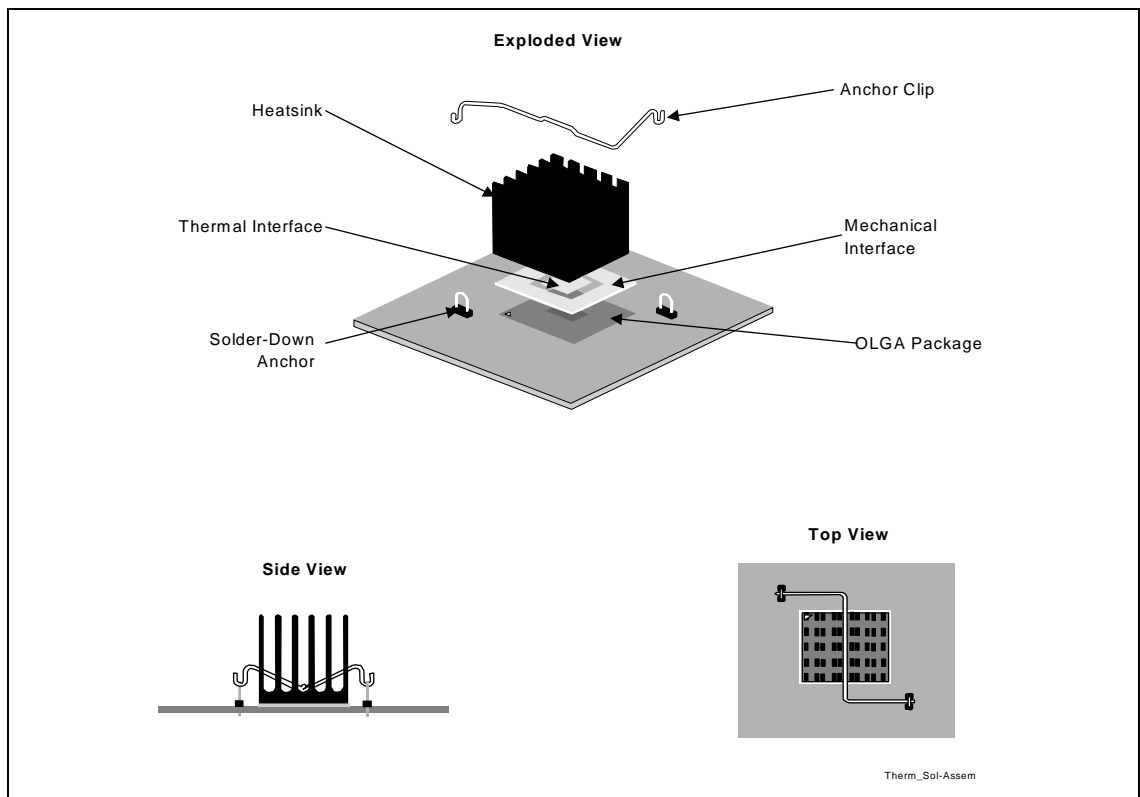
3.2. Thermal Enhancements (Generic Solutions)

Intel has developed Generic Thermal Solutions for the 82850 MCH. These do not preclude the design of user specific solutions that may be based on these designs.

The generic solution is a passive extruded heat sink with thermal and mechanical interfaces. It is attached using a clip with each end hooked through an anchor soldered to the board. The following figure shows different views of the generic solution.

Sources for each component of the thermal solution are provided in Appendix A.

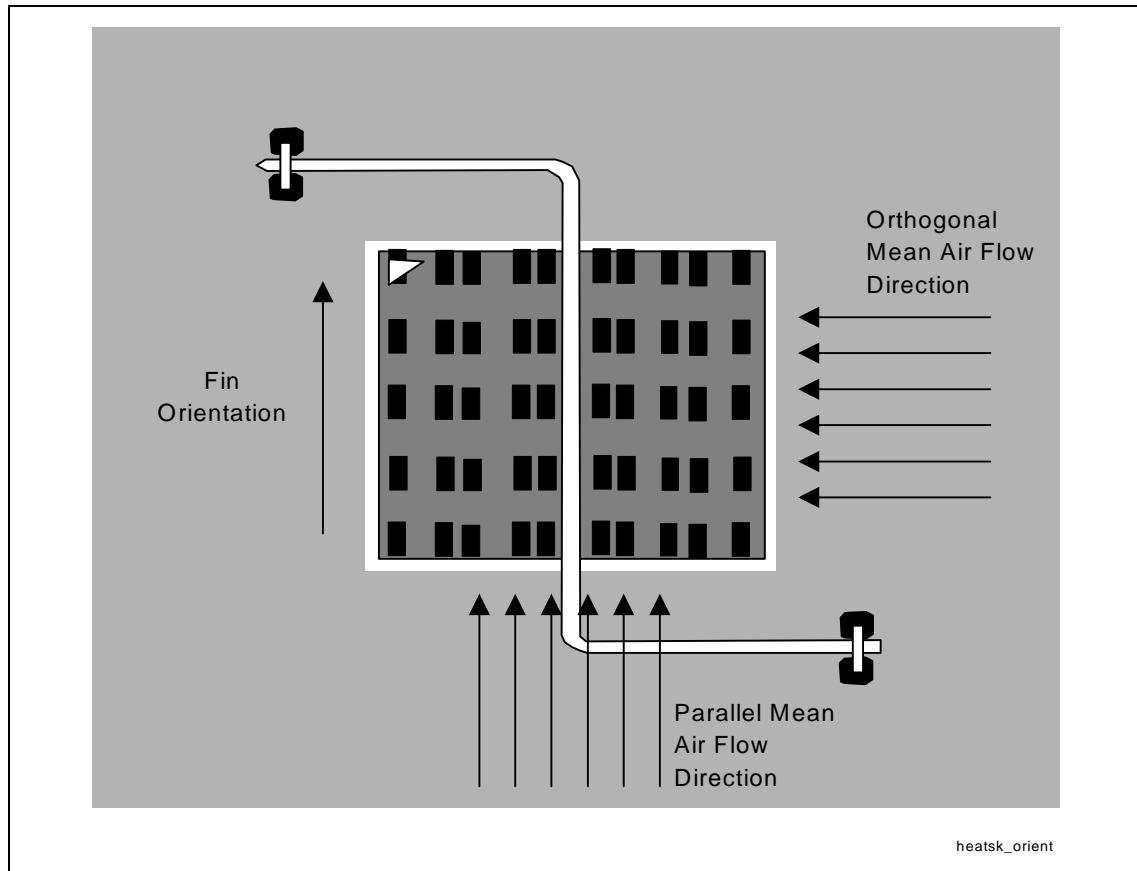
Figure 2. Generic Thermal Solution Assembly



3.2.1. Heat Sink Orientation

To enhance the efficiency of the Generic Thermal Solution Assembly, it is important for the designer to orient the fins properly with respect to the mean air flow direction. Simulation and experimental evidence have shown that the Intel 850 Pin Fin Heat Sink's thermal performance is enhanced when the fins are aligned with the mean air flow direction (see following figure)

Figure 3. Proper Heat Sink Orientation

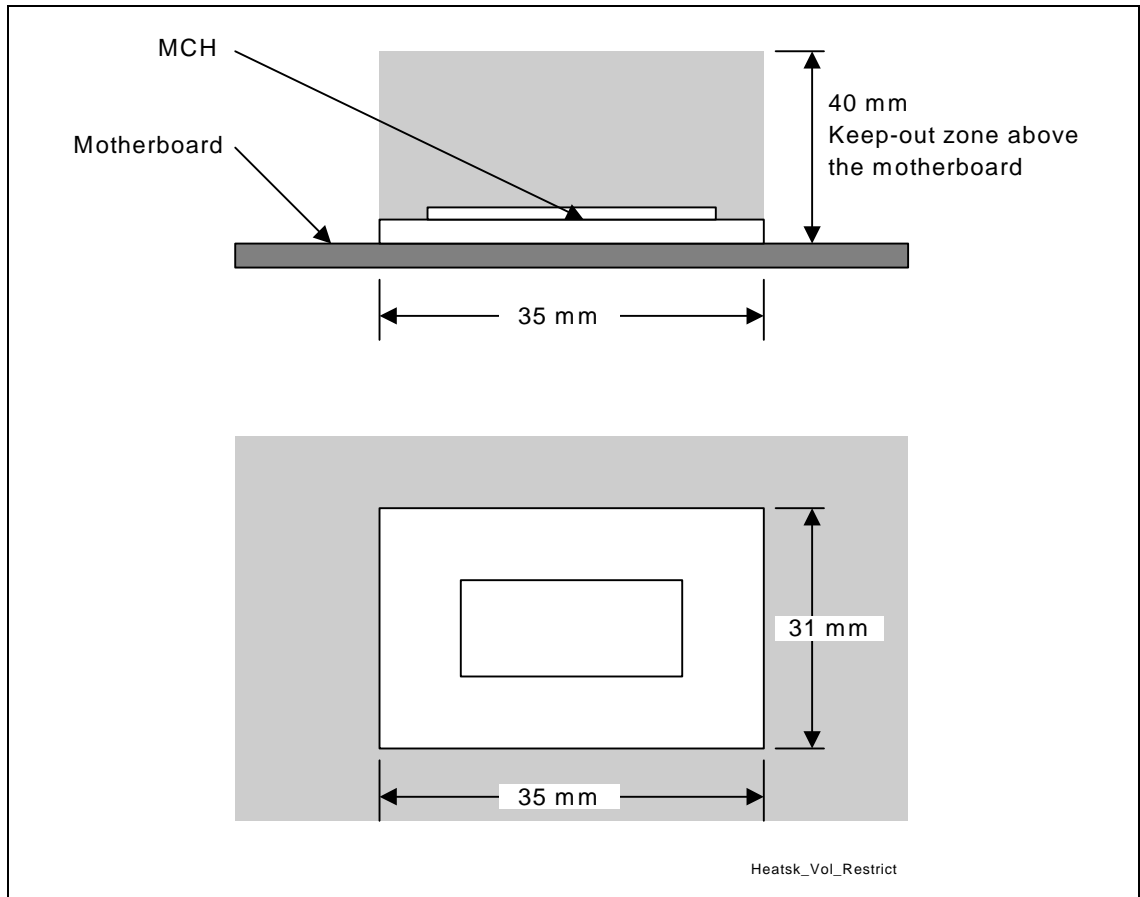


3.2.2. Volume Keepouts

Though each design may have unique mechanical volume and height restrictions or implementation requirements, the height, width and depth constraints typically placed on the Intel® 850 chipset components are shown in the following figure.

When using heat sinks that extend beyond the component, the motherboard component height under the Intel® 850 chipset component is limited to 0.090”.

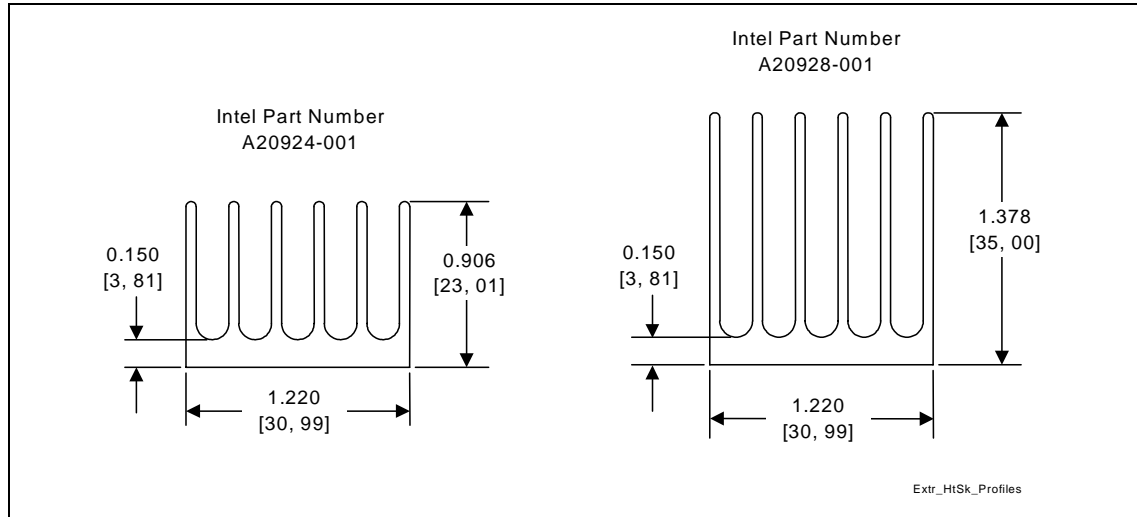
Figure 4. Heat Sink Volume Restrictions for the 82850 MCH



3.2.3. Extruded Heat Sink Profiles

Extruded heat sinks are the generic thermal enhancements for the Intel® 850 chipset. The drawings for these heat sinks are shown in the figure below. Tolerance information is not given in this document. Check with your supplier for specific tolerances. Suppliers for the Extruded heat sinks are discussed in Appendix A.

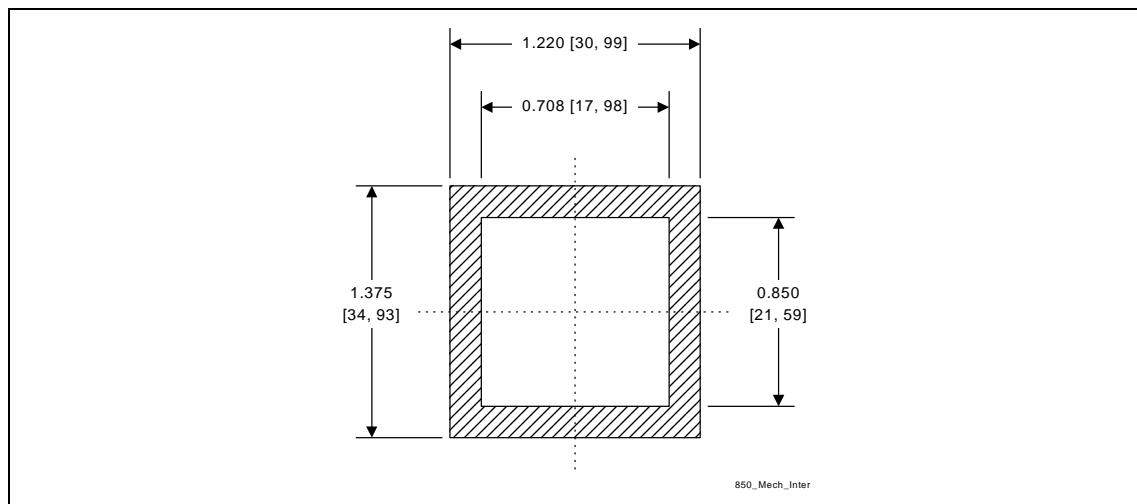
Figure 5. Extruded Heat Sink Profiles for the 82850 MCH



3.2.4. Mechanical Interface Material

To avoid cracking of the exposed die a mechanical interface is used. This interface reduces mechanical loads experienced by the die. The generic solutions use a picture frame gasket of 0.062” thick Intel 850 chipset Mechanical (Poron®) foam. The figure below shows the respective dimensions of gaskets for the Intel® 850 chipset.

Figure 6. Intel® 850 Chipset Mechanical Interface



3.2.5. Thermal Interface Material

To provide good conductivity from the die to the heat sink, a thermal interface material is used. The generic solutions use Chomerics* T-710, 0.005" thick, 0.5" x 0.5".

3.2.6. Heat Sink Clip

The generic solution uses a wire clip with hooked ends. The hooks attach to wire anchors to fasten the clip to the board.

3.2.7. Clip Retention Anchors

For Intel® 850 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 has been modified from a standard three-pin jumper and is soldered to the board like any common through-hole header.

3.2.8. Board Keepout Patterns

The locations of hole patterns and keepout zones for the generic solutions are shown in the following two figures.

Figure 7. 82850 MCH Anchor Layout

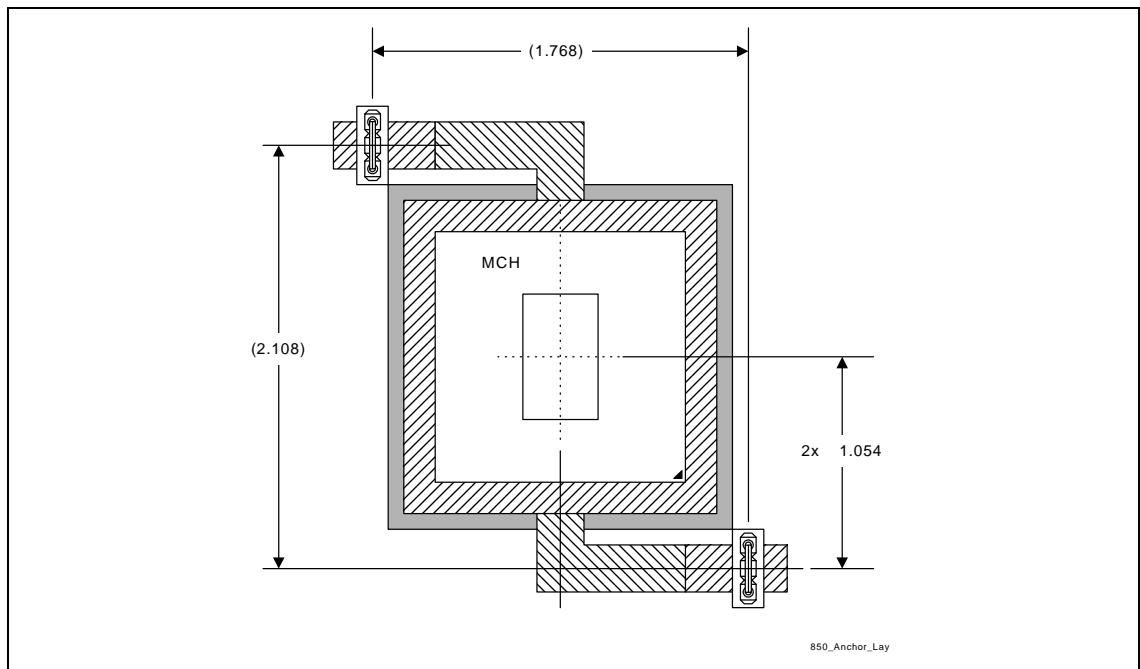
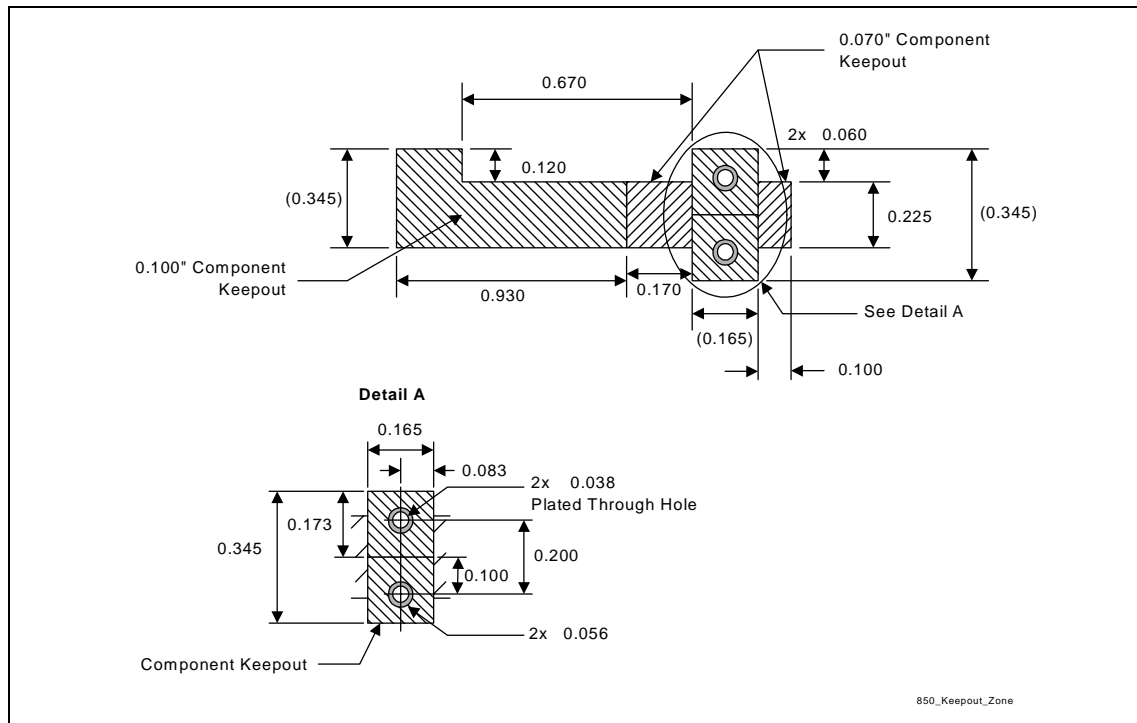


Figure 8. Intel® 850 Chipset Keepout Zones



3.3. Reliability

Each motherboard, heat sink and attach combination may vary the mechanical loading of the component. It is recommended that the user carefully evaluate the reliability of the completed assembly prior to use in high volume. Some general recommendations are shown in the following table.

Table 3. Reliability Validation

Test ¹	Requirement	Pass/Fail Criteria ²
Mechanical Shock	50G, board level 11 msec, 3 shocks/direction	Visual\Electrical Check
Random Vibration	7.3 G, board level 45 minutes/axis, 50 to 2000 Hz	Visual/Electrical Check
Thermal Cycling	-40 °C to +85 °C 1000 Cycles	Visual Check
Unbiased Humidity	85% relative humidity 85 °C, 1000 hours	Visual Check

NOTES:

1. The above 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.

4. Measurements for Thermal Specifications

To appropriately determine the thermal properties of the system, measurements must be made. Guidelines have been established for the proper techniques to be used when measuring the Intel® 850 chipset die temperatures. Section 4.1 provides guidelines on how to accurately measure the die temperature of the Intel® 850 chipset. Section 4.2 contains information on running an application program that will emulate anticipated maximum thermal design power. The flowchart in Figure 10 offers useful guidelines for performance and evaluation.

4.1. Die Temperature Measurements

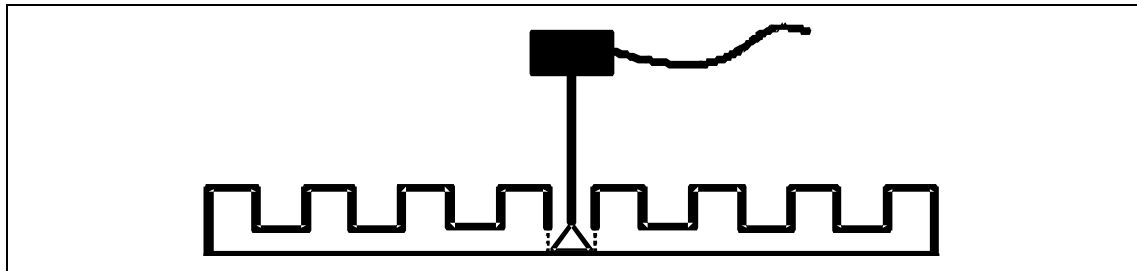
To ensure functionality and reliability, the Intel® 850 chipset is specified for proper operation when T_{die} (die temperature) is maintained at or below their respective maximum die temperatures listed in Table 1 and Table 2. The surface temperature of the die in the geometric center of the die is measured. Special care is required when measuring the T_{die} temperature to ensure an accurate temperature measurement.

When measuring the temperature of a surface that is at a different temperature from the surrounding local ambient air, errors could be introduced 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, convection, conduction through thermocouple leads, or contact between the thermocouple cement and the heat sink base for those solutions that implement a heat sink. To minimize these measurement errors, the following approach is recommended:

Attaching the Thermocouple

- Use 36 gauge or smaller diameter K type thermocouples.
- Ensure that the thermocouple has been properly calibrated.
- Attach the thermocouple bead or junction to the top surface of the die in the center using a high thermal conductivity cement. **It is Critical that the entire thermocouple lead be butted tightly with the die.**
- The thermocouple should be attached at a 90° angle if there is no interference with the thermocouple attach location or leads (refer to following figure). This is the preferred method and is recommended for use with both unenhanced packages as well as packages employing Thermal Enhancements.
- The hole size through the heat sink base to route the thermocouple wires out should be smaller than 0.150" in diameter.
- Make sure there is no contact between the thermocouple cement and heat sink base. This contact will affect the thermocouple reading.

Figure 9. Technique for Measuring Tdie with 90° Angle Attachment

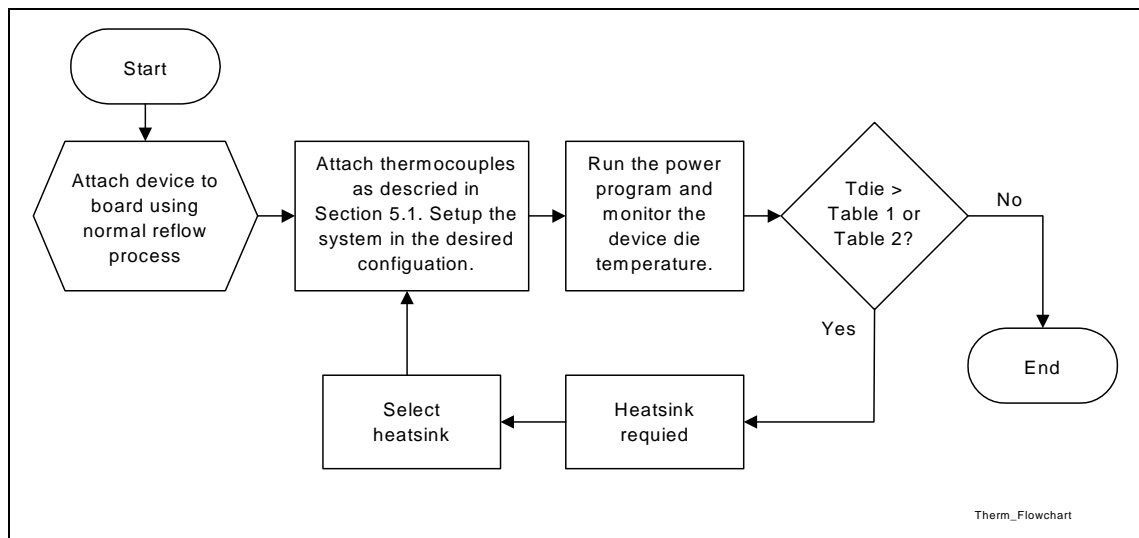


4.2. Power Simulation Software

The Power Simulation Software is a utility designed to test the thermal design power for an Intel® 850 chipsets when used in conjunction with an Intel® Pentium® 4 processor. The combination of the Pentium® 4 processor and the higher bandwidth capability of the Intel® 850 chipset enable new levels of system performance. To ensure the thermal performance of the Intel® 850 chipset under “worst-case realistic application” conditions, Intel has developed a software utility that emulates this anticipated power dissipation.

The power utility has been developed solely for testing Thermal Design Power and customer thermal solutions (Figure 10). 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. See Section 1.2 for information on how to obtain this software.

Figure 10. Thermal Enhancement Decision Flowchart



5. Conclusion

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 heat sinks.

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, thermal enhancements may be implemented in conjunction with enhanced system cooling. The size of the fan or heat sink 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 implementing the Intel® 850 chipset. Properly designed solutions provide adequate cooling to maintain the Intel® 850 chipset die temperatures at or below those listed in Table 1 and Table 2. This is accomplished by providing a low local ambient temperature, adequate local airflow and creating a minimal thermal resistance to heat transfer. By maintaining the respective Intel® 850 chipset die temperature at or below those recommended in this document, a system will function without encountering thermal management issues.

Table 4. Specification Summary

Package Dimensions	
82850 MCH	31 mm x 35 mm x 2.54 mm
Handling Keepout on Substrate	
82850 MCH	2 mm from edge of die
Max Allowable Die Pressure	
82850 MCH	410 kPa
Volume Keepouts	
82850 MCH	31 mm x 35 mm x 40 mm
Operating Environment	
Maximum Temperature	50 °C
Minimum Airflow	150 LFM
Thermal Design Power(TDP)	
82850 MCH	See the <i>Intel® 850 Chipset: 82850 Memory Controller Hub (MCH) Datasheet</i> .
Maximum Die/ Case Temperature without Heat Sink	
82850 MCH	105 °C
ICH2	109 °C
Maximum Die Temperature with Heat Sink	
82850 MCH	85 °C



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Appendix A: Heat Sink and Attach Suppliers

Table 5. Extruded Heat Sinks

Part	Intel Part Number	Suppliers
Intel 850 Pin Fin, 18 gm, 31x35x23 mm	A20924-001	Aavid Thermalloy Foxconn
Intel 850 Pin Fin, 26 gm, 31x35x35 mm	A20928-001	Aavid Thermalloy Foxconn

Table 6. Interface Materials

Part	Intel Part Number	Supplier (Part Number)
Intel 850 Thermal (T-710)	—	Chomerics (69-12-22066-T710)
Intel 850 Mechanical (Poron)	A20097-001	Boyd (TEH-1000-001)

Table 7. Attach Hardware

Part	Intel Part Number	Suppliers
Intel 850 Clip	A20932-001	Aavid Thermalloy Foxconn
Clip Retention Anchor	A13494-002	Foxconn

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

Supplier Contact Information

Aavid Thermalloy, LLC	http://www.aavid.com
Boyd Corporation	http://www.boydcorp.com
Chomerics, Inc.	http://www.chomerics.com
Foxconn Electronics, Inc.	http://www.foxconn.com