Intel® IXP42X Product Line Thermal Design

Application Note

November 2005

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Revision History

Date	Revision	Description
November 2005	001	Initial release of document.

1.0 Introduction

This document describes the thermal characteristics for the Intel® IXP42X Product Line of Network Processors. This document is used to properly design a thermal solution for systems implementing IXP42X product line devices.

Properly designed solutions must provide adequate cooling to maintain the IXP42X product line case temperature (T_{CASE}) at or below the values listed in Table 1 on page 7. Ideally, this is accomplished by providing a low local ambient temperature and creating a minimal thermal resistance to that local ambient temperature. Heat sinks may be required if case temperatures exceed those listed in Table 1.

By maintaining the case temperature at or below the values recommended in this document, the IXP42X product line will function properly and reliably.

1.1 About This Document

This document contains the following main sections:

- Section 2.0, "Thermal Specifications" on page 8, provides IXP42X processor case temperature specifications.
- Section 3.0, "Thermal Attributes" on page 9, provides IXP42X processor thermal characteristic data, package mechanical attributes, and package thermal characteristic data. Use this section to determine your thermal solution requirements.
- Section 4.0, "Thermal Enhancements (If Required)" on page 15, discusses the use of heat sinks: heat sink attach methods, heat sink interfacing, and heat sink reliability.
- Section 5.0, "Measurements for Thermal Specifications" on page 20, provides instructions for measuring the IXP42X processor case temperature with and without a heat sink.
- Section 6.0, "Conclusion" on page 22.
- Appendix A, "Heat Sink and Attachment Suppliers" on Page 23.
- Appendix B, "PCB Guidelines" on Page 25.

1.1.1 Intended Audience

This document is intended for system design engineers using the IXP42X product line. As the market continues to adopt products with higher-speeds and port densities, system designers face increasing thermal challenges. Depending on the type of system and target operating environment, new designs may be required to provide better cooling solutions for silicon devices.

1.1.2 Acronyms and Terminology

Packaging acronyms and terminology used in this document include:

- Ambient — The local ambient temperature of the bulk air approaching the component. It can be measure by placing a thermocouple approximately 1 in. upstream from the component edge.
- Heat Spreader Ball Grid Array (HSBGA) — A surface-mounted package whose PCB-interconnect method consists of eutectic or lead-free solder ball array on the interconnecting side of the package. An integrated heat spreader is used to enhance thermal performance.

Note: For the IXP42X product line, the HSBGA package is rated for extended temperature.

- Junction — Refers to the P-N junction in the silicon. In this document, the term is used as a temperature reference point.
- Lands — The pads on the PCB to which BGA balls are soldered.
- LFM — Linear Feet per Minute (airflow)
- PBGA — Plastic Ball Grid Array. A surface mount package whose PCB-interconnecting method consists of eutectic solder ball array on the interconnect side of the package. The over-molded die is typically mounted on the substrate side opposite the array of balls (die cavity up).

Note: For the IXP42X product line, the PBGA package is rated for commercial temperature.

- PCB — Printed Circuit Board
- PCA — Printed Circuit Assembly. An assembled PCB.
- TDP — Thermal Design Power. The estimated maximum power generated by a component in a realistic application.

  Use maximum power requirement numbers from Table 1 on page 7.
- Θ_{JA} — A parameter specifying the Junction-to-Ambient thermal resistance, °C/W.
- Ψ_{JT} — A parameter specifying the Junction-to-Package-Top thermal resistance, °C/W. Please do not confuse this parameter with the Junction-to-Case thermal resistance.
- T_{CASE} — Case Temperature, °C.
- $T_{CASE\text{-}HS}$ — Case Temperature with Heat Sink, °C.
- $T_{CASE\text{-}NO\ HS}$ — Case Temperature with No Heat Sink, °C.
- $T_{J\ MAX}$ — Maximum junction temperature, °C.
- Heat Spreader — A thermal enhancing solution that is integrated in the package and helps increase thermal performance.

1.1.3 Reference Documents and Information Sources

Document Name	Number	Available From
Integrated Circuit Thermal Measurement Method - Electrical Test Method (Single Semiconductor Device)	JESD51-1	http://www.jedec.org
Integrated Circuits Thermal Test Method Environmental Conditions - Natural Convection (Still Air)	JESD51-2	

1.2 Product Package Thermal Specification

The thermal parameters defined in Table 1 are based on simulated results of packages assembled on standard multi-layer, 2s2p, 1.0-oz., copper-layer boards in a natural-convection environment. The IXP42X product line is available in two packaging types, PBGA and HSBGA. With its heat spreader, the HSBGA provides better thermal performance.

The maximum case temperature is defined as:

$$T_{CASE\ MAX} = T_{J\ MAX} - (\Psi_{JT} * \text{Power Dissipation})$$

If the case temperature exceeds the specified $T_{CASE\ MAX}$, thermal enhancements such as heat sinks or forced air will be required.

Table 1. Package Thermal Characteristics in Standard JEDEC Environment

Package Type	Est. Power (TDP)	Θ_{JA}	Ψ_{JT}	$T_{CASE\ MAX}$ †
35-mm 492HSBGA (Extended Temperature)	2.4 W	12.2° C/W	1.6° C/W	111° C
35-mm 492PBGA (Commercial Temperature)	2.4 W	16.1° C/W	0.5° C/W	113° C

† The maximum case temperature should not be exceeded.

1.3 Measuring the Thermal Conditions

This document provides a method for determining the junction temperature of the IXP42X product line in a specific system, based on case temperature. Case temperature is a function of the local ambient and internal temperatures of the component. This document specifies a maximum allowable T_{CASE} for the IXP42X product line.

1.4 Thermal Considerations

Component temperature in a system environment is a function of the component, board, and system thermal characteristics. The board/system-level thermal constraints include the following:

- Local ambient temperature near the component
- Airflow over the component and surrounding board
- Physical constraints above and surrounding the component that may limit the size of a thermal enhancement.

The component die temperature depends on the following:

- Component power dissipation.
- Component size.
- Packaging materials (effective thermal conductivity).
- Type of interconnection to the substrate and motherboard.
- Presence of a thermal cooling solution.

- Thermal conductivity.
- Power density of the substrate/package, nearby components, and circuit board to which it is attached.

Technology trends continue to push these parameters toward increased performance levels (higher operating speeds), I/O density (smaller packages), and silicon density (more transistors). Power density increases and thermal cooling solutions such as space and airflow become more constrained as operating frequencies increase and packaging sizes decrease. These issues result in an increased emphasis on the following:

- Package and thermal enhancement technology to remove heat from the device.
- System design to reduce local ambient temperatures and ensure that thermal design requirements are met for each component in the system.

1.5 Importance of Thermal Management

The thermal management objective is to ensure that all system component temperatures are maintained within functional limits. The functional temperature limit is the range in which the electrical circuits are expected to meet specified performance requirements. Operation outside the functional limit can degrade system performance, cause logic errors, or cause the component permanent damage. Case temperatures exceeding $T_{CASE\ MAX}$ may result in irreversible changes in the component operating characteristics.

2.0 Thermal Specifications

To ensure proper operation and reliability of the IXP42X processor, the thermal solution must maintain a case temperature preferably below the values specified in Table 2. System- or component-level thermal enhancements are required to dissipate generated heat when case temperature exceeds the maximum temperatures listed in Table 2.

Good system airflow is critical to heat dissipation. When using fans, vents, and ducts, their placement in relation to components determine airflow. Acoustic noise constraints may limit the size and types of fans used; vents and ducts can also be used in certain designs.

To develop a reliable, cost-effective thermal solution, all system variables must be considered. Use system-level thermal characteristics and simulations to account for individual component thermal requirements.

Table 2. Intel® IXP42X Product Line of Network Processors Preliminary Thermal Absolute Maximum Rating

Parameter	Maximum
$T_{CASE\text{-}NO\ HS}$[1] – HSBGA	111° C
$T_{CASE\text{-}NO\ HS}$[1] – PBGA	113° C

1. $T_{CASE\text{-}NO\ HS}$ is defined as the maximum case temperature without any thermal enhancement to the package.

2.1 Case Temperature

The IXP42X processor is designed for normal operation, for which $T_{CASE\ MAX}$ is not to be exceeded. Section 5.1, “Case Temperature Measurements” on page 20 discusses proper guidelines for measuring case temperature.

2.2 Designing for Thermal Performance

To achieve good thermal performance, PCB and airflow should be carefully considered. PCB design recommendations are presented in Appendix B, “PCB Guidelines” on Page 25.

3.0 Thermal Attributes

3.1 Key Notes to Remember

Because system environments and applications vary, please note the following when referring to the data presented in this document.

- The evaluation board used to perform simulations is a four-layer, 4-by-4-inch PCB.
- All data is preliminary and not validated using physical samples.
- Your system design may differ significantly.
- A larger board or additional layers will increase copper area, and may improve heat dissipation and overall thermal performance.

3.2 Intel® IXP42X Product Line of Network Processors Mechanical Attributes

The IXP42X product line is packaged in two slightly different 35-mm packages: a PBGA (commercial temperature), and a HSBGA (extended temperature). Figure 1, Figure 2, and Figure 3 show the mechanical drawing of these devices. For the most current PBGA mechanical drawing, please see the *Intel® IXP42X Product Line of Network Processors and IXC1100 Control Plane Processor Datasheet*.

Figure 1. Intel® IXP42X Product Line of Network Processors 35-mm HSBGA Mechanical Drawing (reference only) — First of Two Drawings

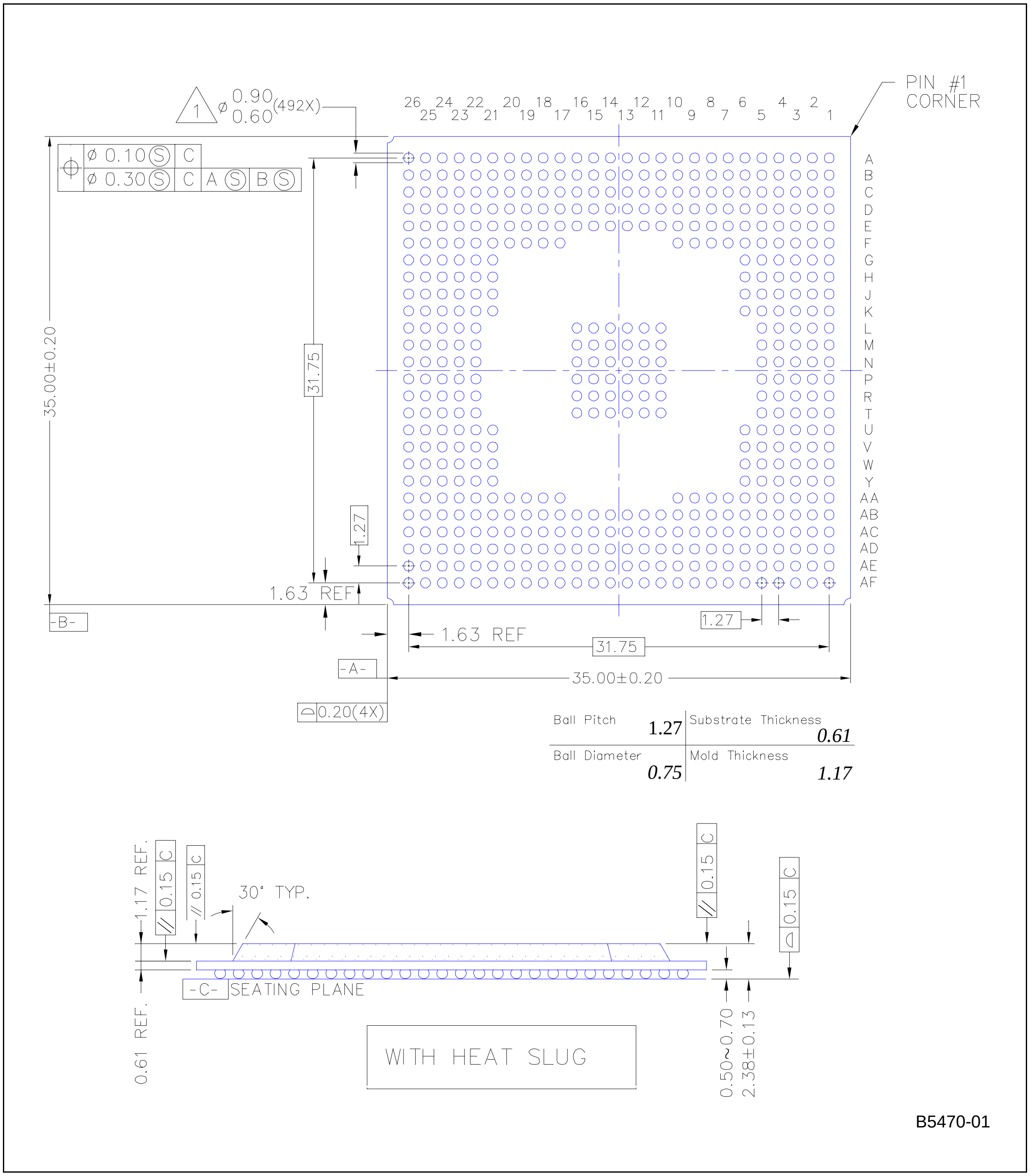


Figure 2. Intel® IXP42X Product Line of Network Processors 35-mm HSBGA Mechanical Drawing (reference only) — Second of Two Drawings

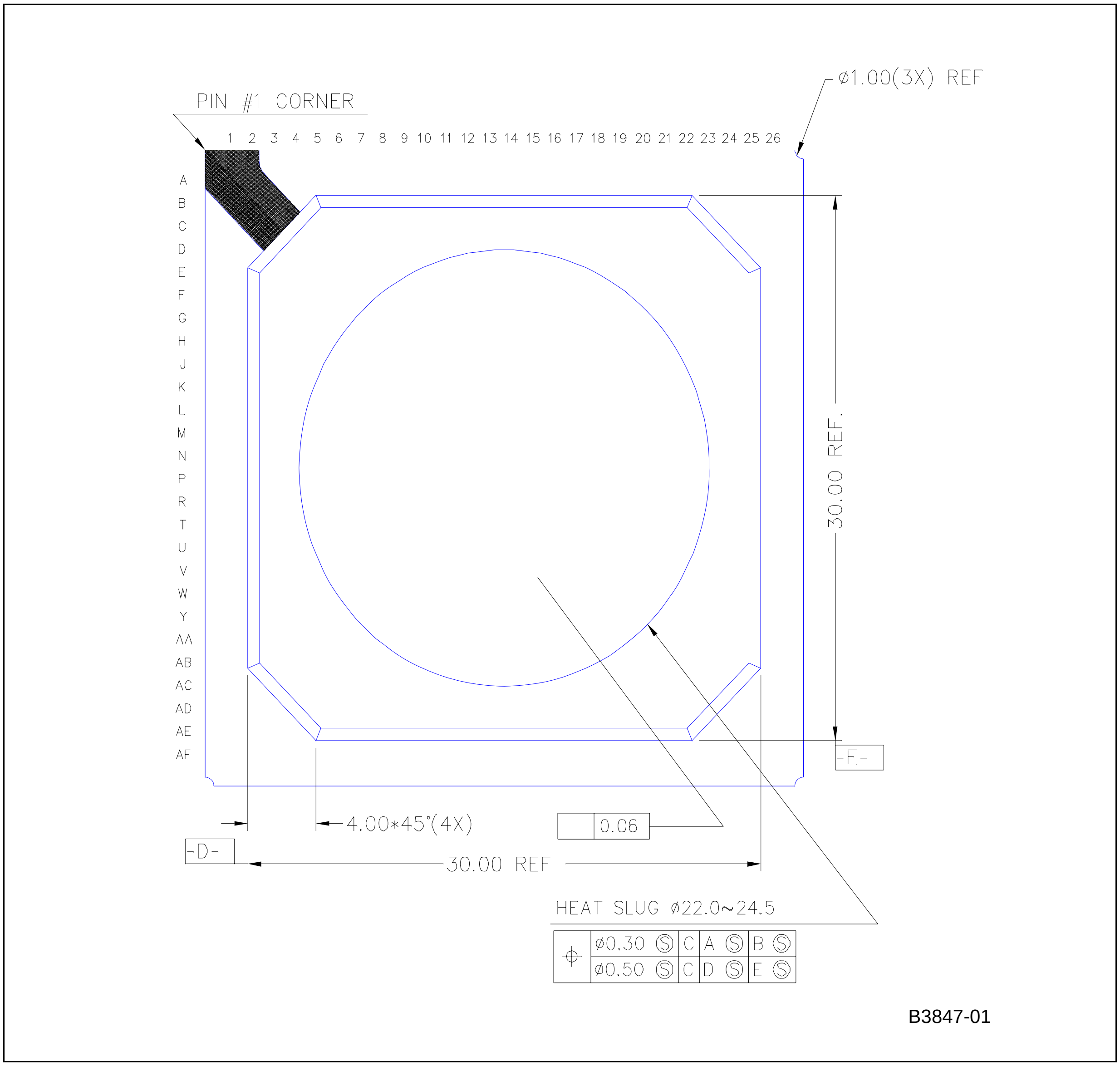
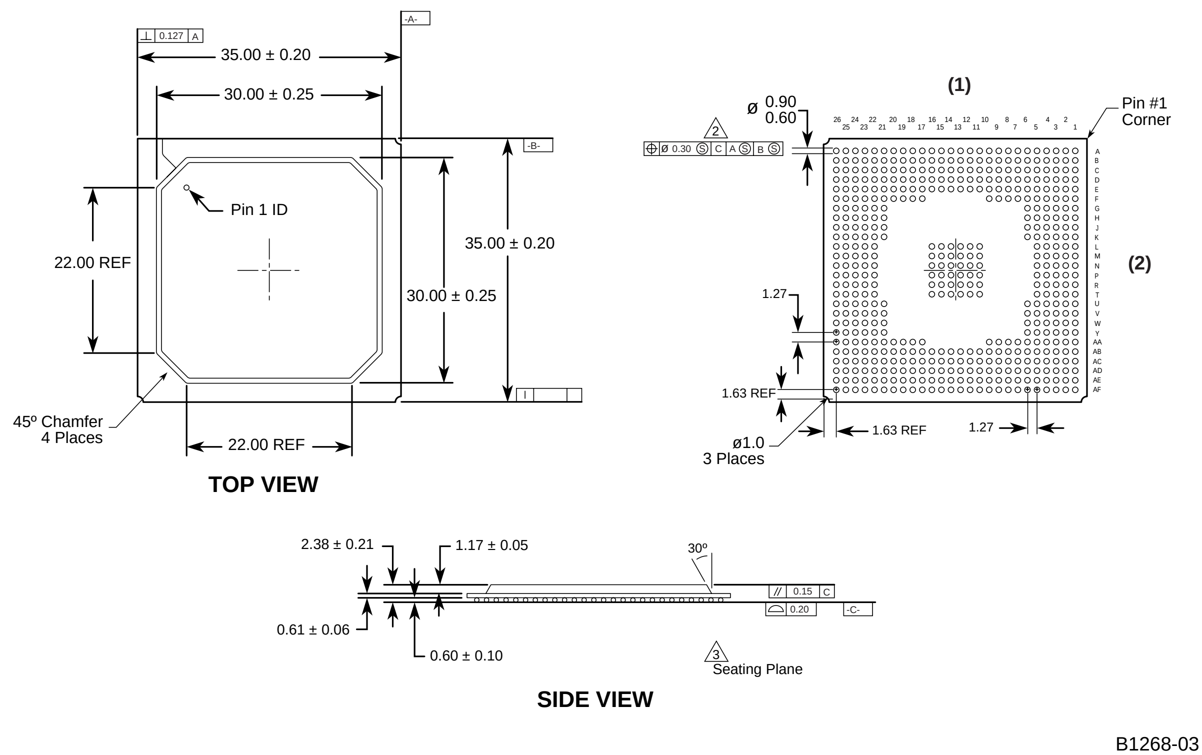


Figure 3. Intel® IXP42X Product Line of Network Processors 35-mm PBGA Mechanical Drawing (reference only)



1. All measurements are in millimeters (mm).
2. The size of the land pad at the interposer side (1) is 0.81 mm.
3. The size of the solder resist at the interposer side (2) is 0.66 mm.

3.3 Package Thermal Characteristics

The graphs and tables in this section are based on simulations. The intent here is to show thermal performance obtained at different airflows with respect to ambient temperature, and provide an estimated case temperature under the conditions shown in Table 3 and Table 4.

Case temperature must not exceed $T_{CASE\ MAX}$. Exceeding this value will violate the operating temperature, resulting in catastrophic hardware failure and possible permanent damage. See Section 3.1, "Key Notes to Remember" on page 9. Figure 4 shows the required local ambient temperature versus airflow for a typical IXP42X processor.

Note that graphs and charts in this section are based on a maximum power dissipation of 2.4W.

Note: Your system design may differ significantly from the typical system board environment used to generate Table 3 and Table 4.

Figure 4. Maximum Allowable Ambient Temperature vs. Airflow for HSBGA

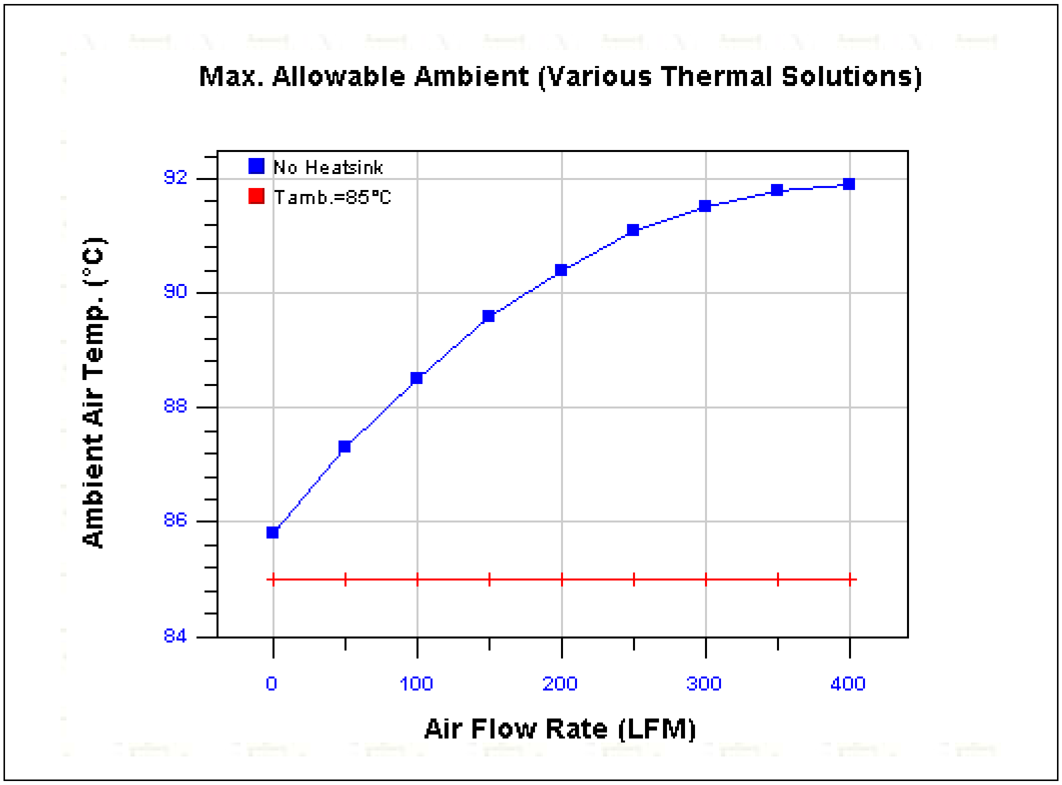


Table 3. Expected Tcase (°C) With No Heat Sink Attached and PDT = 2.4W for HSBGA[1]

Expected Tcase (no GB) Table (Air Flow vs. Ambient)
(Pkg Size=35mm DieX=8.2mm DieY=8.2mm Power=2.4W Heatsink=0 Tj max=115°C Pkg Type=HSBGA Board=4.5x4in 4Layer JEDEC)

No Heatsink Attached — Tcase Max=111°C

100 °C amb.	126	124	123	122	120	119	119	118	118
95 °C amb.	121	119	118	117	115	114	114	113	113
90 °C amb.	116	114	113	112	110	109	109	108	108
85 °C amb.	111	109	108	107	105	104	104	103	103
80 °C amb.	106	104	103	102	100	99	99	98	98
75 °C amb.	101	99	98	97	95	94	94	93	93
70 °C amb.	96	94	93	92	90	89	89	88	88
65 °C amb.	91	89	88	87	85	84	84	83	83
60 °C amb.	86	84	83	82	80	79	79	78	78
AirFlow (LFM)	0	50	100	150	200	250	300	350	400

1. The red-colored value(s) indicate combinations of airflow and local ambient temperature that exceed the allowable case temperature for the IXP42X product line. See Section 3.1 for system assumptions.

Figure 5. Maximum Allowable Ambient Temperature vs. Airflow for PBGA

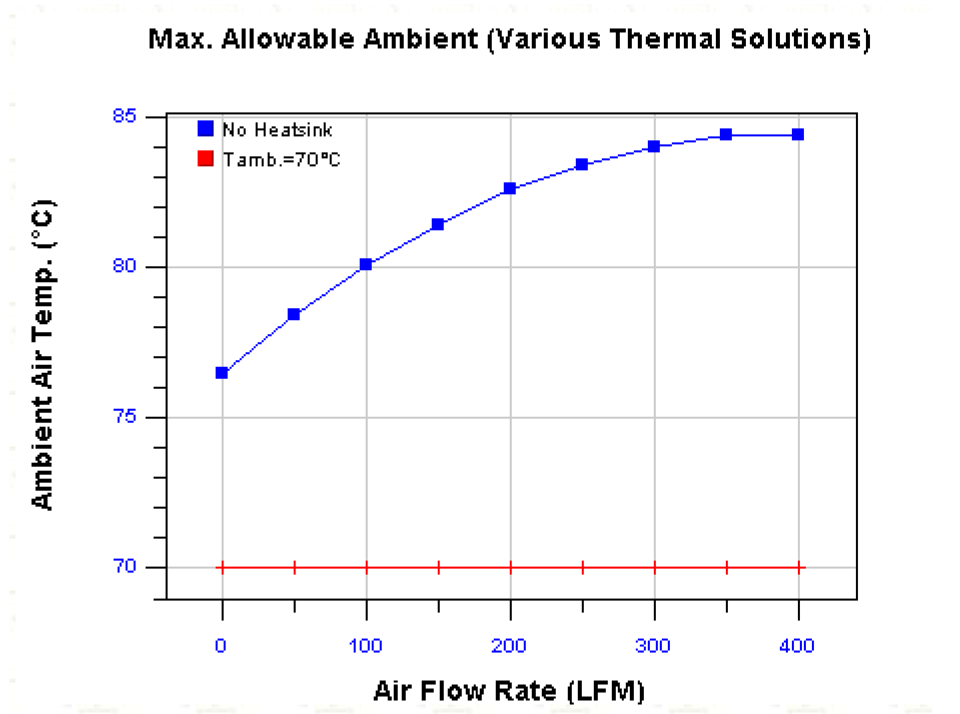


Table 4. Expected Tcase (°C) With No Heat Sink Attached and PDT = 2.4W for PBGA[1]

Expected Tcase (no GB) Table (Air Flow vs. Ambient) (Pkg Size=35mm DieX=8.2mm DieY=8.2mm Power=2.4W Heatsink=0 Tj max=115°C Pkg Type=PBGA-4Layer Board=4.5x4in 4Layer JEDEC)									
No Heatsink Attached									Tcase Max=113°C
85 °C amb.	122	120	118	116	114	113	112	111	111
80 °C amb.	117	115	113	111	109	108	107	106	106
75 °C amb.	112	110	108	106	104	103	102	101	101
70 °C amb.	107	105	103	101	99	98	97	96	96
65 °C amb.	102	100	98	96	94	93	92	91	91
60 °C amb.	97	95	93	91	89	88	87	86	86
55 °C amb.	92	90	88	86	84	83	82	81	81
50 °C amb.	87	85	83	81	79	78	77	76	76
45 °C amb.	82	80	78	76	74	73	72	71	71
AirFlow (LFM)	0	50	100	150	200	250	300	350	400

1. The red-colored value(s) indicate combinations of airflow and local ambient temperature that exceed the allowable case temperature for the IXP42X product line. See Section 3.1 for system assumptions.

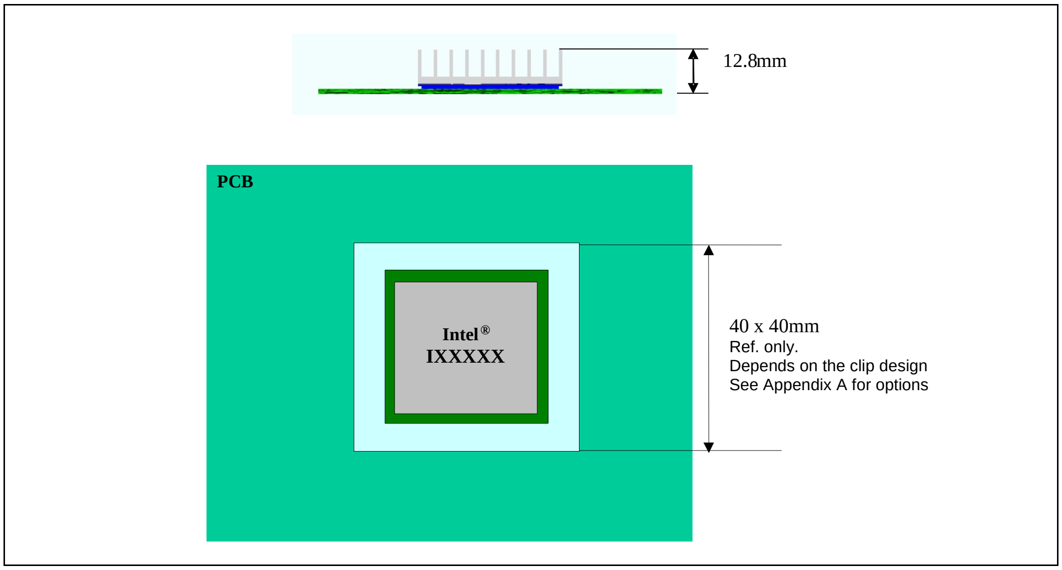
4.0 Thermal Enhancements (If Required)

One method frequently used to improve thermal performance is to increase the component's surface area. Attaching a heat sink to the component top increases surface area, which in turn reduces thermal resistance from the heat source to air, improving heat transfer. A second way to improve thermal performance is by providing airflow, which can be achieved by placing a fan near the component.

4.1 Clearances

To be effective, a heat sink requires a pocket of air around it free of obstructions. Though each design may have unique mechanical restrictions, the recommended clearance zones for a heat sink used with the IXP42X product line are shown in Figure 6.

Figure 6. Heat Sink Volume Restrictions



4.2 Default Enhanced Thermal Solution

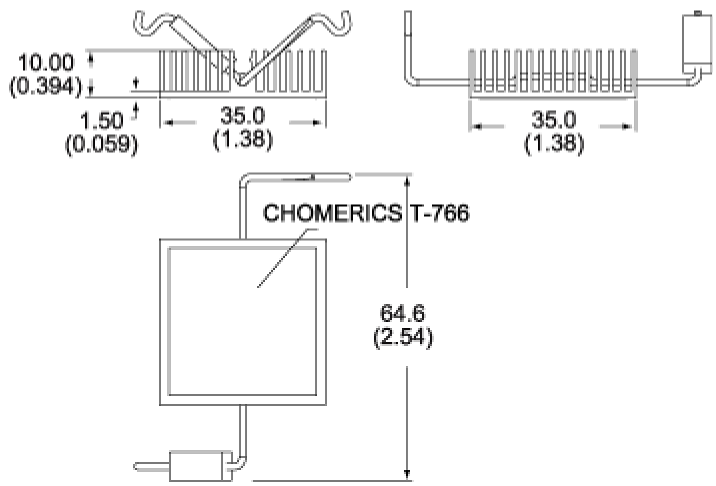
If you have no control over the end-user's thermal environment or if you wish to bypass the thermal modeling and evaluation process, use the Enhanced Thermal Solution discussed in Section 4.0. Enhancement to the Default Thermal Characteristics defined in Table 3 on page 13 and Table 4 on page 14 should improve heat transfer to ambient, cooling the component.

If the case temperature continues to exceed the desired value listed in Table 2 on page 8 after implementing the Enhanced Thermal Solution, additional cooling is needed, this can be provided by improving airflow to the component and/or adding additional thermal enhancements.

4.3 Extruded Heat Sinks

If required, an extruded heat sink is suggested for the IXP42X product line thermal solution. Figure 7 shows the suggested heat sink drawing. Other equivalent heat sinks and their sources are provided in Appendix A, "Heat Sink and Attachment Suppliers".

Figure 7. Extruded Heat Sink



Note: Dimensions are in millimeters and inches (shown in parentheses).

4.4 Attaching the Extruded Heat Sink

The extruded heat sink may be attached using clips with a phase-change, thermal-interface material.

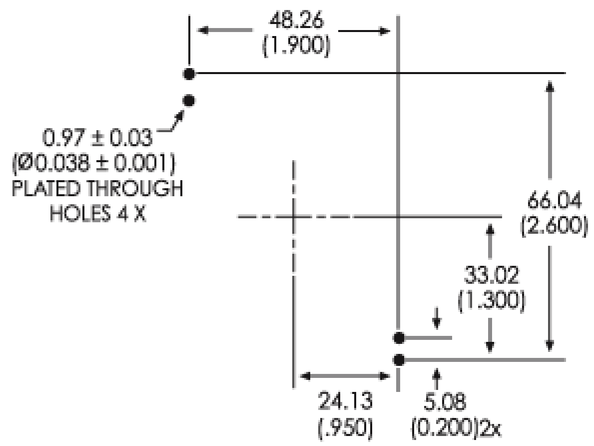
4.4.1 Clips

A well-designed clip, in conjunction with a thermal interface material (such as tape or grease), often offers the best combination of mechanical stability and reworkability.

Use of a clip requires significant advance planning as mounting holes are required in the PCB. Use non-plated mounting with a grounded annular ring on the solder side of the board surrounding the hole. For a typical low-cost clip, set the annular ring inner diameter to 150 mils and an outer diameter to 300 mils. Define the ring to have at least eight ground connections. Set the solder mask opening for these holes with a radius of 300 mils.

Figure 8 and Figure 9 show the location and size of the PCB holes needed for attaching the default thermal solution (see Section 4.3, "Extruded Heat Sinks" on page 16).

Figure 8. Reference Board Anchor Holes for Attaching Default Thermal Solution



4.4.2 Thermal Interface Material (PCM45)

The recommended thermal interface is PCM45 from Honeywell*. PCM45 thermal interface pads are phase-change materials suitable for high-performance IC devices, as shown in Figure 9 on page 18.

These materials exhibit excellent wetting at interfaces during the typical operating temperature range, resulting in very low surface contact resistance. Wetting refers to the ability of a liquid to coat a surface. For wetting to occur, a solid-air interface must be exchanged for a solid-liquid interface. (For additional information, see Section 4.6.2.2, "Wetting/Filling Characteristics of the Material" on page 20.)

The manufacturer's recommended attachment procedure for its thermal interface includes:

1. Ensure that the component surface and heat sink are free from contamination. Using proper safety precautions, clean the package top with a lint-free wipe and isopropyl alcohol.
2. Remove the PCM45 liner and carefully position the Thermal Interface Material (TIM) on the center of the heat sink.
3. Prior to assembly of the heat sink onto the heat dissipating component, place the heat sink and TIM at room temperature (between 21–25° C) for approximately two hours.
4. Remove the taped liner and verify that the TIM is uniformly and securely attached to heat sink.
5. Assemble heat sink to the Internal Heat Spreader (IHS).

   The IHS is the heat spreader contained within the component package.

Additional notes:

- Dents and minor scratches in the material will not affect performance since the material is designed to flow at typical operating temperatures.
- PCM45 pads can be removed for rework using a single-edged razor. Subsequently clean the surface with isopropyl alcohol.

Note: Each PCA, system, and heat sink combination varies in attachment strength. Carefully evaluate the reliability of tape attachments prior to making high-volume use of that method. (See Section 4.5, “Reliability” on page 18.)

Figure 9. PCM45 Phase Change Tape

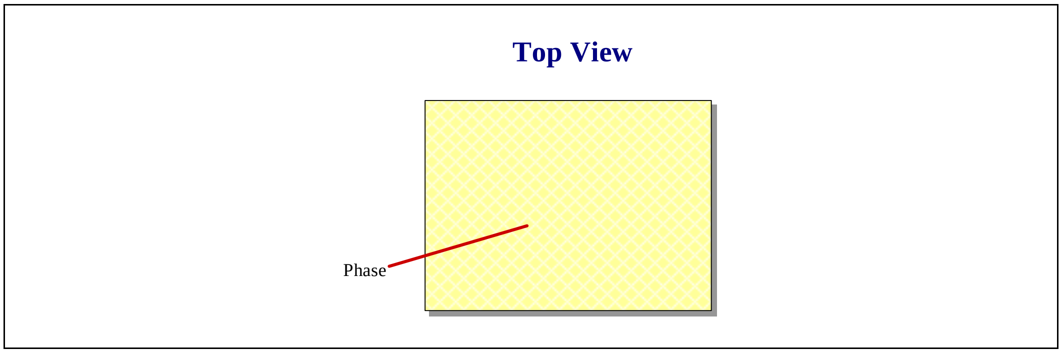
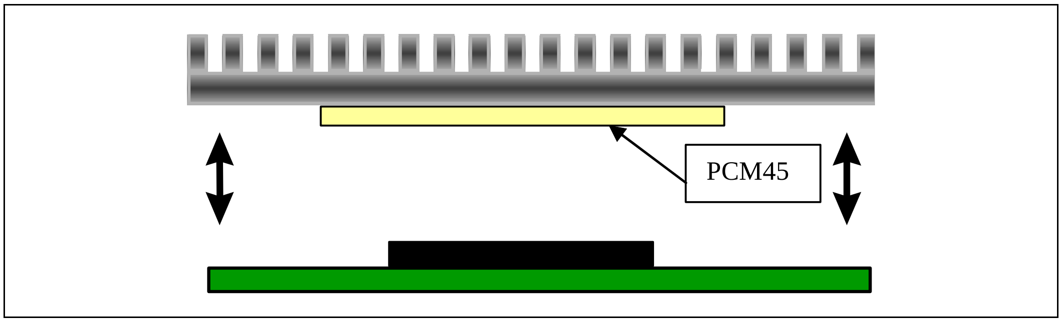


Figure 10. Completing the Attach Process



4.5 Reliability

Each PCA, system, and heat sink combination varies in attach strength and long-term adhesive performance. Carefully evaluate the reliability of the completed assembly prior making high-volume use of this method.

Some reliability testing recommendations are shown in Table 5 on page 18.

Table 5. Reliability Validation (Sheet 1 of 2)

Test[1]	Requirement	Pass/Fail Criteria[2]
Mechanical Shock	• 50 G, board level • 1 ms, 3 shocks/axis	Visual and Electrical Check
Random Vibration	• 7.3 G, board level • 45 minutes/axis, 50 to 2,000 Hz	Visual and Electrical Check

Table 5. Reliability Validation (Sheet 2 of 2)

Test[1]	Requirement	Pass/Fail Criteria[2]
High-Temperature Life	• 85° C • 2,000 hours total • Checkpoints occur at 168, 500, 1,000, and 2,000 hours	Visual and Mechanical Check
Thermal Cycling	• Per-Target Environment (for example: -40° C to +85° C) 500 Cycles	Visual and Mechanical Check
Humidity	• 85% relative humidity • 85° C, 1,000 hours	Visual and Mechanical Check

1. Performed the above tests on a sample size of at least 12 assemblies from 3 lots of material (total = 36 assemblies).
2. Additional Pass/Fail criteria can be added at your discretion.

4.6 Thermal Interface Management for Heat Sink Solutions

To optimize the IXP42X product line heat sink design, it is important to understand the interface between the heat spreader and the heat sink base. Specifically, thermal conductivity effectiveness depends on the following:

- Bond-line thickness
- Interface material area
- Interface material’s thermal conductivity

4.6.1 Bond Line Management

The gap between the heat spreader and the heat sink base impacts heat sink solution performance. The gap is the space that will exist between the heat sink and the components heat spreader, when the two items are attached. The larger the gap between the two surfaces, the greater the thermal resistance.

The thickness of the gap is determined by the flatness of both the heat sink base and the heat spreader, plus the thickness of the thermal interface material (such as PSA, thermal grease, or epoxy) used to join the two surfaces.

The planarity of the IXP42X product line package is 6 mils.

4.6.2 Interface Material Performance

The following two factors impact the performance of the interface material between the heat spreader and the heat sink base:

- Thermal resistance of the material
- Wetting/filling characteristics of the material

4.6.2.1 Thermal Resistance of the Material

Thermal resistance describes the ability of the thermal interface material to transfer heat from one surface to another. The higher the thermal resistance, the less efficient the heat transfer.

The thermal resistance of the interface material has a significant impact on the thermal performance of the overall thermal solution. The higher the thermal resistance, the larger the temperature drop is required across the interface.

4.6.2.2 Wetting/Filling Characteristics of the Material

The wetting/filling characteristic of the thermal interface material is its ability to fill the gap between the heat spreader top surface and the heat sink. Since air is an extremely poor thermal conductor, the more completely the interface material fills the gaps, the lower the temperature-drop across the interface, thus increasing the efficiency of the thermal solution.

5.0 Measurements for Thermal Specifications

Determining the thermal properties of the system requires careful case-temperature measurements. Guidelines for measuring IXP42X product line case temperature are provided in this section.

5.1 Case Temperature Measurements

To ensure functionality and reliability, the IXP42X product line's T_{CASE} must be maintained at or below the maximum case temperatures listed in Table 1 on page 7. Special care is required when measuring the case temperature to ensure an accurate temperature measurement.

Use the following guidelines when making case measurements:

- Measure the surface temperature of the case in the geometric center of the case top.
- Calibrate the thermocouples used to measure T_{CASE} before making temperature measurements.
- Use 36-gauge (maximum) K-type thermocouples.

Care must be taken to avoid errors when measuring a surface temperature that is a different from the surrounding local-ambient air. Measurement errors can 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 (if used).

5.1.1 Attaching the Thermocouple (no heat sink)

The following approach is recommended to minimize measurement errors for attaching the thermocouple with no heat sink:

- Use K-type thermocouples with a diameter of 36 gauge or less.
- Ensure that the thermocouple has been properly calibrated.

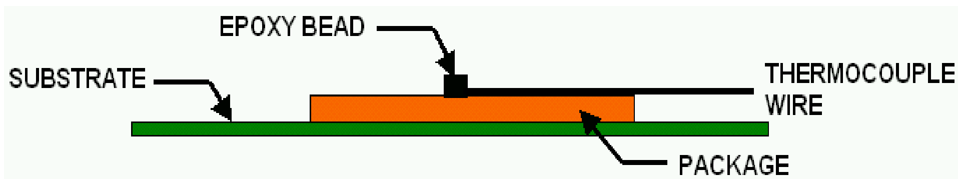
- Attach the thermocouple bead or junction with high-thermal-conductivity cement to the top surface of the package (case), in the center of the heat spreader.

  Note: It is critical that the entire thermocouple lead be butted tightly to the heat spreader.

- If there is no interference with the thermocouple attach location or leads, attach the thermocouple at a 0° angle as shown in Figure 11.

  This is the preferred method and is recommended for use with non-enhanced packages.

Figure 11. Technique for Measuring Tcase with 0° Angle Attachment (no heat sink)



5.1.2 Attaching the Thermocouple (with heat sink)

The following approach is recommended to minimize measurement errors for attaching the thermocouple with heat sink:

- Use 36-gauge or smaller diameter K-type thermocouples.
- Ensure that the thermocouple is properly calibrated.
- Attach the thermocouple bead or junction with high-thermal-conductivity cement to geometric center of the top surface of the package (case).

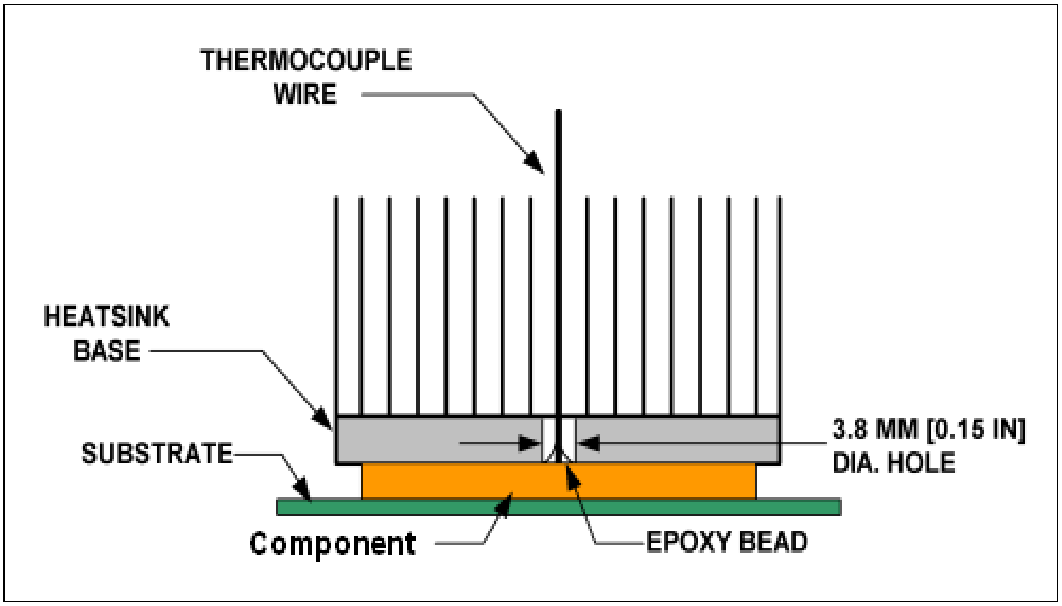
  Note: It is critical that the entire thermocouple lead be butted tightly to the heat spreader.

- If there is no interference with the thermocouple attach location or leads, attach the thermocouple at a 90° angle as shown in Figure 12.

  This is the preferred method and is recommended for use with packages with heat sinks.

- For testing purposes, a hole (no larger than 0.150 in. in diameter) must be drilled vertically through the center of the heat sink to route the thermocouple wires out.
- Ensure there is no contact between the thermocouple cement and heat sink base. Any contact affects the thermocouple reading.

Figure 12. Technique for Measuring Tcase with 90° Angle Attachment (with heat sink)



6.0 Conclusion

Increasingly complex systems require better power dissipation. 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, passive or active heat sinks, or any combination of those methods.

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 IXP42X product line. Properly designed solutions provide adequate cooling to maintain the IXP42X product line case temperature at or below those listed in Table 1 on page 7. Ideally, this is accomplished by providing a low, local-ambient temperature and creating a minimal thermal resistance to that local ambient temperature. Alternatively, heat sinks may be required if case temperatures exceed those listed in Table 1.

By maintaining the case temperature at or below those recommended in this document, the IXP42X product line should function properly and reliably.

Use this document to understand the IXP42X product line thermal characteristics and compare them to your system environment. Measure the IXP42X product line's case temperatures to determine the best thermal solution for your design.

Appendix A Heat Sink and Attachment Suppliers

Note: This section is only applicable to IXP42X processor operating at 667 MHz.

Extruded Heat Sink Sales Locations

- AavidThermalloy.com
  Phone: (972) 633-9371
  http://www.aavidthermalloy.com/

Heat sink option 1: Thermalloy Part Number: 374624B60024

Figure 13. Extruded Heat Sink Photo: Option 1

Heat sink option 2: Thermalloy Part Number: 10-5607-04

Figure 14. Extruded Heat Sink Photo: Option 2

A.1 Attachment Interface Material Sales Locations

See the following Web site for information on the Honeywell PCM45HD phase change thermal interface material:

http://www.electronicmaterials.com/products_services/packaging/pcm45_phas_chg_therm_int_mat.pdf

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Appendix B PCB Guidelines

The following general PCB design guidelines are recommended to maximize the thermal performance of HSBGA packages:

1. When connecting ground (thermal) vias to the ground planes, do *not* use thermal-relief patterns.

   Thermal-relief patterns are designed to limit heat transfer between the vias and the copper planes, thus constricting the heat flow path from the component to the ground planes in the PCB.

2. As board temperature also has an effect on the thermal performance of the package, avoid placing the IXP42X product line of network processors adjacent to high-power-dissipation devices.

3. If airflow exists:
   - Locate the components in the mainstream of the airflow path for maximum thermal performance.
   - Avoid placing the components downstream, behind larger devices or devices with heat sinks that obstruct the airflow or supply excessively heated air.

Note: The above guidelines are not all-inclusive and are defined to give you known, good design practices to maximize the thermal performance of the components.

Figure 15. Top View of the Vias with Thermal Relief and Solid Connections

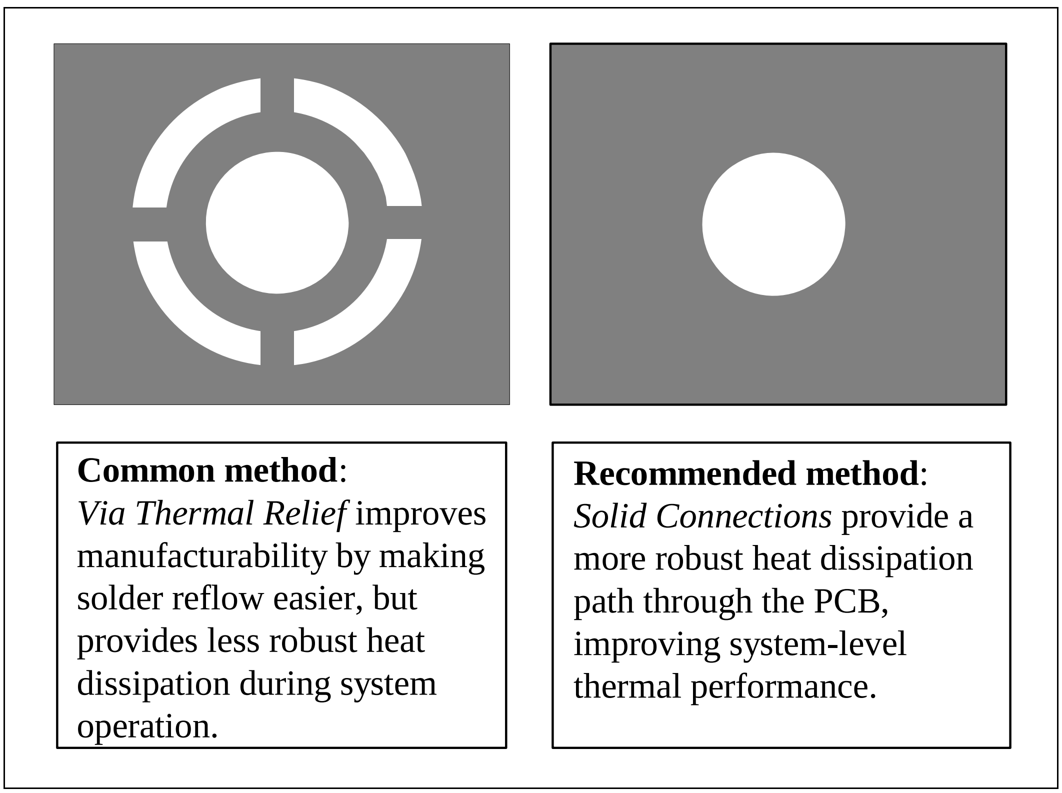

Figure 16. Cross-Sectional View of Recommended PCB Stack-Up for Thermal Performance