



Cortina Systems[®] IXF1104 Quad-Port Ethernet Media Access Controller Thermal Design Considerations: CBGA Version

Application Note

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Revision History

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Revision 001 Revision Date: 26 August 2005
Initial release, with 25mm 552 ball FC-PBGA package.

Reference Information

Test Method	Available From:
Integrated Circuit Thermal Measurement Method-Electrical Test Method	EIAJESD51-1
Integrated Circuits Thermal Test Method Environmental Conditions — Natural Convection (Still Air)	EIAJESD51-2

1.0 Introduction

This document describes the Cortina Systems® IXF1104 Quad-Port Gigabit Ethernet Media Access Controller (IXF1104 MAC) thermal characteristics and suggested thermal solutions. Use this document to properly design a thermal solution for systems implementing the IXF1104 MAC.

Properly designed solutions provide adequate cooling to maintain the IXF1104 MAC case temperature (T_{case}) at or below those listed in [Table 2, Preliminary Thermal Absolute Maximum Rating, on page 8](#). Ideally, this is accomplished by providing a low local ambient temperature and creating a minimal thermal resistance to that local ambient temperature. Heatsinks may be required if case temperatures exceed those listed in [Table 2, Preliminary Thermal Absolute Maximum Rating, on page 8](#). By maintaining the IXF1104 MAC case temperature at or below those recommended in this document, the IXF1104 MAC will function properly and reliably.

1.1 What You Will Find In This Document

This document contains the following sections:

- [Section 2.0, Packaging Terminology, on page 7](#):
Provides definitions for package terminology used in this document.
- [Section 3.0, Thermal Specifications, on page 8](#):
Provides IXF1104 MAC case temperature specifications and where to find power requirements. This section also discusses thermal packaging techniques
- [Section 4.0, Thermal Attributes, on page 10](#):
Provides IXF1104 MAC thermal characteristic data, package mechanical attributes, and package thermal characteristic data. Use this section to determine your thermal solution requirements.
- [Section 5.0, Thermal Enhancements \(If Required\), on page 16](#):
Discusses the use of heatsinks: heatsink attach methods, heatsink interfacing, and heatsink reliability.
- [Section 6.0, Measurements for Thermal Specifications, on page 22](#):
Provides instructions for measuring IXF1104 MAC case temperature with and without a heatsink.

1.2 Intended Audience

System Design Engineers using the IXF1104 MAC. System designers are required to address component and system-level thermal challenges as the market continues to adopt products with higher-speeds and port densities. New designs may be required to provide better cooling solutions for silicon devices depending on the type of system and target operating environment.

1.3 Operating Temperature Range

The IXF1104 MAC is specified for operation from 0 °C to 70 °C ambient temperature in Fiber Mode and -40 °C to 85 °C ambient temperature in copper mode. Thermal enhancements such as heatsink and/or forced airflow are required in environments where ambient air temperature is above 55 °C, when operating in 1000 Mbps copper or fiber mode.

1.4 Measuring the Thermal Conditions

Measurement of actual ambient temperature inside a system is difficult to determine. This document provides a more precise method for determining the operating temperature of the IXF1104 MAC 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 also specifies a maximum allowable T_{case} for the IXF1104 MAC and suggests methods for extending the ambient temperature range up to 85 °C.

1.5 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 consist of the following:

- Local ambient temperature at the component
- Airflow over the component and surrounding board
- Physical constraints at, 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
 - 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 solution 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 ambient temperatures and ensure that thermal design requirements are met for each component in the system

1.6 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 component and/or system damage. Temperatures exceeding the maximum operating limits may result in irreversible changes in the component operating characteristics.

1.7 Thermal Parameters

The thermal parameters defined in [Table 1](#) are based on simulated results of packages assembled on standard multilayer 4s2p 1.0 oz Cu layer boards in a natural convection environment. The maximum case temperature is based on the maximum junction temperature and defined by the relationship, $T_{case-max} = T_{jmax} - (\Psi_{JT} \times Power)$ where Ψ_{JT} is the junction-to-package top thermal characterization parameter. If the case temperature exceeds the specified $T_{case\ max}$, thermal enhancements such as heatsinks or forced air will be required. Θ_{JA} is the package junction-to-air thermal resistance.

Note: Thermal models are available upon request (Flotherm 2-Resister, Delphi, or Detailed format).

Table 1 Package Thermal Characteristics in a Typical Environment

Package Type	Mode of Operation	Estimated Power	Θ_{JA}	Ψ_{JT}	Maximum Junction Temperature	Tcase Maximum ¹
25 mm 552 CBGA	1000 Mbps Copper	3.4 W	19.9 C/W	0.6 C/W	117 °C	115 °C
25 mm 552 CBGA	1000 Mbps Fiber	2.9 W	19.9 C/W	0.6 C/W	117 °C	115 °C
25 mm 552 CBGA	100 Mbps Copper	1.6 W	19.9 C/W	0.6 C/W	117 °C	115 °C

1. Do not exceed the maximum allowable case temperature.

2.0 Packaging Terminology

The following is a list of packaging terminology used in this document:

- **Ceramic Ball Grid Array (CBGA):** A package whose PCB-interconnect method consists of high lead or eutectic solder balls arranged in an array on the interconnect side of the package substrate (typical).
- **Junction:** Refers to a P-N junction on the silicon. In this document, it is used as a temperature reference point (for example, Θ_{JA} refers to the "junction" to ambient temperature).
- **Lands:** The pads on the PCB to which BGA Balls are soldered.
- **PCB:** Printed Circuit Board.
- **Printed Circuit Assembly (PCA):** An assembled PCB.
- **Thermal Design Power (TDP):** The estimated maximum possible/expected power generated in a component by a realistic application. Use Maximum power requirement numbers from the Cortina Systems® IXF1104 Quad-Port Gigabit Ethernet Media Access Controller Datasheet.

3.0 Thermal Specifications

The component Thermal Design Power (TDP) can be found in the Test Specification section of the IXF1104 MAC Datasheet as the maximum power consumption numbers. In general, a system should be designed to accommodate the highest possible thermal power dissipation.

To ensure proper operation and reliability of the IXF1104 MAC, the thermal solution must maintain a case temperature at or below the values specified in [Table 2](#). System-level or component-level thermal enhancements are required to dissipate the generated heat if the case temperature exceeds the maximum temperatures listed in [Table 2](#).

Good system airflow is critical to dissipate the highest possible thermal power. The size and number of fans, vents, and/or ducts, and, their placement in relation to components and airflow channels within the system determine airflow. Acoustic noise constraints may limit the size and types of fans, vents and ducts that can be used in a particular design

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

Table 2 Preliminary Thermal Absolute Maximum Rating

Mode of Operation	Parameter	Maximum
1000 Mbps Copper	T _{case-hs2}	114 °C
	T _{case-no hs1}	115 °C
1000 Mbps Fiber	T _{case-hs2}	114 °C
	T _{case-no hs1}	115 °C
100 Mbps Copper	T _{case-hs2}	115 °C
	T _{case-no hs1}	116 °C
1. T _{case-hs} is defined as the maximum case temperature with the default enhanced thermal solution attached. 2. T _{case-no hs} is defined as the maximum case temperature without any thermal enhancement to the package.		

3.1 Case Temperature

The IXF1104 MAC is specified for operation from 0 °C to 70 °C ambient temperature in fiber mode and -40 °C to 85 °C ambient temperature in copper mode. Cortina also specifies a T_{case} since the measurement of local ambient temperature is difficult to determine. The IXF1104 MAC operates properly as long as the T_{case} is not exceeded. [Section 6.1, Case Temperature Measurements, on page 22](#) discusses proper guidelines for measuring the case temperature.

3.2 Effect of Packaging on Thermal Dissipation

In previous generations of products where QFP packages were the primary package type, the majority of the thermal power dissipated by the product typically flowed into the environment via the package, leads, heat-slug (if applicable), or a combination. With the advent of CBGA packages, very little heat typically flows into the motherboard to which it is mounted. The remaining thermal power is dissipated into the ambient environment by the package itself (with or without a thermal enhancement). In the absence of thermal enhancement, the IXF1104 MAC package heat dissipates most of the heat into the board and rest of the heat flows to the air from top of the die.

3.3 Designing for Thermal Performance

[Appendix B, PCB Guidelines](#) documents the PCB and system design recommendations required to achieve the IXF1104 MAC thermal performance documented herein.

4.0 Thermal Attributes

4.1 Cortina Test System Definitions

The following system examples generate thermal characteristics data in [Table 3, Expected \$T_{case}\$ \(\$^{\circ}C\$ \) With Heatsink Attached at 1000 Mbps Copper Mode](#), on page 12 through [Table 8, Expected \$T_{case}\$ \(\$^{\circ}C\$ \) with No Heatsink Attached at 100 Mbps Copper Mode](#), on page 15:

- The heatsink case assumes the default enhanced thermal solution (see [Section 5.3, Extruded Heatsinks](#), on page 17).
- The evaluation board is a 6 x 6 inch six-layer PCB.
- T_{case} max with a heatsink for 1000 Mbps copper and fiber is 114 $^{\circ}C$
- T_{case} max with no heatsink for 1000 Mbps copper and fiber is 115 $^{\circ}C$
- T_{case} max with a heatsink for 100 Mbps copper is 115 $^{\circ}C$
- T_{case} max with no heatsink for 100 Mbps copper is 116 $^{\circ}C$

Notes:

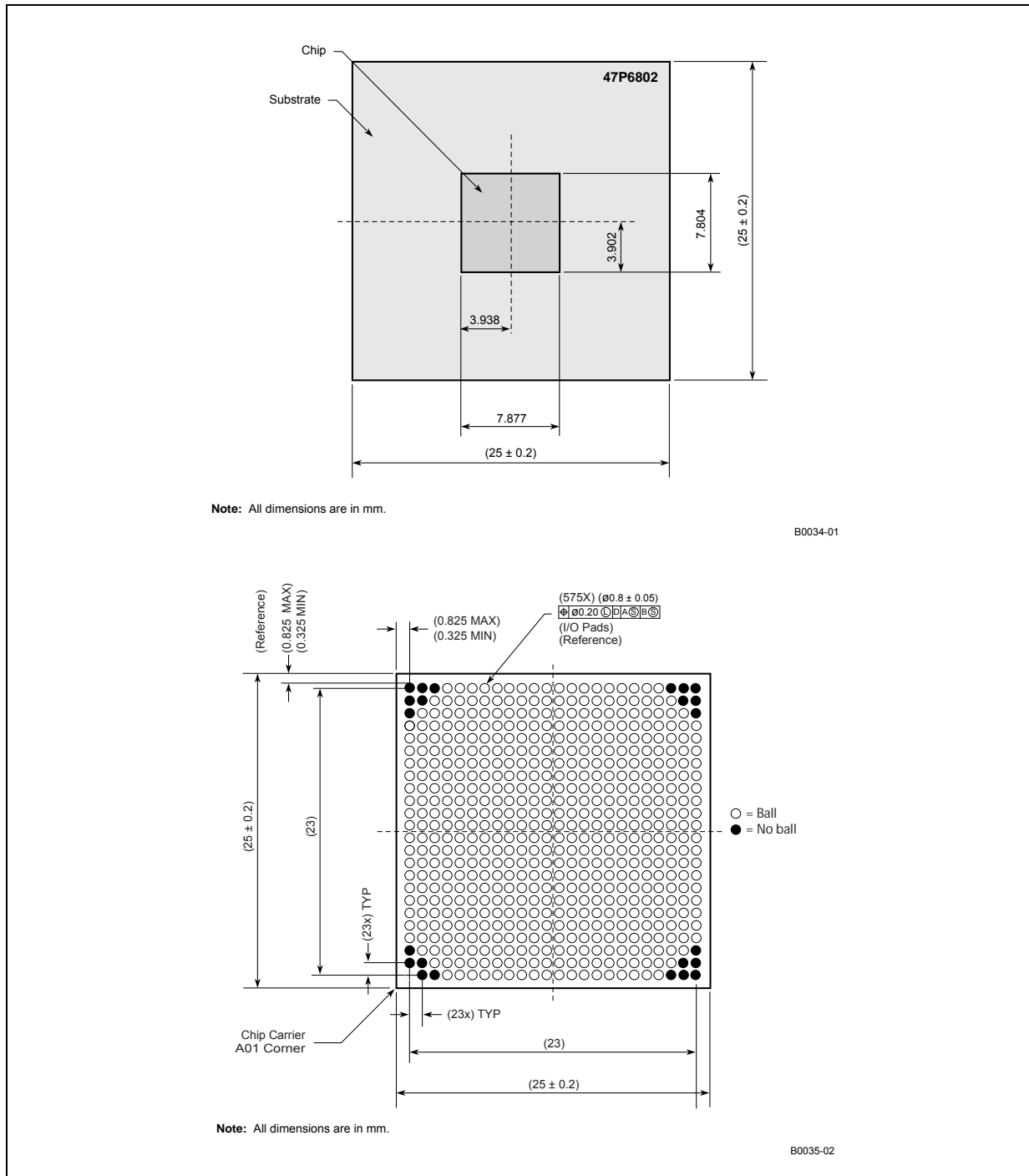
1. All data is preliminary and is not validated against physical samples.
2. Your system design may be significantly different.
3. A larger board size with more than six Cu layers may increase the IXF1104 MAC thermal performance. Slightly lower airflow or higher ambient air may be sufficient to maintain the specified T_{case} .

4.2 IXF1104 MAC Thermal Attributes

4.2.1 CBGA Package Mechanical Attributes

The IXF1104 MAC is packaged as a 25 x 25 mm, 14-layer 552-ball CBGA. As a reference, the mechanical drawings are shown in [Figure 1](#).

Figure 1 25 mm 552-Ball CBGA Mechanical Drawing (Top and Bottom Views)



4.2.2 Package Thermal Characteristics

The following tables help to determine the IXF1104 MAC optimum airflow and heatsink combination:

- Table 3, *Expected T_{case} ($^{\circ}C$) With Heatsink Attached at 1000 Mbps Copper Mode*, on page 12
- Table 4, *Expected T_{case} ($^{\circ}C$) With No Heatsink Attached at 1000 Mbps Copper Mode*, on page 13
- Table 5, *Expected T_{case} ($^{\circ}C$) With Heatsink Attached at 1000 Mbps Fiber Mode*, on page 13
- Table 6, *Expected T_{case} ($^{\circ}C$) With No Heatsink Attached at 1000 Mbps Fiber Mode*, on page 14
- Table 7, *Expected T_{case} ($^{\circ}C$) with Heatsink Attached at 100 Mbps Copper Mode*, on page 14
- Table 8, *Expected T_{case} ($^{\circ}C$) with No Heatsink Attached at 100 Mbps Copper Mode*, on page 15

Notes:

1. Your system design may vary considerably from the typical system board environment used to generate Table 3 through Table 8.
2. Thermal models are available upon request (Detailed Flotherm models). Contact your local Cortina sales representative if you would like to receive IXF1104 MAC thermal models.

Table 3 Expected T_{case} ($^{\circ}C$) With Heatsink Attached at 1000 Mbps Copper Mode

		Airflow (LFM)				
		0	100	200	300	400
Amb Temp ($^{\circ}C$)	85	134	116	107	104	102
	75	124	106	97	94	92
	70	119	101	92	89	87
	65	114	96	87	84	82
	55	104	86	77	74	72
	45	94	76	67	64	62
	35	84	66	57	54	52
	0	49	31	22	19	17

1. The shaded values indicate airflow/ambient combinations that exceed the allowable case temperature for the IXF1104 MAC; the unshaded values do not.
 2. See Section 4.1, *Cortina Test System Definitions*, on page 10 for system definitions.
 3. T_{case} Spec = 114 $^{\circ}C$.

Table 4 Expected T_{case} (°C) With No Heatsink Attached at 1000 Mbps Copper Mode

		Airflow (LFM)				
		0	100	200	300	400
Amb Temp (°C)	85	151	128	119	114	111
	75	141	118	109	104	101
	70	136	113	104	99	96
	65	131	108	99	94	91
	55	121	98	89	84	81
	45	111	88	79	74	71
	35	101	78	69	64	61
	0	66	43	34	29	26

1. The shaded values indicate airflow/ambient combinations that exceed the allowable case temperature for the IXF1010; the unshaded values do not.
2. See [Section 4.1, Cortina Test System Definitions, on page 10](#) for system definitions.
3. T_{case} Spec = 115 °C.

Table 5 Expected T_{case} (°C) With Heatsink Attached at 1000 Mbps Fiber Mode

		Airflow (LFM)				
		0	100	200	300	400
Amb Temp (°C)	85	127	111	104	101	99
	75	117	101	94	91	89
	70	112	96	89	86	84
	65	107	91	84	81	79
	55	97	81	74	71	69
	45	87	71	64	61	59
	35	77	61	54	51	49
	0	42	26	19	16	14

1. The shaded values indicate airflow/ambient combinations that exceed the allowable case temperature for the IXF1104 MAC; the unshaded values do not.
2. See [Section 4.1, Cortina Test System Definitions, on page 10](#) for system definitions.
3. T_{case} Spec = 114 °C.

Table 6 Expected T_{case} (°C) With No Heatsink Attached at 1000 Mbps Fiber Mode

		Airflow (LFM)				
		0	100	200	300	400
Amb Temp (°C)	85	141	122	114	110	107
	75	131	112	104	100	97
	70	126	107	99	95	92
	65	121	102	94	90	87
	55	111	92	84	80	77
	45	101	82	74	70	67
	35	91	72	64	60	57
	0	56	37	29	25	22

1. The shaded values indicate airflow/ambient combinations that exceed the allowable case temperature for the IXF1010; the unshaded values do not.
2. See [Section 4.1, Cortina Test System Definitions, on page 10](#) for system definitions.
3. T_{case} Spec = 115 °C.

Table 7 Expected T_{case} (°C) with Heatsink Attached at 100 Mbps Copper Mode

		Airflow (LFM)				
		0	100	200	300	400
Amb Temp (°C)	85	108	99	96	94	93
	75	98	89	86	84	83
	70	93	84	81	79	78
	65	88	79	76	74	73
	55	78	69	66	64	63
	45	68	59	56	64	53
	35	58	49	46	44	43
	0	23	14	11	9	8

1. See [Section 4.1, Cortina Test System Definitions, on page 10](#) for system definitions.
2. T_{case} Spec = 114 °C.

Table 8 Expected T_{case} (°C) with No Heatsink Attached at 100 Mbps Copper Mode

		Airflow (LFM)				
		0	100	200	300	400
Amb Temp (°C)	85	116	106	101	99	97
	75	106	95	91	89	87
	70	101	90	86	84	82
	65	96	85	81	79	77
	55	86	75	71	69	67
	45	76	65	61	59	57
	35	66	55	51	49	47
	0	31	20	16	14	12

1. See [Section 4.1, Cortina Test System Definitions](#), on page 10 for system definitions.
 2. T_{case} Spec = 115 °C.

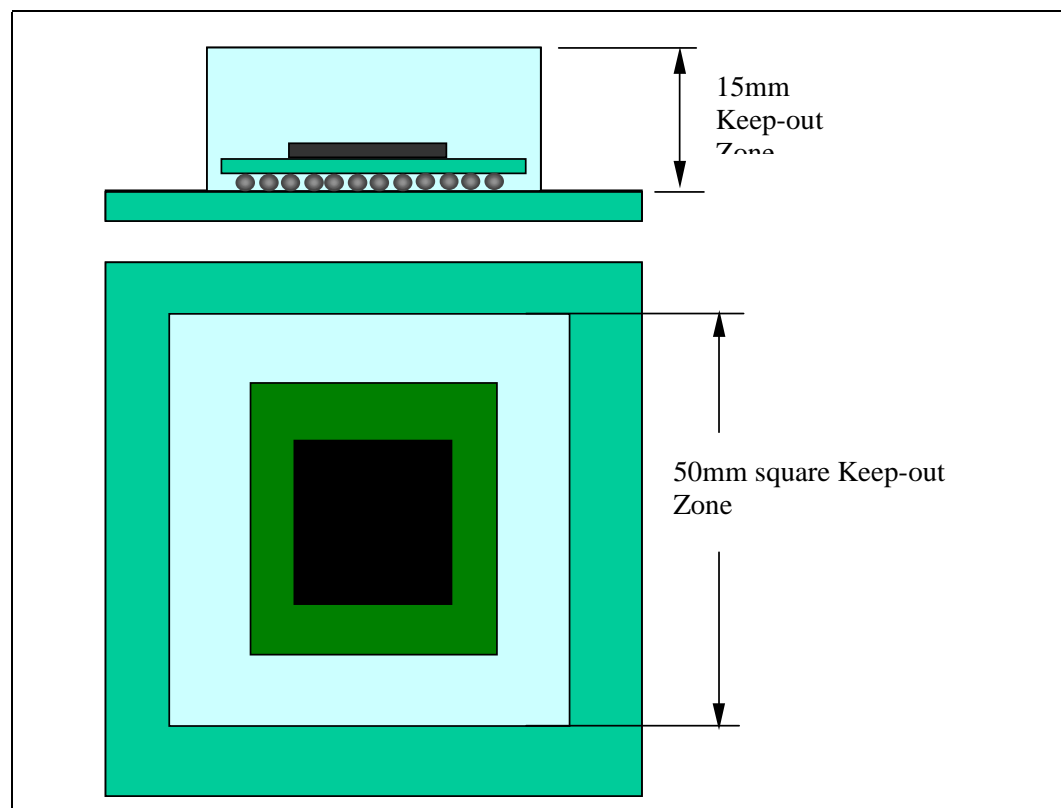
5.0 Thermal Enhancements (If Required)

One method frequently used to improve thermal performance is to increase the component's surface area by attaching a metallic heatsink to the component top. Increasing the surface area of the heatsink reduces the thermal resistance from the heatsink to the air-increasing heat transfer.

5.1 Clearances

To be effective, a heatsink requires a pocket of air around it free of obstructions. Though each design may have unique mechanical restrictions, the recommended clearance zones for a heatsink used with the IXF1104 MAC are shown in [Figure 2](#).

Figure 2 Heatsink Volume Restrictions



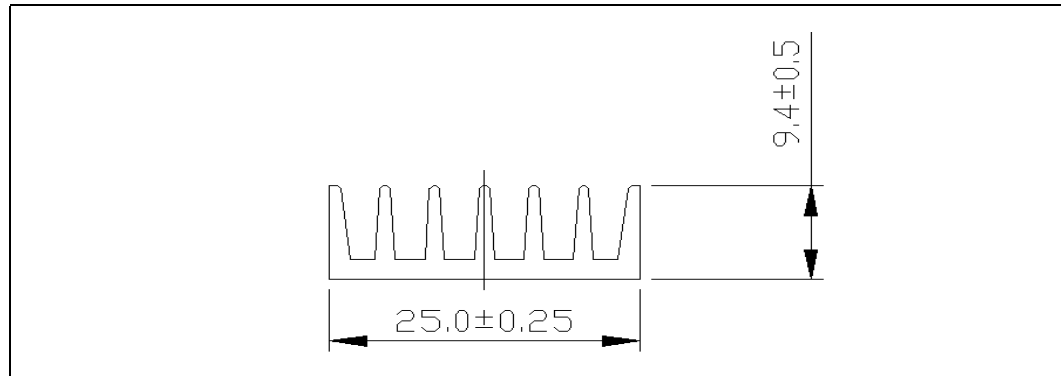
5.2 Default Enhanced Thermal Solutions

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 Default Enhanced Thermal Solution (discussed in the following section). The Default Enhanced Thermal Solution replicates the performance defined in [Table 3](#) and [Table 8](#) at the thermal design power. If the case temperature continues to exceed the appropriate value listed in [Table 3](#) after implementing the Default Enhanced Thermal Solution, additional cooling is needed. This may be achieved by improving airflow to the component and/or adding additional thermal enhancements.

5.3 Extruded Heatsinks

An extruded heatsink is the default thermal solution for the IXF1104 MAC if airflow improvements are not implemented or successful. [Figure 3](#) displays the extruded heatsink drawing. Sources for extruded heatsinks are discussed in [Appendix B, PCB Guidelines](#).

Figure 3 Extruded Heatsink Diagram



5.4 Attaching the Extruded Heatsink

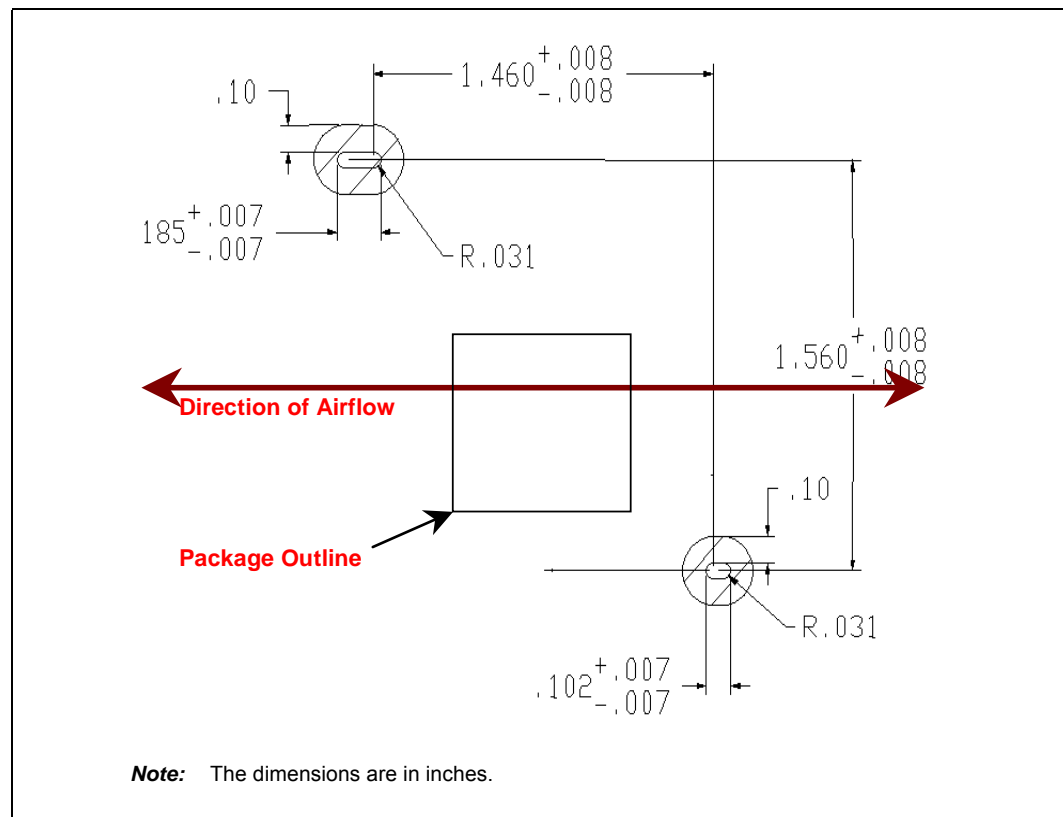
The extruded heatsink may be attached using clips and thermal interface (tape, grease, phase-change, etc.).

5.4.1 Clips

A well-designed clip, in conjunction with a thermal interface material (tape, grease, etc.) often offers the best combination of mechanical stability and rework-ability. 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 5 shows the location and size of PCB holes needed to attach the default thermal solution (see [Section 5.3, Extruded Heatsinks, on page 17](#)).

Figure 4 Reference Board Holes Used to Attach Default Thermal Solution (Top view)



5.4.2 Thermal Interface (T710, Single Layer)

For users who prefer attachment with thermal interface pads, Cortina recommends THERMFLOW™ T710 from Chomerics*. THERMFLOW™ T710 thermal interface pads are phase change materials specially formulated for use in high performance devices requiring minimum thermal resistance for maximum heatsink performance and component reliability. These pads combine the consistency and ease of use of elastomeric pads with the low thermal impedance of thermal grease.

Following is the manufacturer's recommended attach procedure list for the recommended thermal interface. The recommended steps for release liner removal are:

Note: For best results, use the release liner tab to “peel” the blue release liner back off the thermal pad as opposed to “pulling” it off.

1. Apply the thermal pad to the heatsink with the blue release liner facing up.

Note: Removing the blue release liner from the THERMFLOW pad prior to applying the pad to the heatsink is extremely difficult and is not recommended.

2. Starting as close as possible to one corner of the pad, bend back the release liner tab onto itself, forming a 120 to 180 degree angle.

3. Peel back from the starting corner to the opposite corner, maintaining the 120 to 180 degree angle.
4. Use a steady pressure when peeling the release liner tab back. Jerking or yanking the tab with too much pressure can pull the tab off the blue release liner.
5. When the blue release liner and its tab have been completely removed, they can be discarded and you are ready to attach the heatsink to the component to be cooled.

Note: Once removed, a slight gray haze on the bottom of the blue release liner is normal and will not affect performance of the applied THERMFLOW pad.

6. Because of its phase change nature, slight scratches or marks inadvertently made to the surface of the THERMFLOW pad before the heatsink is assembled to the component to be cooled will not affect the thermal performance of the pad.

Note: Each PCA, system, and heatsink combination varies in attach strength. Carefully evaluate the reliability of tape attaches prior to high-volume use (see 5.5 Reliability).

Figure 5 Phase Change Tape

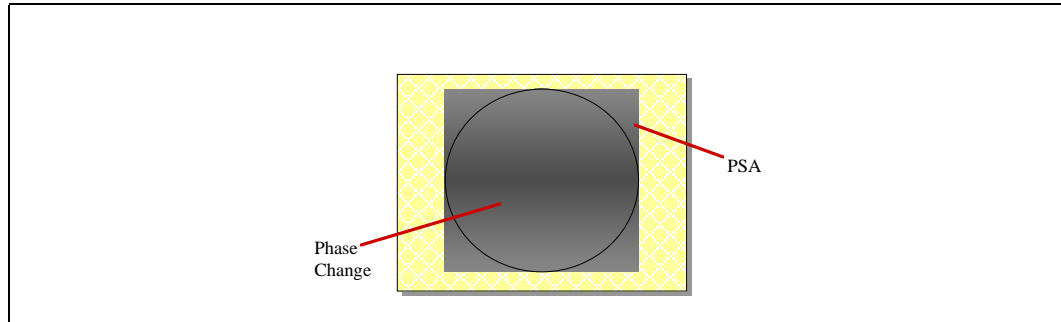
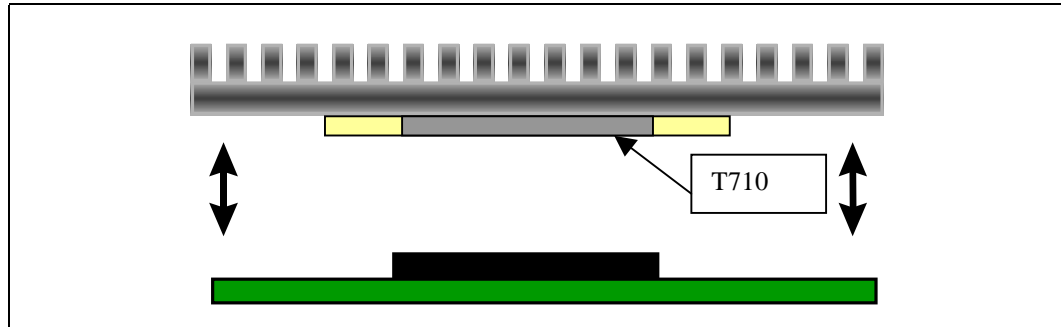


Figure 6 Completing the Attach Process



5.5 Reliability

As every PCA, system, heatsink and attach-process combination may introduce variances in attach strength and long term adhesive performance, it is generally recommended that the user carefully evaluate the reliability of the completed assembly prior to use in high volume. Some general recommendations are shown in [Table 9](#).

Table 9 Reliability Validation

Test ¹	Requirement	Pass/Fail Criteria ²
Mechanical Shock	50G, board level 11 ms, 3 shocks/axis	Visual and electrical check
Random Vibration	7.3 G, board level 45 minutes/axis, 50 to 2000 Hz	Visual and electrical check
High-Temperature Life	85 °C, 2000 hours total, Checkpoints occur at 168, 500, 1000, and 2000 hours	Visual and mechanical check
Thermal Cycling	Per Target Environment (-40 °C to +85 °C) 500 Cycles	Visual and mechanical check
Humidity	85% relative humidity 85 °C, 1000 hours	Visual and mechanical check
1. Perform 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 may be added at your discretion.		

5.6 Thermal Interface Management for Heatsink Solutions

To optimize the IXF1104 MAC heatsink design, it is important to understand the interface between the heat spreader and the heatsink base. Specifically, thermal conductivity effectiveness depends on the following:

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

5.6.1 Bond Line Management

The gap between the top of the package and the heatsink base impacts heat-sink solution performance. 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 heatsink base and the package top, plus the thickness of the thermal interface material (PSA, thermal grease, epoxy) used to join the two surfaces.

5.6.2 Interface Material Performance

Two following two factors impact the performance of the interface material between the die and the heatsink base:

1. Thermal resistance of the material
2. Wetting/filling characteristics of the material.

5.6.2.1 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 an interface is at transferring heat. 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 required across the interface.

5.6.2.2 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 heatsink. 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, increasing the efficiency of the thermal solution.

6.0 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 IXF1104 MAC case temperature. [Section 6.1](#) provides guidelines on how to accurately measure the case temperature of the IXF1104 MAC.

6.1 Case Temperature Measurements

Maintain the IXF1104 MAC T_{case} at or below the maximum case temperatures listed in [Table 2, Preliminary Thermal Absolute Maximum Rating, on page 8](#) to ensure functionality and reliability. Special care is required when measuring the T_{case} temperature to ensure an accurate temperature measurement. Use the following guidelines when making T_{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 introducing errors into the measurements when measuring a surface temperature that is a different temperature from the surrounding local ambient air. Measurement errors may 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, and/or contact between the thermocouple cement and the heat-sink base (if used).

6.1.1 Attaching the Thermocouple (No Heatsink)

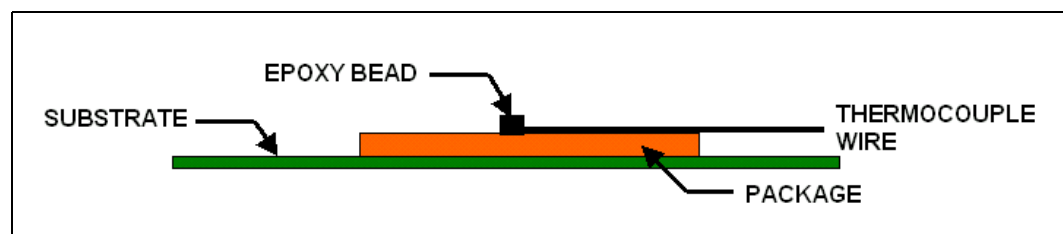
The following approach is recommended to minimize measurement errors for attaching the thermocouple with no heatsink:

- 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 package (case) in the center of the heat spreader using high thermal conductivity cements.

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

- Attach the thermocouple at a 0° angle if there is no interference with the thermocouple attach location or leads (refer to [Figure 7](#)). This is the preferred method and is recommended for use with non-enhanced packages.

Figure 7 Technique for Measuring T_{case} with 0° Angle Attachment



6.1.2 Attaching the Thermocouple (Heatsink)

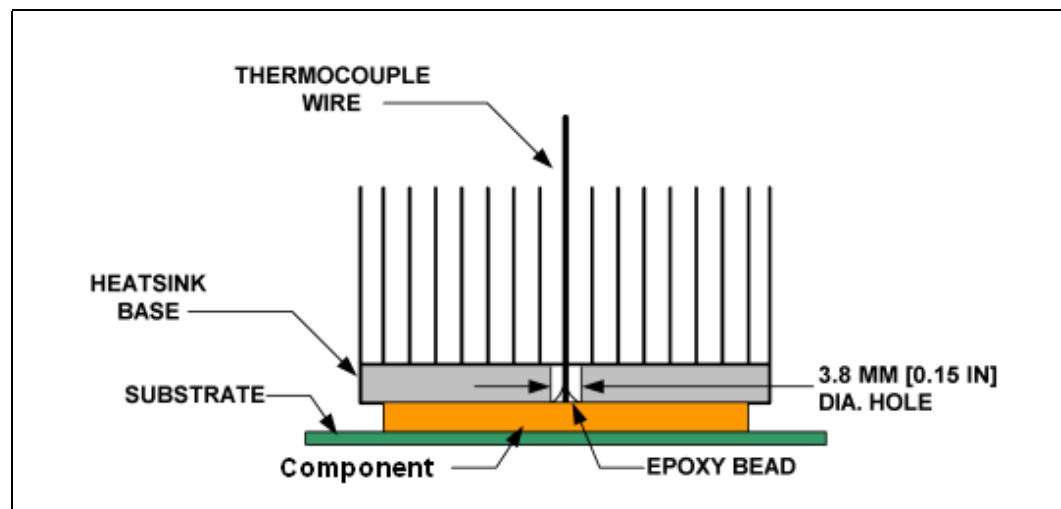
The following approach is recommended to minimize measurement errors for attaching the thermocouple with heatsink:

- Use 36 gauge or smaller diameter K-type thermocouples.
- Ensure that the thermocouple is properly calibrated.
- Attach the thermocouple bead or junction to the case's top surface in the geometric center using a high thermal conductivity cement.

Note: It is critical that the entire thermocouple lead be butted tightly against the case.

- Attach the thermocouple at a 90° angle if there is no interference with the thermocouple attach location or leads (refer to [Figure 8](#)). This is the preferred method and is recommended for use with packages with heatsinks.
- For testing purposes, a hole (no larger than 0.150" in diameter) must be drilled vertically through the center of the heatsink to route the thermocouple wires out.
- Ensure there is no contact between the thermocouple cement and heatsink base. Any contact affects the thermocouple reading.

Figure 8 Technique for Measuring T_{Case} with 90° Angle Attachment



7.0 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 heatsinks, or any combination.

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 heatsink 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 IXF1104 MAC. Properly designed solutions provide adequate cooling to maintain the IXF1104 MAC case temperature at or below those listed in [Table 2, Preliminary Thermal Absolute Maximum Rating, on page 8](#). Ideally, this is accomplished by providing a low local ambient temperature and creating a minimal thermal resistance to that local ambient temperature. Alternatively, heatsinks may be required if case temperatures exceed those listed in [Table 2](#). By maintaining the IXF1104 MAC case temperature at or below those recommended in this document, the IXF1104 MAC will function properly and reliably.

Use the sections in this document to understand the IXF1104 MAC thermal characteristics and compare to your system environment and measured IXF1104 MAC case temperatures to determine the best thermal solution for your design.

Appendix A Heatsink and Attach Suppliers

Extruded Heatsink Sales Locations:

CCI Thermal Technologies, 714-739-5797

Part Numbers

Heatsink — CCI Part Number 335C846501A

Clip — CCI Part Number 334C839901A

Heatsink, Clip, and Thermal Interface Assembly — Intel* Part Number A83774-001

Attach Interface Material Sales Locations:

See the following web site for information on Chomerics T-710 Phase Change Thermal Interface: www.chomerics.com/products/thermflow710.htm

Appendix B PCB Guidelines

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

1. When connecting ground (thermal) vias to the ground planes, do not use thermal-relief patterns.
2. 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. See [Figure 10, Vias with Thermal Relief and Solid Connections \(Top View\)](#), on page 27 and [Figure 11, Recommended PCB Stack-Up for Thermal Performance \(Cross-Sectional View\)](#), on page 27.
3. As board temperature also has an effect on the thermal performance of the package, avoid placing HFIXF1104CE adjacent to high power dissipation devices.
4. 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 heatsinks that obstruct the air flow or supply excessively heated air.

Figure 9 Recommended PCB Layout for Thermal Performance (Top View)

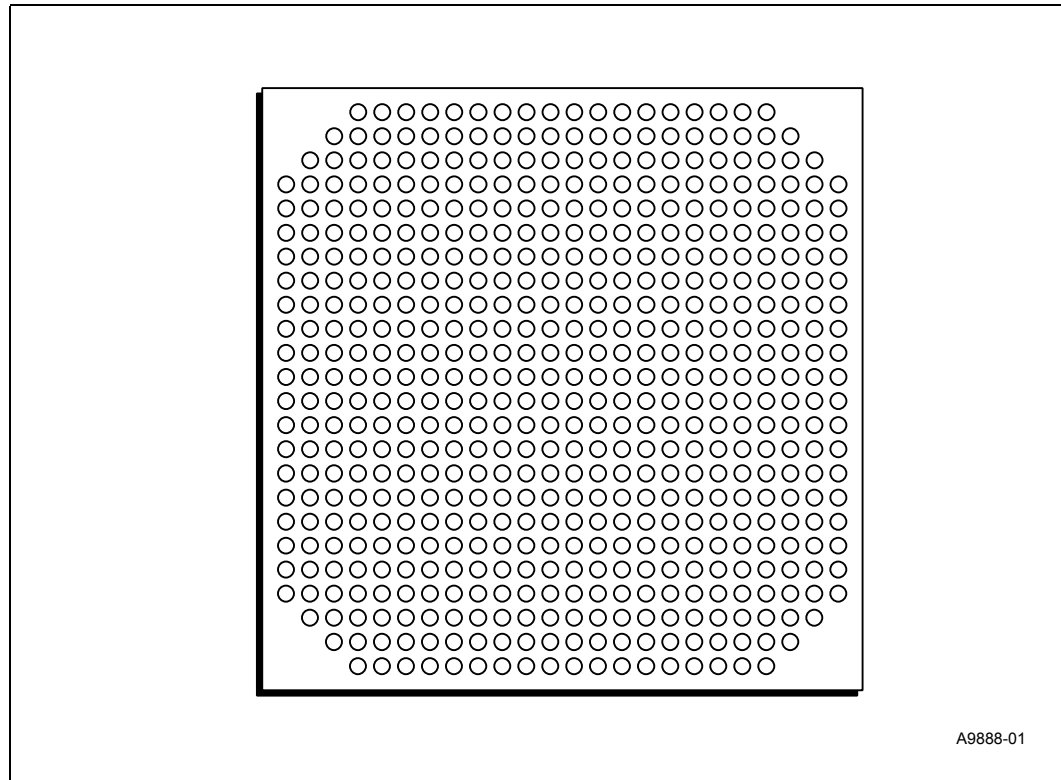


Figure 10 Vias with Thermal Relief and Solid Connections (Top View)

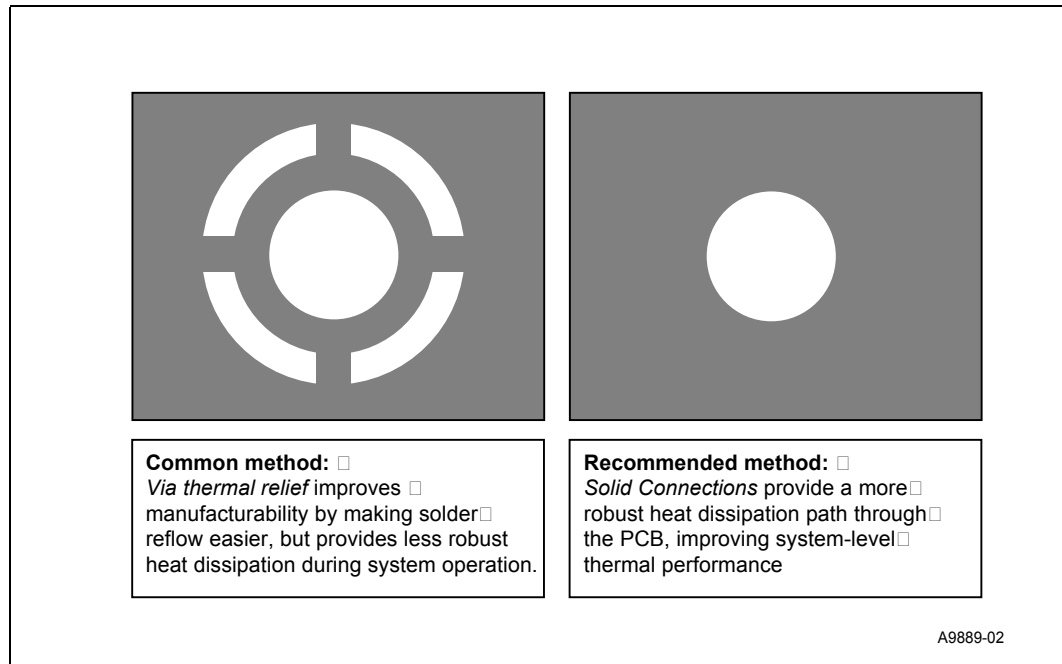
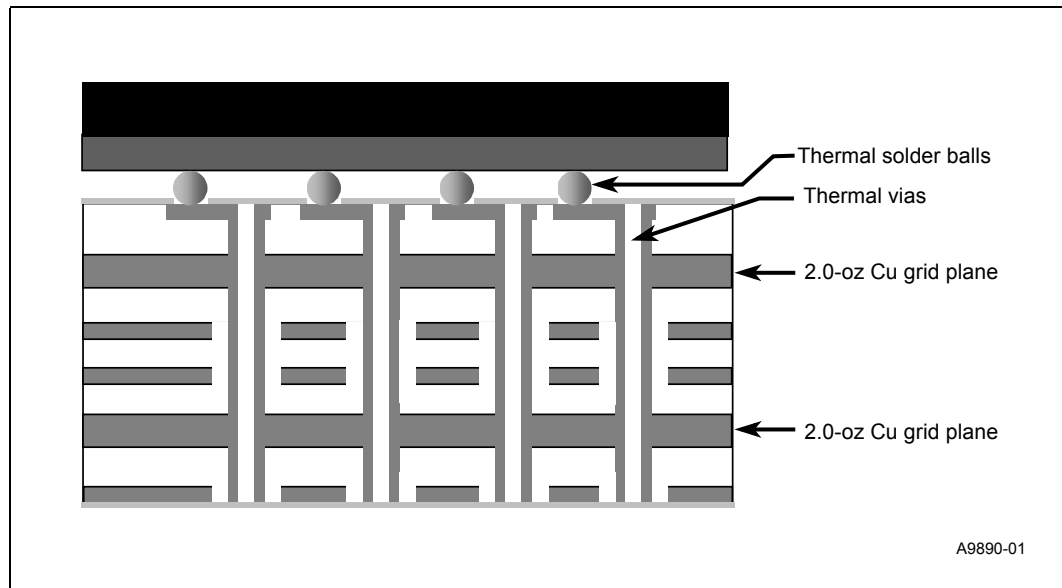


Figure 11 Recommended PCB Stack-Up for Thermal Performance (Cross-Sectional View)





For additional product and ordering information:

www.cortina-systems.com