



# **Cortina Systems® IXF1110 1000 Mbps Ethernet Media Access Controller: Thermal Design Considerations**

**Application Note**

---

**8 September 2007**

**Document Number 250289**

**Revision 3.0**

---

This document contains information proprietary to Cortina Systems, Inc. (Cortina). Any use or disclosure, in whole or in part, of this information to any unauthorized party, for any purposes other than that for which it is provided is expressly prohibited except as authorized by Cortina in writing. Cortina reserves its rights to pursue both civil and criminal penalties for copying or disclosure of this material without authorization.

**INFORMATION IN THIS DOCUMENT IS PROVIDED IN CONNECTION WITH CORTINA SYSTEMS® PRODUCTS.**

**NO LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE, TO ANY INTELLECTUAL PROPERTY RIGHTS IS GRANTED BY THIS DOCUMENT.**

**EXCEPT AS PROVIDED IN CORTINA'S TERMS AND CONDITIONS OF SALE OF SUCH PRODUCTS, CORTINA ASSUMES NO LIABILITY WHATSOEVER, AND CORTINA DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY RELATING TO THE SALE AND/OR USE OF CORTINA PRODUCTS, INCLUDING LIABILITY OR WARRANTIES RELATING TO FITNESS FOR A PARTICULAR PURPOSE, MERCHANTABILITY OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.**

Cortina products are not intended for use in medical, life saving, life sustaining, critical control or safety systems, or in nuclear facility applications.

Cortina Systems® and the Cortina Systems logo are the trademarks or registered trademarks of Cortina Systems, Inc. and its subsidiaries in the U.S. and other countries. Other names and brands may be claimed as the property of others.

Copyright © 2002–2007 Cortina Systems, Inc. All rights reserved.

---

## Contents

<b>1.0</b>	<b>Introduction.....</b>	<b>6</b>
1.1	Intended Audience.....	6
1.2	What You Will Find in This Document .....	6
1.3	Packaging Terminology .....	6
1.4	Reference Documents And Information Sources .....	7
<b>2.0</b>	<b>Thermal Design Requirements.....</b>	<b>8</b>
2.1	Measuring Thermal Conditions.....	8
2.2	Thermal Considerations.....	8
2.3	Importance of Thermal Management.....	8
<b>3.0</b>	<b>Thermal Specifications .....</b>	<b>10</b>
3.1	Operating Temperature Range.....	10
3.2	Case Temperature.....	10
3.3	Effect of Packaging on Thermal Dissipation .....	10
3.4	Product Package Thermal Specification .....	11
3.5	Designing for Thermal Performance.....	11
<b>4.0</b>	<b>Thermal Attributes.....</b>	<b>12</b>
4.1	Typical System Definitions.....	12
4.2	IXF1110 MAC Thermal Attributes.....	13
4.2.1	CBGA Package Mechanical Attributes .....	13
4.2.2	Package Thermal Characteristics.....	15
<b>5.0</b>	<b>Thermal Enhancements (If Required).....</b>	<b>16</b>
5.1	Clearances.....	16
5.2	Default Enhanced Thermal Solutions .....	17
5.3	Extruded Heatsinks.....	17
5.4	Attaching the Extruded Heatsink .....	18
5.4.1	Clips.....	18
5.4.2	Thermal Interface (T710, Single Layer) .....	18
5.5	Reliability .....	20
5.6	Thermal Interface Management for Heatsink Solutions.....	20
5.6.1	Bond Line Gap.....	21
5.6.2	Interface Material Performance .....	21
<b>6.0</b>	<b>Measurements for Thermal Specifications .....</b>	<b>22</b>
6.1	Case Temperature Measurements .....	22
6.1.1	Attaching the Thermocouple (No Heatsink).....	22
6.2	Attaching the Thermocouple (Heatsink) .....	23
<b>7.0</b>	<b>Conclusion .....</b>	<b>24</b>
<b>A</b>	<b>Heatsink and Attach Suppliers.....</b>	<b>25</b>
A.1	Extruded Heatsink Sales Locations .....	25
A.2	Sales Locations .....	25
<b>B</b>	<b>PCB Layout Requirements for Thermal Efficiency .....</b>	<b>26</b>

---

## Figures

1	CBGA Mechanical Drawings (Top/Bottom Views).....	13
2	CBGA Package Side View Diagram.....	14
3	CBGA Heatsink Volume Restrictions .....	16
4	Extruded Heatsink Drawing .....	17
5	Reference Board Holes for Attaching Default Thermal Solution (Top View) .....	18
6	T710 Phase Change Tape .....	19
7	Completing the Attach Process .....	20
8	Technique for Measuring Tcase with 0° Angle Attachment.....	22
9	Technique for Measuring Tcase with 90° Angle Attachment.....	23
10	Top View of Recommended PCB Layout for Thermal Performance .....	26
11	Top View of the Vias with Thermal Relief and Solid Connections .....	27
12	Cross-sectional View of Recommended PCB Stack-up for Thermal Performance .....	27

## Tables

1	CBGA Thermal Absolute Maximum Rating .....	10
2	Package Thermal Characteristics in a Typical Environment .....	11
3	Expected Tcase (°C) with Heatsink Attached for 9.4mm Tall Heatsink at 6.0W .....	15
4	Expected Tcase (°C) for No Heatsink Attached at 6.0W .....	15
5	Reliability Validation .....	20

---

## Revision History

<b>Revision 3.0</b> <b>Revision Date: 8 September 2007</b>
First release of this document from Cortina Systems, Inc.
<b>Revision Number: 002</b> <b>Revision Date: 24 November 2003</b>
Rearranged certain sections in this document.
Modified <a href="#">Section 1.3, "Importance of Thermal Management"</a> (changed 85 °C to 70 °C).
Added <a href="#">Section 3.0, "Product Package Thermal Specification"</a> .
Modified <a href="#">Table 2, "IXF1110 CBGA Thermal Absolute Maximum Rating"</a> .
Modified <a href="#">Figure 2, "IXF1110 CBGA Package Side View Diagram"</a> .
Modified <a href="#">Table 3, "IXF1110 Expected Tcase (°C) with Heatsink Attached at 1000 Mbps"</a> .
Added <a href="#">Table 4, "IXF1110 Expected Tcase (°C) with No Heatsink Attached at 1000 Mbps"</a> .
Added <a href="#">Figure 5, "IXF1110 Reference Board Holes for Attaching Default Thermal Solution (Top View)"</a>
Modified <a href="#">Section 6.4.2, "Thermal Interface (THERMFLOW T710)"</a> .
Modified <a href="#">Table 5, "IXF1110 Reliability Validation"</a> .
Modified <a href="#">Section 8.0, "Conclusion"</a> .
Modified <a href="#">Appendix A, "Heatsink and Attach Suppliers"</a> .
Modified <a href="#">Figure 12, "IXF1110 Cross-sectional View of Recommended PCB Stack-up for Thermal Performance"</a> .
<b>Revision Number: 001</b> <b>Revision Date: July 2002</b>
Preliminary release

---

## 1.0 Introduction

This Application Note describes the thermal characteristics and required thermal solutions for Cortina Systems® IXF1110 1000 Mbps Ethernet Media Access Controller (IXF1110 MAC). Use this document to properly design a thermal solution for systems implementing the IXF1110 MAC.

Properly designed solutions provide adequate cooling to maintain the IXF1110 MAC case temperature (Tcase) at or below those listed in [Table 1 on page 10](#). 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 1](#). By maintaining the IXF1110 MAC case temperature at or below those recommended in this document, the IXF1110 MAC will function properly and reliably.

### 1.1 Intended Audience

This document is intended for System Design Engineers using the IXF1110 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.

### 1.2 What You Will Find in This Document

This document contains the following sections:

- [Section 2.0, Thermal Design Requirements, on page 8](#) provides definitions for package terminology used in this document.
- [Section 3.4, Product Package Thermal Specification, on page 11](#) provides package thermal characteristics.
- [Section 3.0, Thermal Specifications, on page 10](#) provides IXF1110 MAC case temperature specifications and where to find power requirements. This section also discusses thermal packaging techniques.
- [Section 4.0, Thermal Attributes, on page 12](#) provides IXF1110 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 IXF1110 MAC case temperature with and without a heatsink.
- [Section 7.0, Conclusion, on page 24](#) offers conclusions and recommendations.

### 1.3 Packaging Terminology

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

- **Ceramic Ball Grid Array (CBGA)**. A package where the PCB-interconnect method consists of High Lead or eutectic solder balls arranged in an array on the interconnect side of the package's ceramic substrate (typical).

- **Junction:** Refers to a P-N junction on the silicon itself. In this document, junction is used as a temperature reference point (for example,  $\Theta_{JA}$  refers to the “junction” to ambient temperature).
- **Lands:** The pads on the PCB to which BGA Balls are soldered.
- **Printed Circuit Board (PCB)**
- **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® IXF1110 1000 Mbps Ethernet Media Access Controller Datasheet (document number 250210).
- **Linear Feet per Minute (airflow): LFM**

## 1.4 Reference Documents And Information Sources

Document Name or Information Source	Available From
Cortina Systems® IXF1010 10-Port 100/1000 Mbps Ethernet Media Access Controller Datasheet: Longform	Document #249839
Cortina Systems® IXF1110 10-Port 1000 Mbps Ethernet Media Access Controller Datasheet: Longform	Document #250210
Integrated Circuit Thermal Measurement Method – Electrical Test Method	EIA/JESD51-1
Integrated Circuits Thermal Test Method Environmental Conditions – Natural Convection (Still Air)	EIAJESD51-2

---

## 2.0 Thermal Design Requirements

### 2.1 Measuring Thermal Conditions

This document provides a more precise method for determining the operating temperature of the IXF1110 MAC in a specific system based on case temperature, which is a function of the local ambient and internal temperatures of the component. This document also specifies a maximum allowable Tcase for the IXF1110 MAC and suggests methods for extending the ambient temperature range up to 70 °C based on the IXF1110 MAC maximum allowable Tcase (see [Section Table 1, CBGA Thermal Absolute Maximum Rating, on page 10](#)).

### 2.2 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 parameters:

- Component power dissipation
- Die 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 the circuit board to which it is attached.

Technology trends continue to push these parameters with increased performance levels (higher operating speeds, MHz/GHz), Input/Output (I/O) density (smaller packages), and silicon density (more transistors). Power density increases and thermal cooling solution space become more constrained as operating frequencies increase and packaging sizes decrease. This results 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

### 2.3 Importance of Thermal Management

The thermal management objective is to ensure that all system component temperatures are maintained within operating limits. The operating temperature limit is the range in which the electrical circuits are expected to meet specified performance requirements. Operation outside the operating limits 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.

## 3.0 Thermal Specifications

Refer to the IXF1110 MAC Datasheet for the maximum power dissipation of the IXF1110 MAC. In general, design your system to accommodate the highest possible power dissipation.

To ensure proper operation and reliability of the IXF1110 MAC, the thermal solution must maintain a case temperature at or below the values specified in [Table 1](#). 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 1](#).

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

All of the system variables must be considered to develop a reliable, cost-effective thermal solution. Use system-level thermal characterization and simulation to account for the individual component thermal requirements.

**Table 1 CBGA Thermal Absolute Maximum Rating**

Mode of Operation	Parameter	Maximum
1000 Mbps	$T_{\text{case-hs}}^2$	122 °C
	$T_{\text{case-no hs}}^1$	123 °C
1. $T_{\text{case-no hs}}$ is defined as the maximum case temperature with the default thermal enhancement attached (see <a href="#">Section 5.0, Thermal Enhancements (If Required)</a> , on page 16). 2. $T_{\text{case-hs}}$ is defined as the maximum case temperature without any default thermal enhancement to the package.		

### 3.1 Operating Temperature Range

The IXF1110 MAC is specified for operation over the 0 °C to 70 °C ambient temperature range. Thermal enhancements such as heatsinks and/or forced airflow are required in environments where ambient temperature is above 55 °C.

Refer to [Section 4.2.2, Package Thermal Characteristics](#), on page 15 to determine what options are available for your target operating environment.

### 3.2 Case Temperature

Case temperature is a function of the local ambient temperature and the internal temperature of the component under evaluation. As a local ambient temperature is not directly specified for the IXF1110 MAC, the only restriction is that the maximum case temperature is not exceeded. [Section 6.1, Case Temperature Measurements](#), on page 22 discusses proper guidelines for measuring the case temperature.

### 3.3 Effect of Packaging on Thermal Dissipation

In previous product generations where QFP packages may have been the primary package type, the majority of the thermal power dissipated by the product typically flowed into the environment through a combination of package, leads, heat-slug (if applicable). With the advent of CBGA package types, 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 thermal enhancement). In the absence of thermal enhancement, the IXF1110 MAC package heat dissipates most of the heat into the motherboard and the rest of the heat flows to the air through a metal cap to which the die is attached.

### 3.4 Product Package Thermal Specification

Table 2 lists the thermal parameters that 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  $\Psi_{JT}$  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.  $\Theta_{JA}$  is the package junction-to-air thermal resistance.

**Table 2 Package Thermal Characteristics in a Typical Environment**

Package Type	Mode of Operation	Estimated Maximum Power <sup>2</sup>	$\Theta_{JA}$	$\Psi_{JT}$	Maximum Junction Temperature	$T_{case\ Maximum}^1$
25x25 mm 552-ball CBGA	1000 Mbps	6.0 W	19.9 °C/W	0.6 °C/W	125 °C	123 °C
1. Do not exceed the maximum allowable case temperature. 2. Maximum power, also known as Thermal Design Power (TDP), is a system design target associated with the maximum component operating temperature specifications. Maximum power values are determined based on typical DC electrical specification and maximum ambient temperature for a worst-case realistic application running at maximum utilization.						

### 3.5 Designing for Thermal Performance

Section Appendix B, *PCB Layout Requirements for Thermal Efficiency, on page 26* documents the PCB and system design recommendations required to achieve IXF1110 MAC optimal thermal performance.

---

## 4.0 Thermal Attributes

### 4.1 Typical System Definitions

The following system definitions are used to generate the thermal characteristics data in [Table 3](#) and [Table 4 on page 15](#):

- The heatsink case assumes the Default Enhanced Thermal Solution (see [Section 5.2, Default Enhanced Thermal Solutions, on page 17](#)).
- The evaluation board is a 6 x 6 inch PCB.

**Notes:**

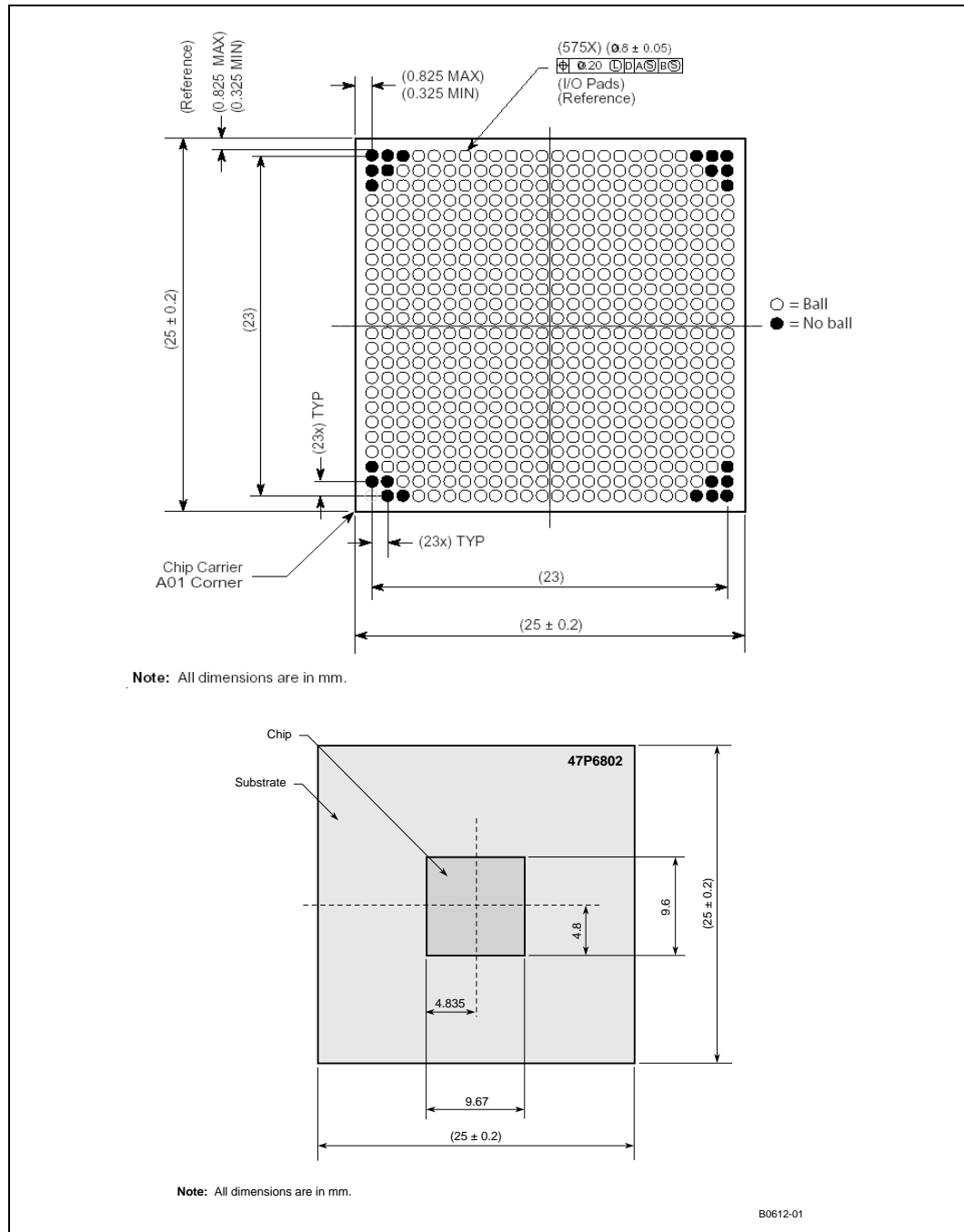
1. Your system design may be significantly different.
2. A larger board size with more than six Cu layers may increase the IXF1110 MAC thermal performance. Slightly lower airflow or higher ambient air may be sufficient to maintain the specified Tcase.

## 4.2 IXF1110 MAC Thermal Attributes

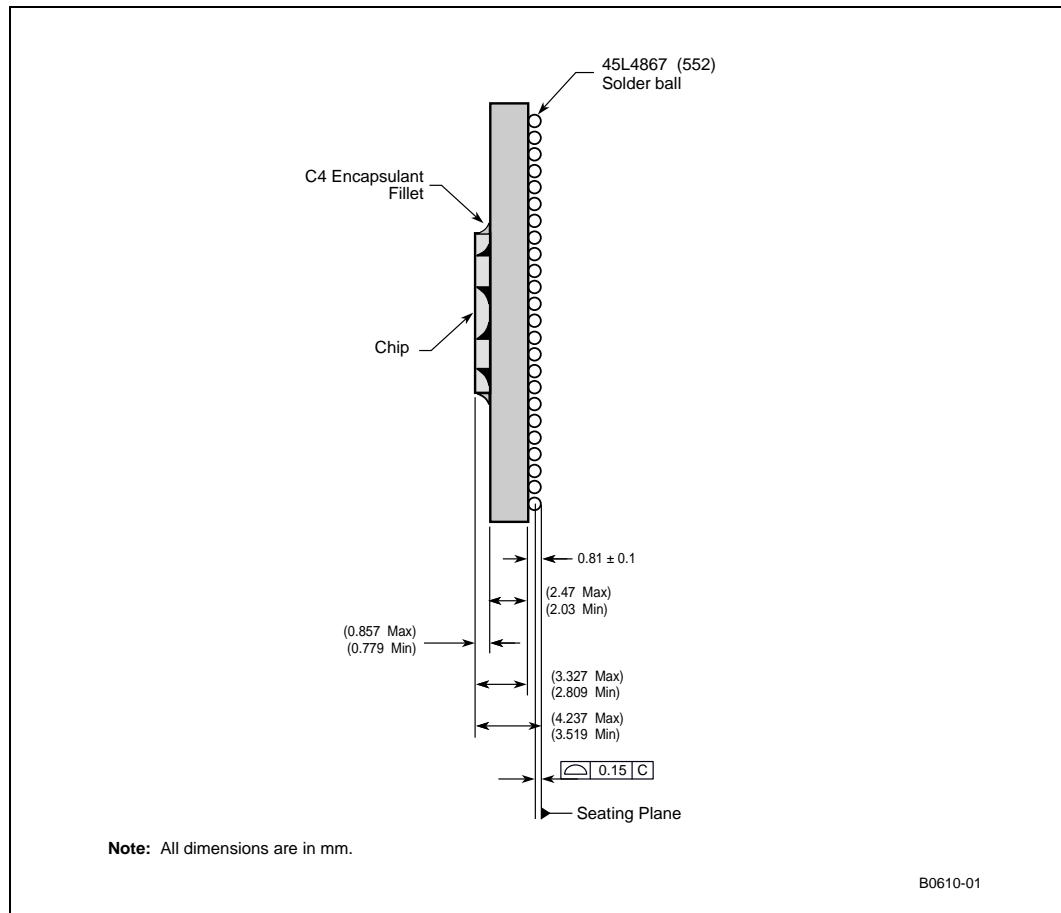
### 4.2.1 CBGA Package Mechanical Attributes

The IXF1110 MAC is packaged as a 25x25 mm 552-ball CBGA. Figure 1 shows the IXF1110 MAC mechanical drawings.

Figure 1 CBGA Mechanical Drawings (Top/Bottom Views)



**Figure 2 CBGA Package Side View Diagram**



## 4.2.2 Package Thermal Characteristics

Table 3 and Table 4 aid in determining the optimum airflow and heatsink combination for the IXF1110 MAC. The tables show case temperature as a function of airflow and ambient at the Thermal Design Power (TDP) for a typical IXF1110 MAC system, and may be used by the customer to evaluate prospective system solutions.

**Table 3 Expected Tcase (°C) with Heatsink Attached for 9.4mm Tall Heatsink at 6.0W**

		Airflow (LFM)				
		0	100	200	300	400
Amb Temp (°C)	85	191	150	126	120	115
	75	181	140	116	110	105
	70	176	135	111	105	100
	65	171	130	106	100	95
	55	161	120	96	90	85
	45	151	110	86	80	75
	35	141	100	76	70	65
	0	106	65	41	35	30

**Notes:**

1. The shaded values indicate airflow/ambient combinations that exceeded the allowable case temperature for the IXF1110 MAC; the unshaded values do not.
2. See Section 4.1, *Typical System Definitions*, on page 12 for system definitions.
3. Tcase Spec = 122 °C.

**Table 4 Expected Tcase (°C) for No Heatsink Attached at 6.0W**

		Airflow (LFM)				
		0	100	200	300	400
Amb Temp (°C)	85	233	168	153	145	140
	75	213	158	143	135	130
	70	208	153	138	130	125
	65	203	148	133	125	120
	55	193	138	123	115	110
	45	183	128	113	105	100
	35	173	118	103	95	90
	0	138	83	68	60	55

**Notes:**

1. The shaded values indicate airflow/ambient combinations that exceeded the allowable case temperature for the IXF1110 MAC; the unshaded values do not.
2. See Section 4.1, *Typical System Definitions*, on page 12 for system definitions.
3. Tcase Spec = 123 °C.

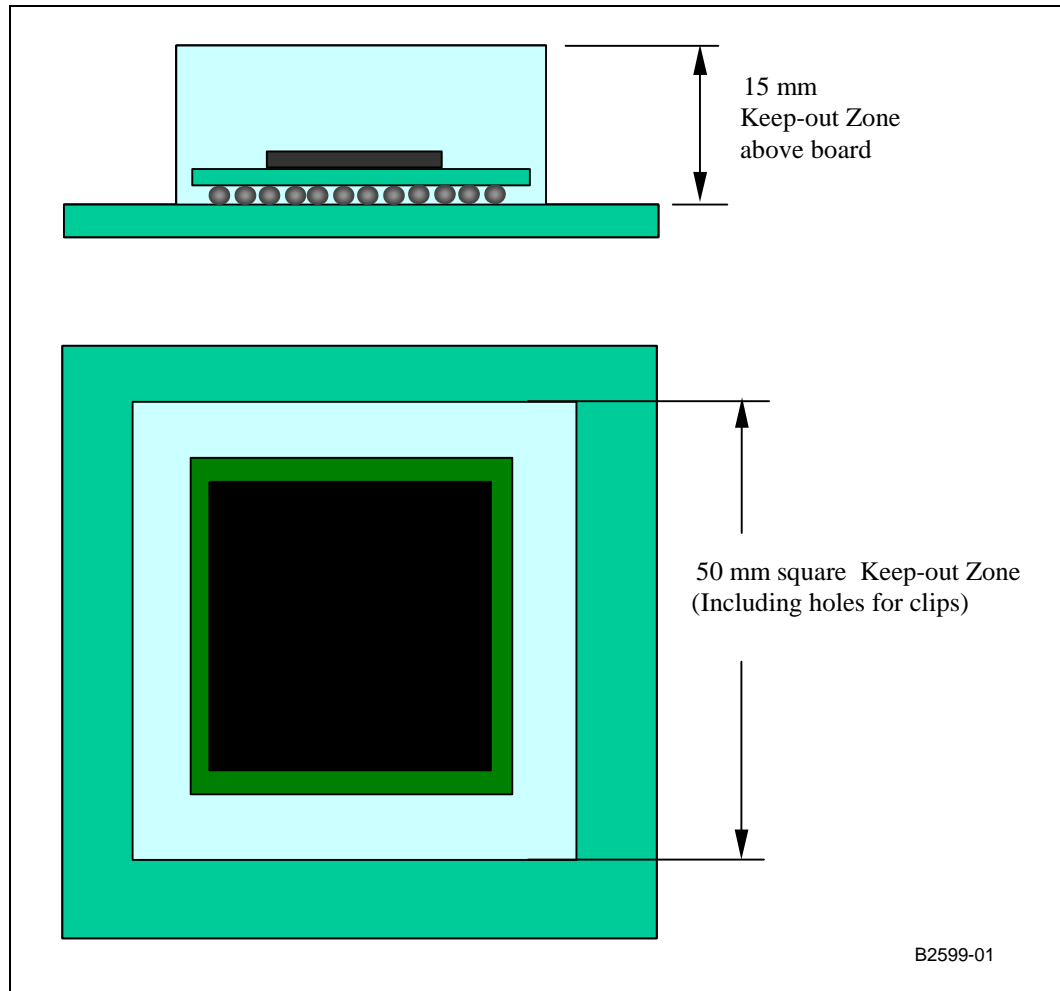
## 5.0 Thermal Enhancements (If Required)

One method 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 needs a pocket of air around it free of obstructions. [Figure 3](#) shows the recommended clearance zones for a heatsink used with the IXF1110 MAC, although each design may have unique mechanical volume and height restrictions or implementation requirements.

**Figure 3** CBGA Heatsink Volume Restrictions



## 5.2 Default Enhanced Thermal Solutions

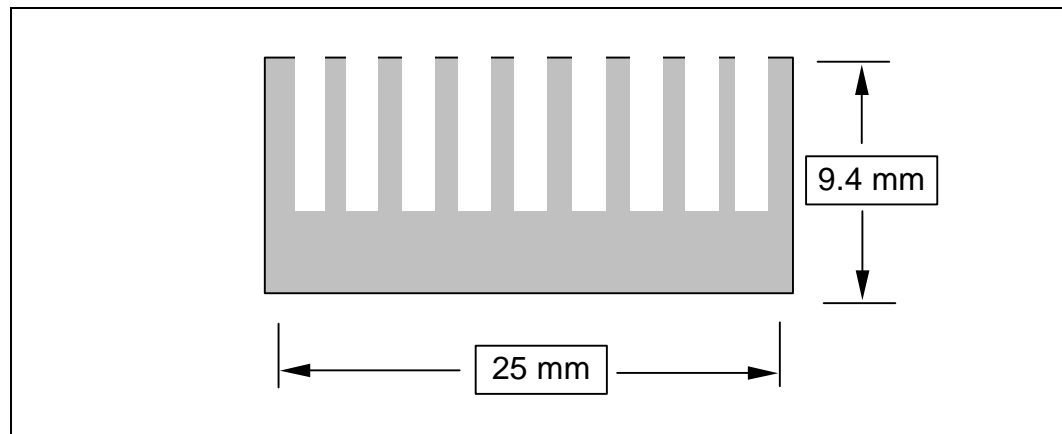
If you have no control over the end-user's thermal environment or if you wish to bypass the thermal modeling and evaluation process, use the Default Enhanced Thermal Solution (DTS) (discussed in [Section 5.3, Extruded Heatsinks](#)). The Default Enhanced Thermal Solution replicates the performance defined in [Section 4.2.2, Package Thermal Characteristics](#), on page 15 at the thermal design power.

If the case temperature continues to exceed the appropriate value listed in [Table 1, CBGA Thermal Absolute Maximum Rating](#), on page 10 after implementing the DTS, additional cooling is needed. This may be achieved by improving airflow to the component and/or adding additional thermal enhancements.

## 5.3 Extruded Heatsinks

If required, the following extruded heatsink is the suggested IXF1110 MAC thermal solution. [Figure 4](#) illustrates the extruded heatsink drawing. Other equivalent heatsinks and their sources are provided in [Section Appendix A, Heatsink and Attach Suppliers](#), on page 25.

**Figure 4** Extruded Heatsink Drawing



## 5.4 Attaching the Extruded Heatsink

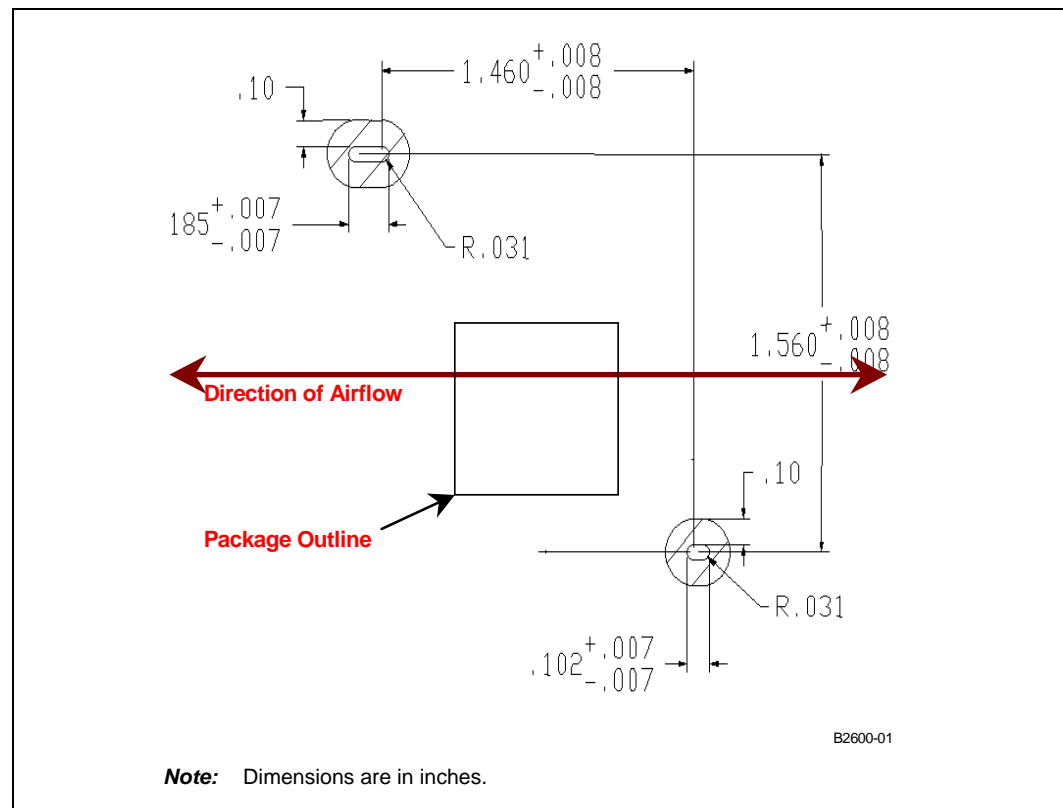
The extruded heatsink may be attached using clips with a phase change thermal interface.

### 5.4.1 Clips

A well-designed clip, in conjunction with a thermal interface material solution (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 5.3, *Extruded Heatsinks*, on page 17.)

Figure 5 Reference Board Holes for Attaching Default Thermal Solution (Top View)



### 5.4.2 Thermal Interface (T710, Single Layer)

Cortina recommends the Chomerics\* THERMFLOW™ T710 as the IXF1110 MAC thermal interface. The Chomerics\* THERMFLOW™ T710 thermal interface pads are phase change material 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 elastometric pads with the low thermal impedance of thermal grease.

Following is the manufacturer's recommended attach procedure list for the Chomerics\* THERMFLOW™ T710 thermal interface (recommended steps for release liner removal).

**Note:** For best results, the release liner tab should be used to “peel” the blue release liner 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 Chomerics\* THERMFLOW™ T710 pad prior to applying the pad to the heatsink is extremely difficult and is not recommended.

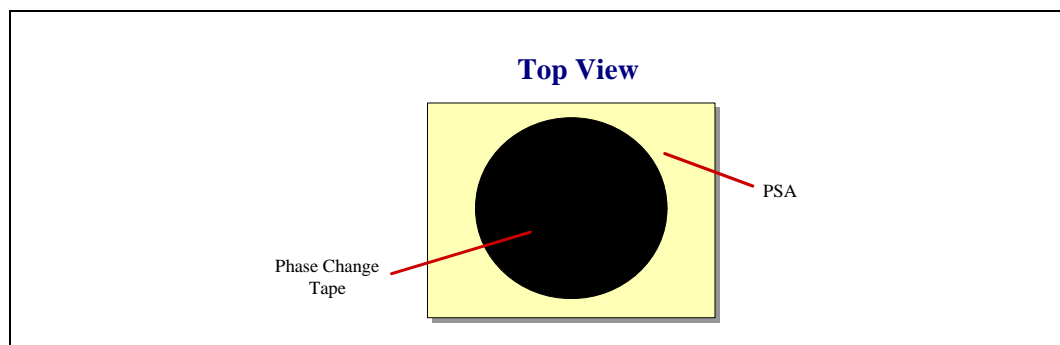
2. Starting as close as possible to one corner of the pad, bend back the release liner tab onto itself, forming a 120 to 180 degree angle.
3. Peel back from the starting corner to the opposite corner, maintaining the 120 to 180 degree angle.
4. Use a steady pressure when peeling the release liner tab back. Jerking or yanking the tab with too much pressure can pull the tab off the blue release liner.
5. The blue release liner and its tab may be discarded once they are completely removed. Attach the heatsink to the component to be cooled.

**Note:** After removal, a slight gray haze on the bottom of the blue release liner is normal and will not affect performance of the applied Chomerics\* THERMFLOW™ T710 pad.

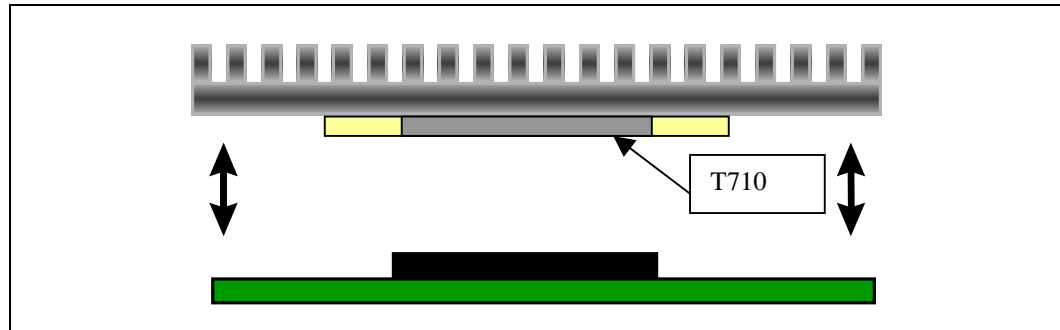
6. Because of its phase change nature, slight scratches or marks inadvertently made to the Chomerics\* THERMFLOW™ T710 pad surface before the heatsink is assembled to the component to be cooled will not affect the thermal performance of the pad.

Figure 6 shows the Chomerics\* THERMFLOW™ T710 phase change tape and Figure 7 illustrates completion of the attachment process.

**Figure 6** T710 Phase Change Tape



**Figure 7** Completing the Attach Process



## 5.5 Reliability

Each PCA, system, heatsink and attach-process combination varies in attach strength and long-term adhesive performance. Carefully evaluate the reliability of the completed assembly prior to high-volume use. [Table 5](#) lists some reliability recommendations.

**Table 5** Reliability Validation

Test <sup>1</sup>	Requirement	Pass/Fail Criteria <sup>2</sup>
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 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 (for example, -40 to +85 °C) 500 Cycles	Visual and Mechanical Check
Humidity	85% relative humidity 85 °C, 1000 hours	Visual and Mechanical Check
1. Perform these tests on a sample size of at least 12 assemblies from three lots of material (total = 36 assemblies). 2. Additional pass/fail criteria may be added at the discretion of the user.		

## 5.6 Thermal Interface Management for Heatsink Solutions

For solutions where a heatsink is required, it is important to understand the impact of factors related to the interface between the die top and the heatsink base. Specifically, thermal conductivity effectiveness depends on the following:

- *Bond Line Gap*
- *Interface Material Performance*

---

### 5.6.1 Bond Line Gap

The gap between the die and the heat-sink 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 die top, plus the thickness of the thermal interface material (for example, PSA, thermal grease, epoxy) used to join the two surfaces.

### 5.6.2 Interface Material Performance

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

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

#### 5.6.2.1 Thermal Conductivity of the Material

Thermal conductivity describes the ability and ease of the thermal interface material to transfer heat from one surface to another. The higher the thermal conductivity, the more efficient an interface is at transferring heat. The thermal conductivity of the interface material has a significant impact on the thermal performance of the overall thermal solution. The lower the thermal conductivity, the larger 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 die 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 solution.

## 6.0 Measurements for Thermal Specifications

Determining the thermal properties of the system requires careful case temperature measurements. [Section 6.1](#) provides guidelines for measuring IXF1110 MAC case temperature.

### 6.1 Case Temperature Measurements

Maintain IXF1110 MAC case temperature at or below the maximum case temperatures listed in [Table 1, CBGA Thermal Absolute Maximum Rating, on page 10](#) to ensure functionality and reliability. Special care is required when measuring the case temperature to ensure an accurate temperature measurement. Use the following guidelines when making case temperature measurements.

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

**Caution:** Care must be taken to avoid introducing errors into the measurements when measuring a surface temperature that is different 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, or contact between the thermocouple cement and the heatsink (if used).

#### 6.1.1 Attaching the Thermocouple (No Heatsink)

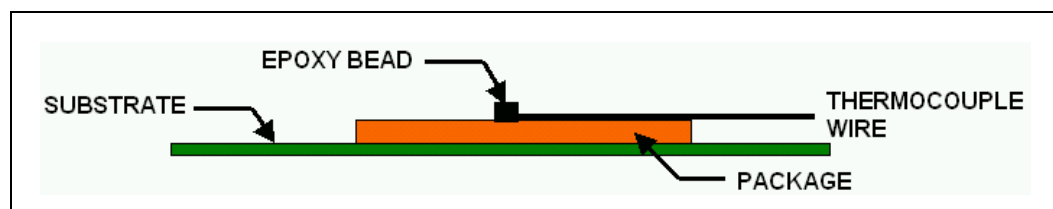
Use the following approach to minimize these measurement errors when attaching the thermocouple with no heatsink:

- 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 die top using high thermal conductivity cements.
- Use 36-gauge or smaller diameter K-type thermocouples.

**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 8](#)). This is the preferred method and is recommended for use with unenhanced packages.

**Figure 8** Technique for Measuring T<sub>case</sub> with 0° Angle Attachment



## 6.2 Attaching the Thermocouple (Heatsink)

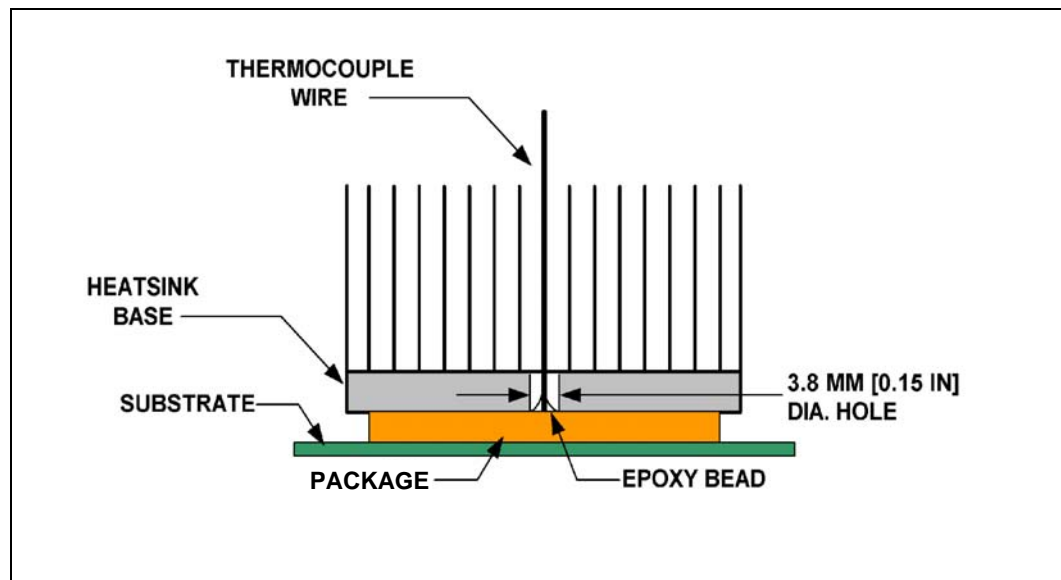
The following approach is recommended to minimize measurement errors when attaching the thermocouple with heatsink:

- 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 case 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 9](#)). This is the preferred method and is recommended for use with packages with heatsinks.
- For testing purposes, drill a hole vertically through the center of the heatsink to route the thermocouple wires out (should be smaller than 0.150" in diameter).
- Ensure there is no contact between the thermocouple cement and heatsink base. Any contact affects the thermocouple reading.

**Figure 9** Technique for Measuring  $T_{case}$  with 90° Angle Attachment



---

## 7.0 Conclusion

Increasingly complex systems require careful attention to thermal design to ensure that the additional heat is properly dissipated. Heat can be dissipated using a combination of improved system cooling, selective use of ducting, and passive or active heatsinks.

The simplest and most cost-effective method for proper heat dissipation 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 IXF1110 MAC. Properly designed solutions provide adequate cooling to maintain the IXF1110 MAC case temperature at or below those listed in [Table 1, CBGA Thermal Absolute Maximum Rating, on page 10](#). Maintaining the IXF1110 MAC case temperature at or below those recommended in this document ensures that a system functions properly and reliably.

---

## Appendix A Heatsink and Attach Suppliers

### A.1 Extruded Heatsink Sales Locations

ACK Technology, Inc.  
6081 Dale Street #C  
Buena Park, CA 90621-4162  
United States  
Phone: 714-739-5797  
Fax: 714-739-5898  
<http://www.acktechnology.com>

### A.2 Sales Locations

For Chomerics\* THERMFLOW™ T710 Tape, please go to:  
<http://www.chomerics.com/contact.htm>

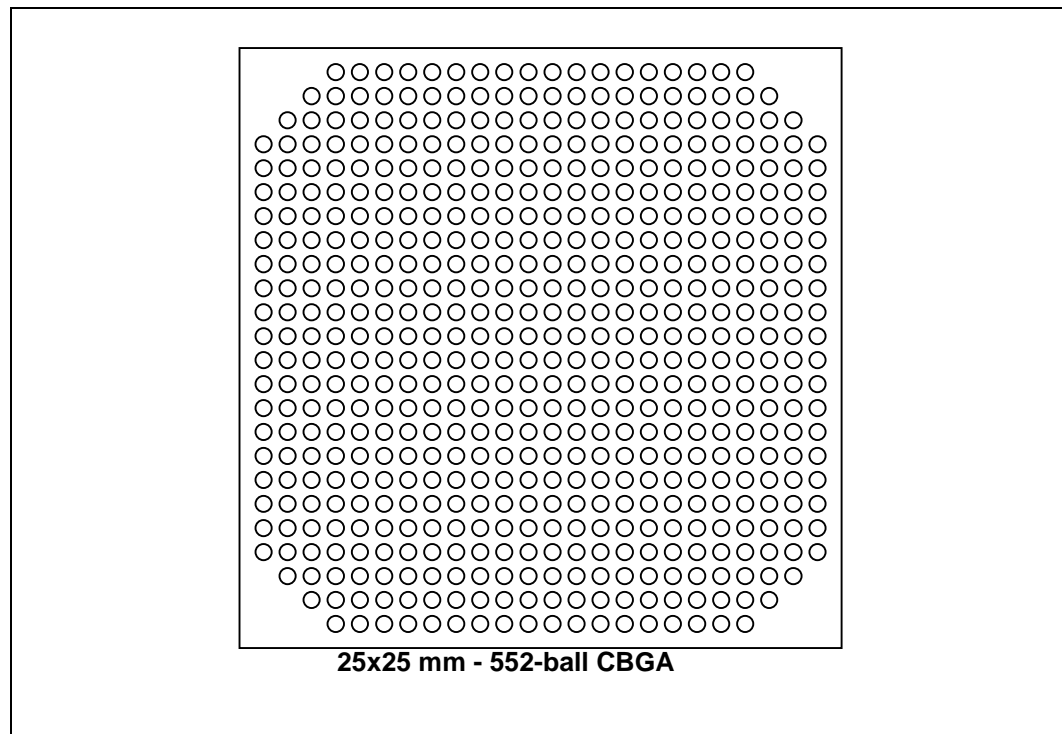
## Appendix B PCB Layout Requirements for Thermal Efficiency

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

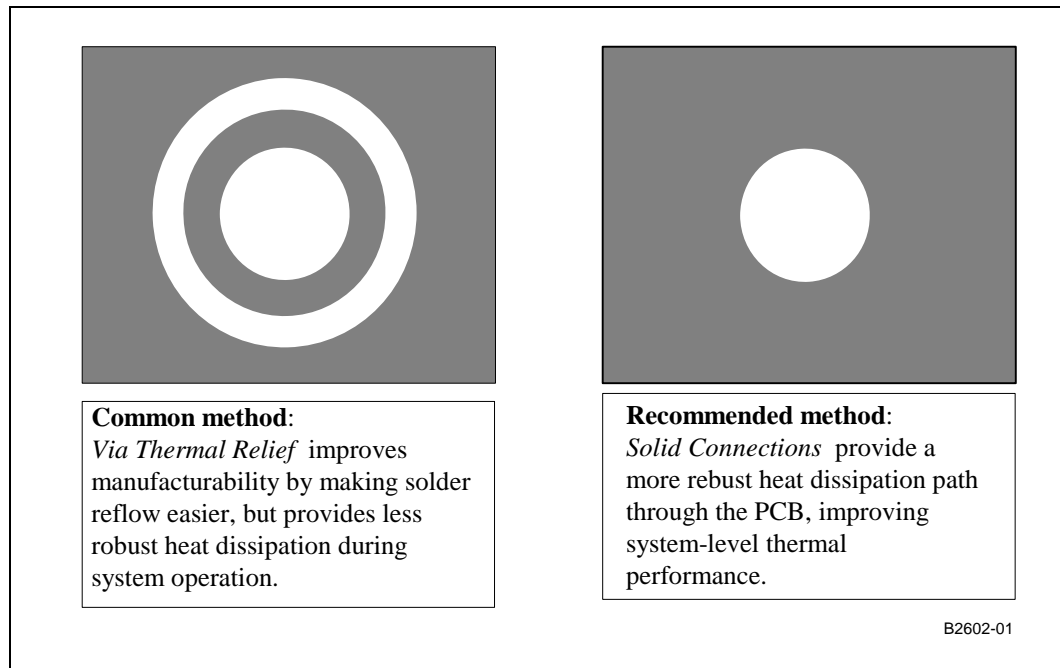
1. Do not use thermal-relief patterns when connecting ground (thermal) vias to the ground plane(s) (see [Figure 10](#), [Figure 11](#), and [Figure 12](#)). Thermal-relief patterns are designed to limit heat transfer between the vias and the copper planes, thus constricting the heat flow path from the component to the PCB ground planes.
2. As board temperature also has an effect on the thermal performance of the package, avoid placing IXF1110 MAC 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 heatsinks that obstruct the air flow or supply excessively heated air.

**Note:** The previous guidelines are not all-inclusive and are defined to provide to maximize the thermal performance of the components.

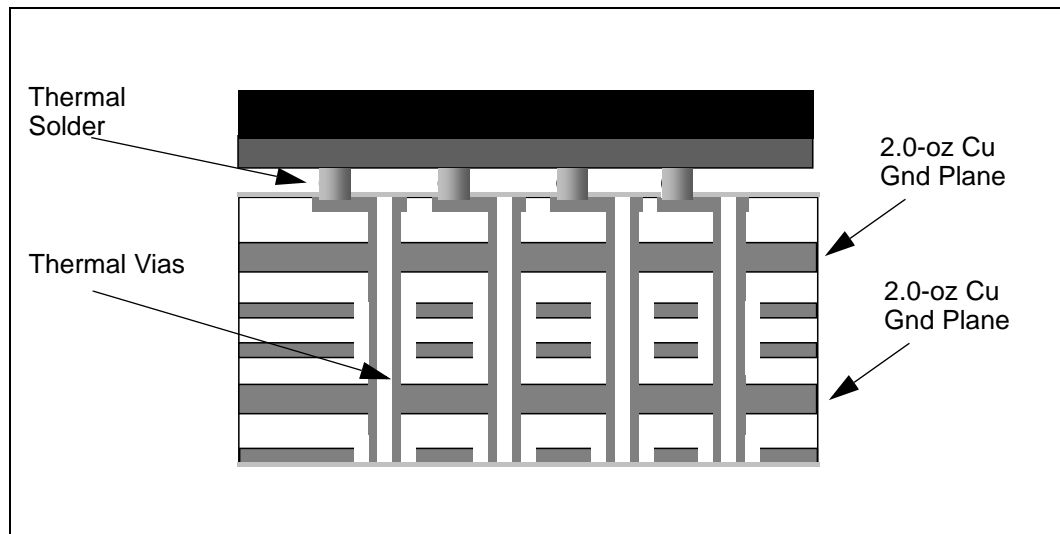
**Figure 10** Top View of Recommended PCB Layout for Thermal Performance



**Figure 11 Top View of the Vias with Thermal Relief and Solid Connections**



**Figure 12 Cross-sectional View of Recommended PCB Stack-up for Thermal Performance**



---

## Contact Information

**Cortina Systems, Inc.**  
**840 W. California Ave**  
**Sunnyvale, CA 94086**

**408-481-2300**

[sales@cortina-systems.com](mailto:sales@cortina-systems.com)

[apps@cortina-systems.com](mailto:apps@cortina-systems.com)

[www.cortina-systems.com](http://www.cortina-systems.com)

**For additional product and ordering information:**

[www.cortina-systems.com](http://www.cortina-systems.com)

**To provide comments on this document:**

[documentation@cortina-systems.com](mailto:documentation@cortina-systems.com)