



Intel[®] IXP2800 Network Processor

Electrical, Mechanical, and Thermal Specification (EMTS)
Application Note

August 2004



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Revision History

Date	Revision	Description
August 2003	001	Initial Release.
March 2004	002	Updated for WP-DPD041201-04, which increases the board strain limit from 600e-6 inch/inch to 1200e-6 inch/inch.
April 2004	003	Updated Tables 12 and 13.
August 2004	004	Preparation for web posting.

1.0 Introduction

This document describes the electrical, mechanical, and thermal characteristics of the Intel[®] IXP2800 network processor and recommends guidelines for meeting the related requirements imposed on platforms.

1.1 Related Documents

Please refer to the following Intel documents for more information:

- *Intel[®] IXP2400/IXP2800 FCBGA Universal Daisy Chain Test Vehicle (with integrated heat spreader) User Guide*
- *Intel[®] IXP2800 Network Processor Thermal/Mechanical Design Guideline Application Note*
- *Intel[®] IXP2800 and IXP2850 Network Processors Datasheet*

1.2 Terminology

Commonly used terms are as follows:

- Flip Chip Ball Grid Array (FCBGA) – Microprocessor packaging using “flip chip” design, where the processor is attached to the substrate face-down for better signal integrity, more efficient heat removal, and lower inductance.
- Integrated Heat Spreader (IHS) – The metallic surface used to attach a heatsink or other thermal solution to the IXP2800 Network Processor.
- OEM – Original Equipment Manufacturer.
- Processor Core – The processor’s execution engine. All AC timing and signal integrity specifications relate to the pads of the processor core.
- Retention mechanism – The support components that are mounted through the motherboard to provide mechanical retention for the processor and heatsink assembly.

2.0 Electrical Specifications

For the most current electrical specifications, refer to the *Intel[®] IXP2800 and IXP2850 Network Processors Datasheet*.

3.0 Mechanical Specifications

The IXP2800 network processor uses a Flip Chip Ball Grid Array (FCBGA) packaging technology, with an integrated heat spreader (IHS). The IXP2800 network processor includes the processor die. Mechanical specifications for the processor are given in this section. See [Section 1.2](#) above for terminology definitions.

[Figure 1](#) provides a basic processor assembly drawing and includes the components that comprise the entire processor.

Figure 2 provides a top view of the IXP2800 network processor package component placement detail.

Table 1, Table 2, and Table 3 provide dimensions for the processor package.

Figure 3 presents the package IHS flatness and tilt.

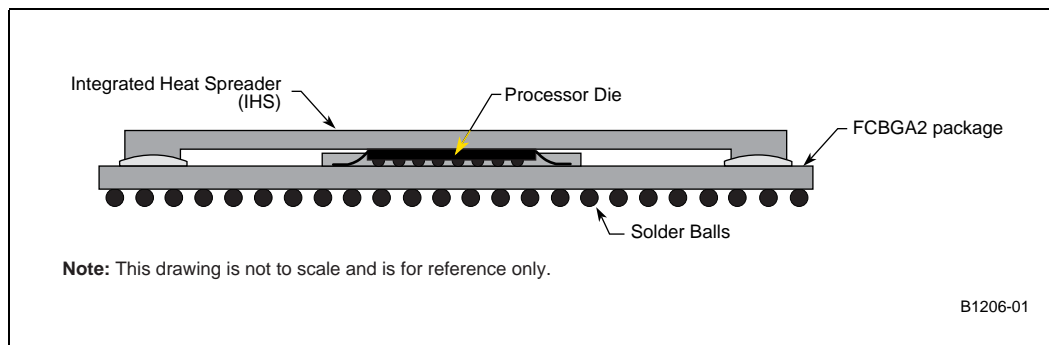
Note: For Figure 1 through Figure 3, the following notes apply:

- Unless otherwise specified, figure dimensions are in millimeters.
- Figures and drawings labeled as “Reference Dimensions” are provided for informational purposes only. Reference Dimensions are extracted from the mechanical design database and are nominal dimensions with no tolerance information applied. Reference Dimensions are *not* checked as part of the processor manufacturing process. Unless noted as such, dimensions in parentheses without tolerances are Reference Dimensions.
- The IXP2800 network processor uses a 37.5 mm FCBGA package and for the purpose of this section, it is referred to as the “processor package.” Thermal solutions should be designed to support the processor package. See the *Intel® IXP2800 Network Processor Thermal/Mechanical Design Guideline Application Note* for more information about thermal design.

3.1 Mechanical Specifications

This section describes the IXP2800 network processor mechanical specifications.

Figure 1. IXP2800 Package Assembly Drawing



3.1.1 Package Dimensions

The IXP2800 network processor is contained in a 1356-ball package, as shown in Figure 2.

Figure 2. IXP2800 General Mechanical Drawing

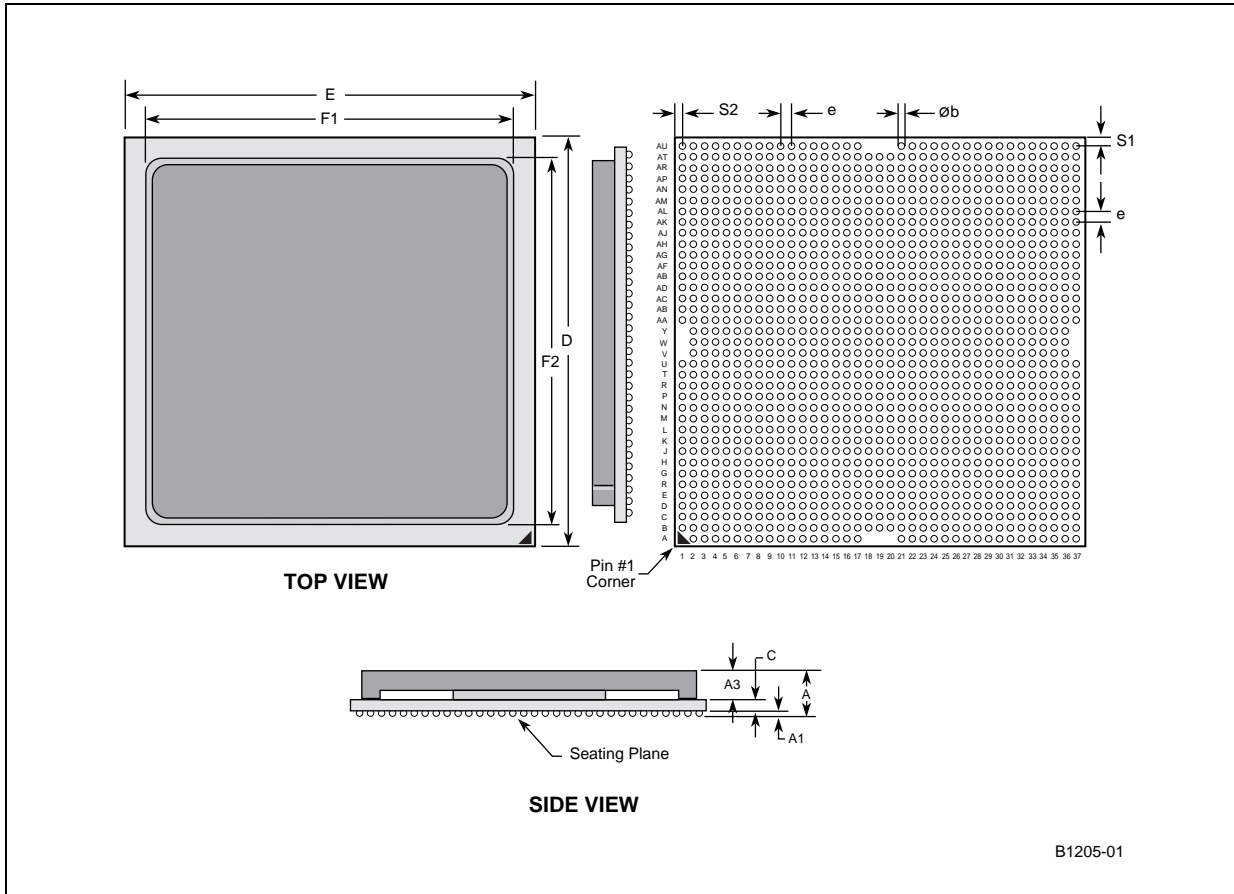


Table 1. IXP2800 Package Dimensions (Sheet 1 of 2)¹

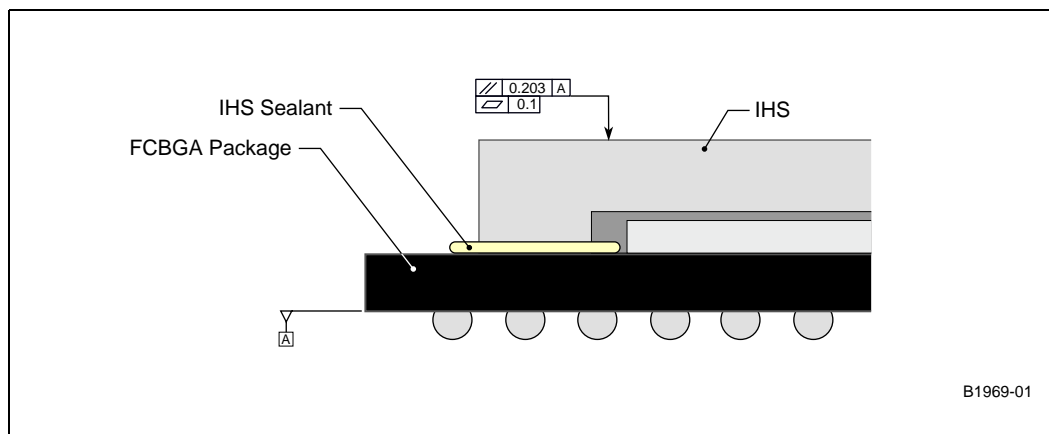
1356 BGA			
Symbol	Min	Nominal	Max
A	3.891	4.228	4.565
A1	0.40	0.5	0.60
A3	2.266	2.378	2.49
b	0.61 Ref.		
C	1.225	1.35	1.475
D	37.45	37.5	37.55
E	37.45	37.5	37.55
F1	33.4	33.5	33.6
F2	33.4	33.5	33.6

Table 1. IXP2800 Package Dimensions (Sheet 2 of 2)¹

1356 BGA			
Symbol	Min	Nominal	Max
e		1.00	
S1		0.750	
S2		0.750	

1. All measurements are in millimeters (mm).

Figure 3. IXP2800 Package IHS Flatness and Tilt Drawing



3.2 Package Load Specifications

This section defines package mechanical specification limits for the package in a surface-mounted condition; these mechanical limits should not be exceeded. For details on interpretation of limits during development of the processor thermal solution, refer to the *Intel[®] IXP2800 Network Processor Thermal/Mechanical Design Guideline Application Note*.

Mechanical attributes discussed in this section are defined in [Table 2](#).

Table 2. IXP2800 Network Processor Package Mechanical Attribute Definitions (Sheet 1 of 2)

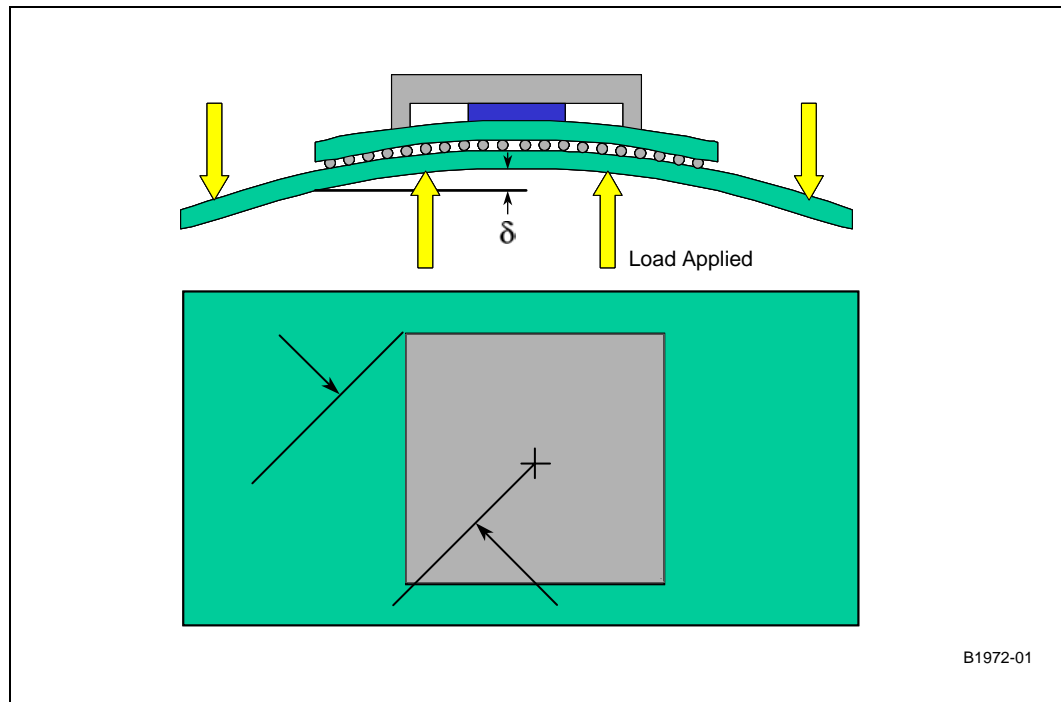
Term	Definition
Static load limit	Maximum sustained force that can be applied by the thermal solution to the package, throughout product life.
Transient load limit	Maximum force that can be applied for a short duration to the package.
Dynamic load limit	Maximum force (static + inertial) that can be applied by the thermal solution to the package during rapid acceleration (shock).
Tensile load limit	Maximum tensile force that can be applied to the package.
Shear load limit	Maximum shear force that can be applied to the package.

Table 2. IXP2800 Network Processor Package Mechanical Attribute Definitions (Sheet 2 of 2)

Term	Definition
Torque limit	Maximum torque that can be applied to the package.
Board deflection limit	Maximum deflection of the board under the package during board handling and test conditions.
Board strain limit	Maximum strain of the board under the package during shock and vibration events.

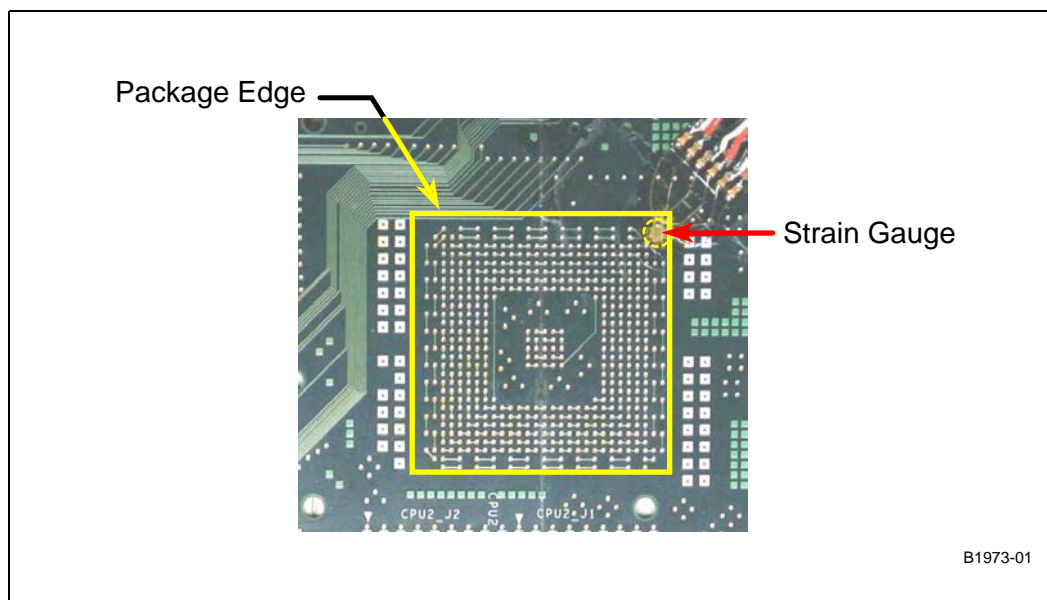
Board-measurement locations for board deflection and strain are defined in [Figure 4](#) and [Figure 5](#), respectively.

Figure 4. IXP2800 Network Processor Board Deflection



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Figure 5. IXP2800 Network Processor Board Strain Gauge Placement



Strain gauges are placed on the backside of the board at the corner(s) of the package. For reference, Intel uses strain gauges configured in a 60-mil stacked rectangular rosette with 120-ohm resistance.

3.2.1 Package Dynamic, Transient, and Static Load Specifications

Table 3 provides dynamic, transient, and static load specifications for the IXP2800 network processor. All specifications in this section refer to compressive loading of the package. These mechanical load limits should not be exceeded during heat sink assembly, mechanical stress testing, or standard drop and shipping conditions. The heat sink attachment solutions must not induce continuous stress onto the processor, with the exception of a uniform load to maintain the thermal interface between the heat sink and the package Integrated Heat Spreader (IHS). Refer to the *Intel® IXP2800 Network Processor Thermal/Mechanical Design Guideline Application Note* for more information about thermal interface load recommendations. It is not recommended to use any portion of the processor package substrate as a mechanical reference or load-bearing surface for thermal solutions.

Table 3. IXP2800 Network Processor Package Dynamic, Transient, and Static Load Specifications

Attribute	Package Specification ¹	Load-Induced Board Deflection ²
Static Compressive Load Limit	30 lbf	0.0005 inch
Transient Compressive Load Limit ³	40 lbf	0.001 inch
Dynamic Compressive Load Limit ⁴	30 lbf static + 22 lbf dynamic	0.001 inch

1. Package load specifications should not be exceeded.
2. The load-induced board deflection measured during package testing has been provided as a guideline. Induced board deflection values related to these tests are not necessarily package limits.
3. The Transient Load Limit is intended to simulate the application of a thermal solution to the package. Transient loads are often transferred to the package during assembly of the thermal solution.
4. The Dynamic Load Limit includes the static load applied by the thermal solution, and the inertial load applied during the compressive shock event.

3.2.2 Package Tensile Load Specification

This attribute is used to define the upper limit of tensile force that can be applied to the package. In some cases, removal of the thermal solution may apply tensile load on the package IHS. In addition, the package may be subjected to tensile loads during shock and vibration events. [Table 4](#) provides tensile load limit specifications for the IXP2800 network processor.

Table 4. IXP2800 Network Processor Package Tensile Load Specification

Attribute	Package Specification ¹
Tensile load limit	35 lbf

1. Package load specifications should not be exceeded.

3.2.3 Package Shear Load and Torque Specifications

These attributes are used to define the upper limit of shear force and torque that can be applied to the package. In some cases, removal of the thermal solution may apply shear load and torque on the package IHS. In addition, the package may be subjected to shear loads during shock and vibration events. [Table 5](#) provides shear load and torque specifications for the IXP2800 network processor.

Table 5. IXP2800 Network Processor Package Shear Load and Torque Specifications

Attribute	Package Specification ¹
Shear load limit	35 lbf
Torque limit	40 in x lbf

1. Package load specifications should not be exceeded.

3.2.4 Package Board Deflection Specification

This attribute is used to define the upper limit of board flexure across the package. In some cases, the board may be subjected to bending during handling operations, such as ICT. The loading is such that the outer joints are in tension, convex bending. Board deflection is measured as shown in [Figure 4](#). [Table 6](#) provides board deflection specifications for the IXP2800 network processor.

Table 6. IXP2800 Network Processor Package Board Deflection Specification

Attribute	Package Specification ¹
Board deflection limit ^{2,3}	0.009 in.

1. Package load specifications should not be exceeded.
2. Board deflection limits should not be exceeded.
3. Board deflection as defined in [Figure 4](#).

3.2.5 Package Board Strain Specifications

The following sections describe the IXP2800 network processor package board strain specifications.

3.2.5.1 Package Board Strain in Shock Events

This attribute is used to define the upper limit for board flexure induced by a shock event. Strain gauges are attached to the board during the shock event, as defined in Figure 5. Sufficient mechanical stiffness should be incorporated into the thermal solution and motherboard design to ensure that these mechanical limits are not exceeded during shock events. Table 7 provides board strain specifications in shock events for the IXP2800 network processor.

Table 7. IXP2800 Network Processor Package Board Strain Specification in Shock Events

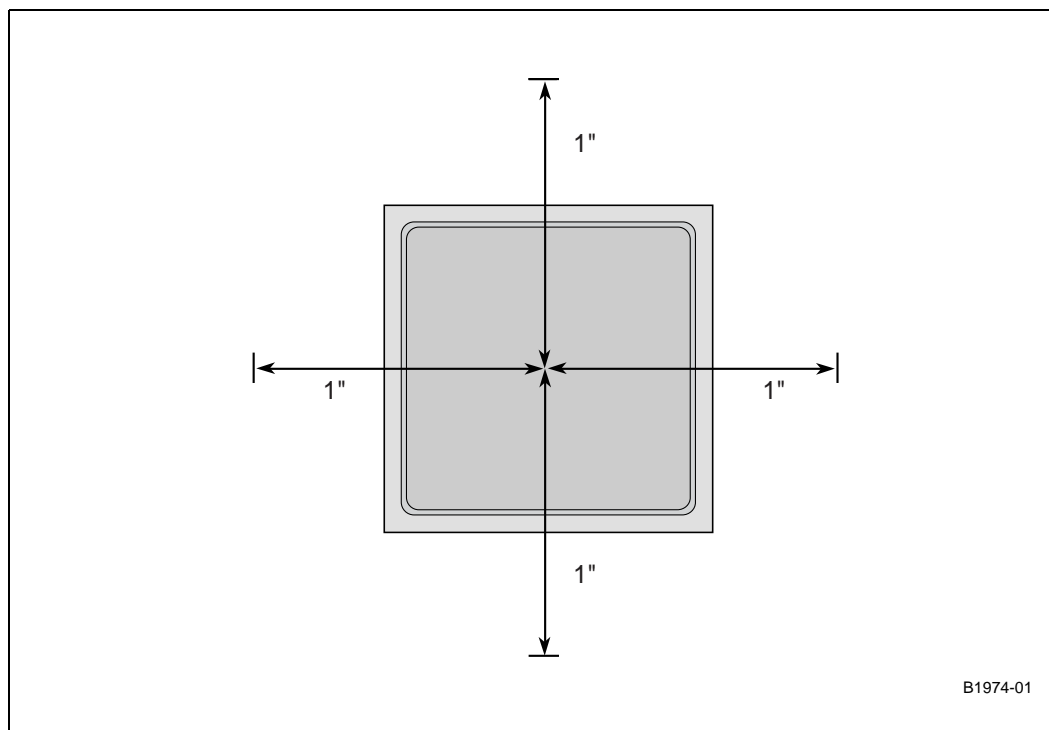
Attribute	Package Specification ¹
Board strain limit in shock events ^{2,3,4,5,6}	1200e-6 inch/inch

1. Package load specifications should not be exceeded.
2. Board strain limits should not be exceeded.
3. Single mode bending.
4. Intel test board response exhibited first resonant frequency at ~100 Hz.
5. May vary with OEM board shock response.
6. Board strain as defined in Figure 5.

3.2.5.2 Package Board Deflection

Package board deflection under shock load **must not exceed 10 mils** within 1 inch of the center of the IXP2800 network processor, as shown in Figure 6.

Figure 6. Package Board Deflection Limit Location



3.2.5.3 Package Board Strain in Random Vibration

This attribute is used to define the upper limit for board flexure induced by random vibration. Strain gauges are attached to the board during the vibration event, as defined in [Figure 5](#). The strain limit is the RMS value of the strain measured. Sufficient mechanical stiffness and dampening should be incorporated into the thermal solution and motherboard design to ensure these mechanical limits are not exceeded during random vibration. [Table 8](#) provides board strain specifications in random vibration for the IXP2800 network processor.

Table 8. IXP2800 Network Processor Package Board Strain Specification in Random Vibrations

Attribute	Package Specification ¹
Board strain limit in random vibration ^{2,3,4,5,6}	50e-6 inch/inch

1. Package load specifications should not be exceeded.
2. Board strain limits should not be exceeded.
3. Single mode bending.
4. Intel test board response exhibited first resonant frequency at ~100 Hz.
5. May vary with OEM board shock response.
6. Board strain as defined in [Figure 5](#).

3.2.6 Package Mechanical Specification Summary

[Table 9](#) summarizes the mechanical specifications for the IXP2800 network processor.

Table 9. IXP2800 Network Processor Package Mechanical Specification Summary

Attribute	Package Specification ¹
Static compressive load limit	30 lbf
Transient compressive load limit ²	40 lbf
Dynamic compressive load limit ³	30 lbf static + 22 lbf dynamic
Tensile load limit	35 lbf
Shear load limit	35 lbf
Torque limit	40 in x lbf
Board deflection limit ^{4,5}	0.009 inch
Board strain limit in shock events ^{4,6,7,8,9}	1200e-6 inch/inch
Board strain limit in random vibration ^{4,6,7,8,9}	50e-6 inch/inch

1. Package load specifications should not be exceeded.
2. The Transient Load Limit is intended to simulate the application of a thermal solution to the package. Transient loads are often transferred to the package during assembly of the thermal solution.
3. The Dynamic Load Limit includes the static load applied by the thermal solution, and the inertial load applied during the compressive shock event.
4. Board deflection limits should not be exceeded.
5. Board deflection as defined in [Figure 4](#).
6. Single mode bending.
7. Intel test board response exhibited first resonant frequency at ~100 Hz.
8. May vary with OEM board shock response.
9. Board strain as defined in [Figure 5](#).

3.3 Mass Specifications

Table 10 specifies the processor mass. This includes all components that make up the entire IXP2800 network processor.

Table 10. IXP2800 Network Processor Mass

Component	Maximum Mass
IXP2800	30 g

3.4 Materials

The IXP2800 network processor is assembled from several components. The basic material properties are described in Table 11.

Table 11. IXP2800 Network Processor Material Properties

Component	Material
Integrated heat spreader	Nickel-plated copper
FC-mBGA2	BT resin
BGA balls	Eutectic solder

3.5 Ball-Out Diagram

Package ball grid coordinates for the IXP2800 network processor can be found in the *Intel® IXP2800 and IXP2850 Network Processors Datasheet*.

3.6 IXP2800 Network Processor Ball Assignments

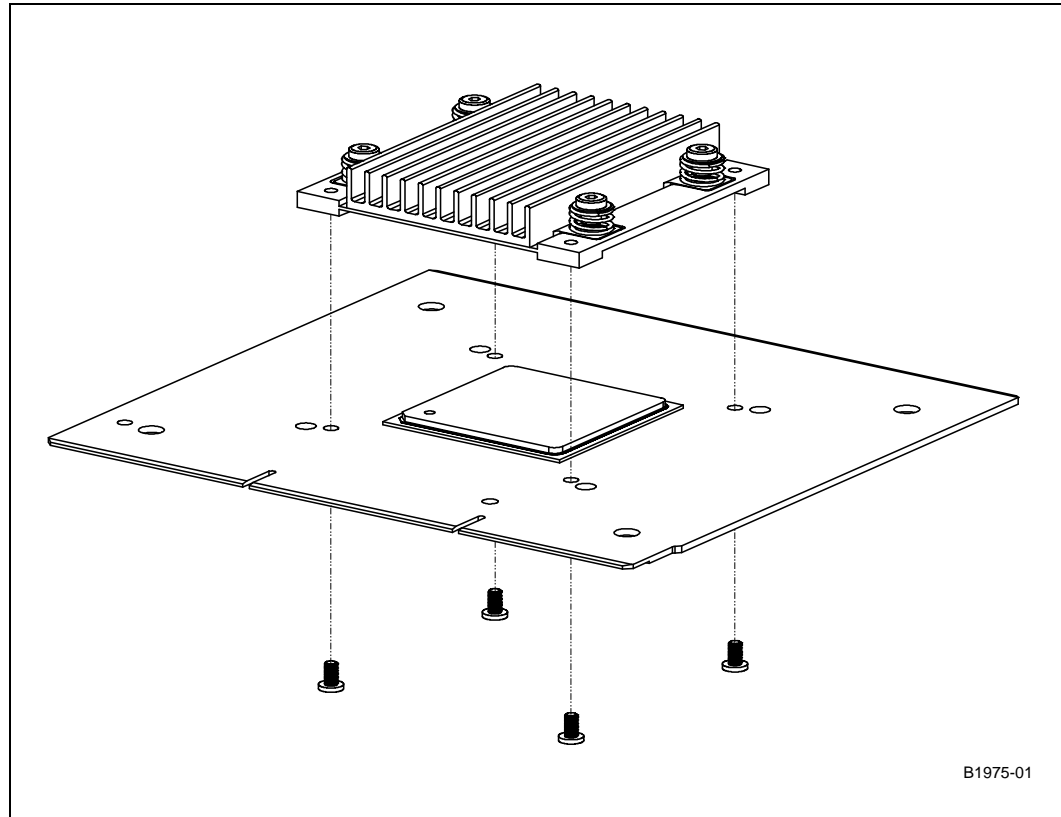
Ball assignments for the IXP2800 network processor can be found in the *Intel® IXP2800 and IXP2850 Network Processors Datasheet*.

4.0 Thermal Specifications

This section provides the thermal specifications necessary for designing a thermal solution for the IXP2800 network processor. Thermal solutions should include a heatsink that attaches to the integrated heat spreader (IHS). The IHS provides a common interface intended to be compatible with many heatsink designs. Thermal specifications are based on the temperature of the IHS top, referred to as T_{CASE} . Thermal solutions should be designed to maintain the processor within T_{CASE} specifications. For information on performing T_{CASE} measurements for thermal solution design and validation, refer to the *Intel® IXP2800 Network Processor Thermal/Mechanical Design Guideline Application Note*.

See [Figure 7](#) for an exploded view of the processor package and thermal solution assembly.

Figure 7. IXP2800 Network Processor with Thermal and Mechanical Components (Exploded View)



4.1 Thermal Design Power Specifications

Table 12 specifies the thermal design power dissipation for the IXP2800 network processor. The processor power listed in Table 12 is described in two ways: stepping and frequency.

Intel recommends that system thermal designs utilize the maximum power indicated in Table 12, which also lists the minimum and maximum processor T_{CASE} temperature specifications. A thermal solution should be designed to ensure that the temperature of the processor never exceeds these specifications. For further information, see the *Intel® IXP2800 Network Processor Thermal/Mechanical Design Guideline Application Note*.

Table 12. IXP2800 Network Processor Thermal Design Power¹

Component/Stepping	Frequency	Max Power ² (W)	Typical Power ³	T _{JUNCTION} Max (°C)	T _{CASE} Max (°C)
IXP2800 – A1/A2	1.4 GHz	35 ⁴	28 ⁴	120 ⁴	112 ⁴
IXP2800 – A1/A2	1.0 GHz	28	23	120	114
IXP2800 – B0	1.4 GHz	31.5	25.5	120	113.3
IXP2800 – B0	1.0 GHz	23	18.5	120	115.1

1. These specifications are based on pre-silicon estimates and simulations. These specifications will be updated with characterized data from silicon measurements at a later date.
2. Maximum Processor Power is the maximum thermal power that can be dissipated by the processor. Intel recommends that thermal solutions be designed utilizing the maximum power value.
3. Typical processor power is estimated for most real application environments running at typical voltage and current.
4. An airflow of 350 LFM is required for the Intel Reference Solution.

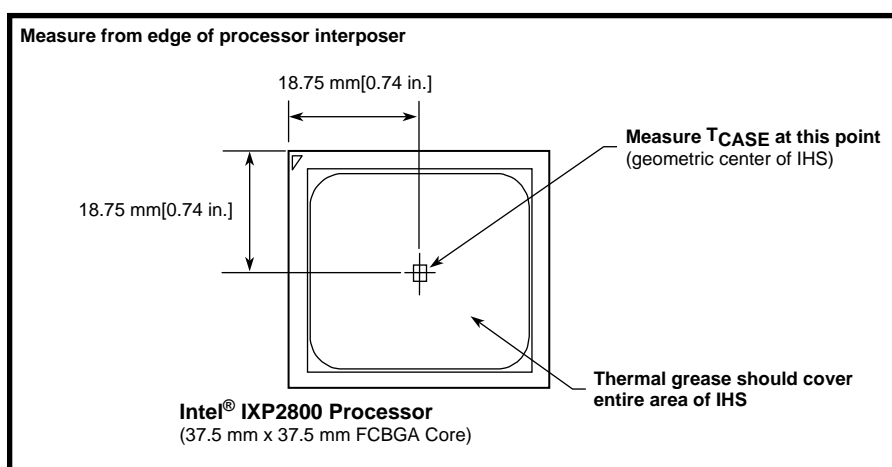
4.2 Measurements for Thermal Specifications

The following section describes the IXP2800 network processor thermal specifications measurements.

4.2.1 Processor Case Temperature Measurement

The minimum and maximum case temperature (T_{CASE}) for the IXP2800 network processor is specified in Table 12; these temperature specifications are meant to ensure correct and reliable operation of the network processor. Figure 8 illustrates the thermal measurement point for T_{CASE}. For information on performing T_{CASE} measurements for thermal solution design and validation, refer to the *Intel IXP2800 Network Processor Thermal/Mechanical Design Guideline Application Note*.

Figure 8. Thermal Measurement for Processor T_{CASE}



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5.0 Thermal Diode Features

The IXP2800 network processor incorporates an on-die thermal diode. A thermal sensor located on the system board may be used to monitor the die temperature of the processor for thermal management and long-term die temperature change purposes. Table 13 and Table 14 provide the thermal diode parameter and interface specifications.

Table 13. IXP2800 Network Processor Thermal Diode Parameters

Symbol	Min	Typ	Max	Units	Notes ¹
I _{forward bias}	5		450	μA	2
n_ideality	0.9933	1.0045	1.0368		3,4,5

1. Not 100% tested, specified by design characterization.
2. Intel does not support or recommend operation of the thermal diode under reverse bias.
3. At room temperature with a forward bias of 630 mV.
4. n_ideality is the diode ideality factor parameter, as represented by the diode equation: $I = I_0(e^{(V_d/q)/(nkT)} - 1)$.
5. Due to an errata item for the A and B stepping of the device, the junction temperature reported by the thermal monitoring device will be incorrect and return a temperature that is between 5° and 40° C too high. The temperature accuracy can be improved to +/- 10° C by using the following equation:

$$T_{diode} = (((T_{diodeReading} + 273.15) * 1.008) / n_{ideality} - 273.15)$$
 where n_ideality = 1.115178 and T_{diodeReading} is the temperature returned by the temperature monitoring device.

Table 14. IXP2800 Network Processor Thermal Diode Interface

Pin Name	Pin Number	Pin Description
Test_diode_a	J29	Diode anode
Test_diode_c	K29	Diode cathode

