Intel® 6400/6402 Advanced Memory Buffer

Thermal/Mechanical Design Guide

For the Intel® 5000 Chipset Series based Platforms

December 2006

Reference Number: 313066-003

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Revision History

Revision Number	Description	Date
-001	• Initial release of the document.	June 2006
-002	• Updated Intel 6400/6402 Advanced Memory Buffer thermal specificatons for all Intel® 5000P/5000V/5000X Chipset-Based Platforms in Section 3.2 • Added 3 DIMMs/channel Intel 6400/6402 Advanced Memory Buffer thermal specifications for all Intel 5000P/5000V/5000X Chipset-Based Platforms in Section 3.2 • Updated reference FB-DIMM thermal specifications for all Intel 5000P/5000V/5000X Chipset-Based Plaforms in Section 3.2 • Added 3 DIMMs/channel reference FB-DIMM thermal specifications for all Intel 5000P/5000V/5000X Chipset-Based Platforms in Section 3.2 • Added Full DIMM Heatspreader Installation Drawing to Appendix B	July 2006
-003	• Changed the document title from *Intel® 6400/6402 Advanced Memory Buffer Thermal/Mechanical Design Guide* to *Intel® 6400/6402 Advanced Memory Buffer Thermal/Mechanical Design Guide for the Intel® 5000 Chipset Series based Platforms* • Added definition for Intel® 6400/6402 Advanced Memory Buffer's thermal sensor output register in Section 1.2 • Updated Intel 6400/6402 Advanced Memory Buffer thermal specificatons for all Intel® 5000P/5000V/5000X Chipset-Based Platforms in Section 3.2 • Updated reference FB-DIMM thermal specifications for all Intel 5000P/5000V/5000X Chipset-Based Plaforms in Section 3.2 • Added Intel 6400/6402 Advanced Memory Buffer thermal sensor accuracy information in Section 3.3 • Corrected description for the full DIMM heatspreader reference thermal solution in Section 8	December 2006

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1 Introduction

As the complexity of computer systems increases, so do the power dissipation requirements. Care must be taken to ensure that the additional power is properly dissipated. Typical methods to improve heat dissipation include selective use of ducting, and/or passive heat dissipation devices.

The goals of this document are to:

- Outline the mechanical operating limits and specifications for the Intel® 6400/6402 Advanced Memory Buffer.
- Outline the thermal operating limits and specifications for the Intel® 6400/6402 Advanced Memory Buffer specific to that of the Intel 5000® Chipset Series based platforms.
- Outline reference TDP specifications for FB-DIMM specific to that of the Intel 5000® Chipset Series based platforms.
- Describe an Intel 6400/6402 Advanced Memory Buffer only wire clip heatspreader reference thermal solution.
- Describe an Intel 6400/6402 Advanced Memory Buffer only c-clip heatspreader reference thermal solution.
- Describe a full DIMM heatspreader reference thermal solution.

Properly designed thermal solutions provide adequate cooling to maintain the Intel 6400/6402 Advanced Memory Buffer die temperatures at or below thermal specifications. This is accomplished by providing a low local-ambient temperature, ensuring adequate local airflow, and minimizing the die to local-ambient thermal resistance. By maintaining the Intel 6400/6402 Advanced Memory Buffer die temperature at or below the specified limits, a system designer can ensure the proper functionality, performance, and reliability of the chipset. Operation outside the functional limits can degrade system performance and may cause permanent changes in the operating characteristics of the component.

The simplest and most cost effective method to improve the inherent system cooling characteristics is through careful chassis design and placement of fans, vents, and ducts. When additional cooling is required, component thermal solutions may be implemented in conjunction with system thermal solutions. The size of the fan or heatsink can be varied to balance size and space constraints with acoustic noise.

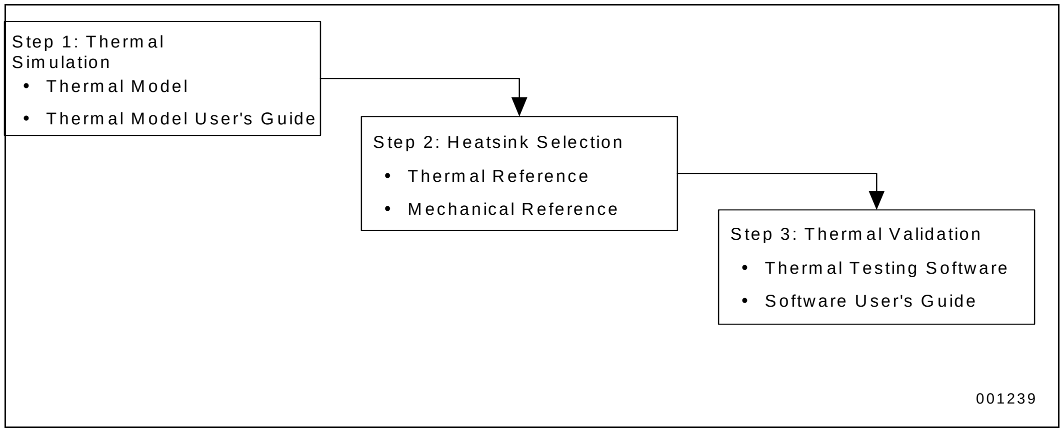
This document addresses thermal design and specifications for the Intel 6400/6402 Advanced Memory Buffer components only. For thermal design information on other chipset components, refer to the respective component datasheet. For the PXH, refer to the *Intel® 6700PXH 64-bit PCI Hub (PXH) Thermal/Mechanical Design Guidelines*. For the Intel 631xESB/632xESB I/O Controller Hub, refer to the *Intel® 631xESB/632xESB I/O Controller Hub Thermal/Mechanical Design Guide*.

Note: Unless otherwise specified, the term “GB” refers to the Intel 6400/6402 Advanced Memory Buffer.

1.1 Design Flow

To develop a reliable, cost-effective thermal solution, several tools have been provided to the system designer. Figure 1-1 illustrates the design process implicit to this document and the tools appropriate for each step.

Figure 1-1. Thermal Design Process



1.2 Definition of Terms

AMB	Advanced Memory Buffer. This component allows buffering of memory traffic to support large memory capacities. The Advanced Memory Buffer interface is responsible for handling FB-DIMM channel and memory requests to and from the local DIMM and for forwarding requests to other DIMMs on the FB-DIMM channel.
BGA	Ball grid array. A package type, defined by a resin-fiber substrate, onto which a die is mounted, bonded and encapsulated in molding compound. The primary electrical interface is an array of solder balls attached to the substrate opposite the die and molding compound.
BLT	Bond line thickness. Final settled thickness of the thermal interface material after installation of heatspreader.
ESB2	Intel® 631xESB/632xESB I/O Controller Hub. The chipset component that integrates an Ultra ATA 100 controller, six Serial ATA host controller ports, one EHCI host controller, and four UHCI host controllers supporting eight external USB 2.0 ports, LPC interface controller, flash BIOS interface controller, PCI interface controller, Azalia / AC'97 digital controller, integrated LAN controller, an ASF controller and a ESI for communication with the Intel 6400/6402 Advanced Memory Buffer. The Intel 631xESB/632xESB I/O Controller Hub component provides the data buffering and interface arbitration required to ensure that system interfaces operate efficiently and provide the bandwidth necessary to enable the system to obtain peak performance.
FB-DIMM	Fully Buffered DIMM.
FDHS	Full DIMM Heatspreader. See Figure 8-3 for details.
GB	Intel® 6400/6204 Advanced memory Buffer. An AMB reference design that complies with the Fully Buffered DIMM (FB-DIMM) Channel Specification.

P_{adj_DIMM}	Total power dissipation of adjacent DIMM. (W)
P_{DRAM}	Total power of DRAMs (W). It equals to total FB-DIMM power minus the Intel 6400/6402 Advanced Memory Buffer power.
PXH	Intel® 6700PXH 64-bit PCI Hub. The chipset component that performs PCI bridging functions between the PCI Express* interface and the PCI Bus. It contains two PCI bus interfaces that can be independently configured to operate in PCI (33 or 66 MHz) or PCI-X* mode 1 (66, 100 or 133 MHz), for either 32 or 64 bit PCI devices.
Rank	A DIMM is organized as one or two physical sets of memory, called ranks. Note that single rank or dual rank is different from single-sided or double-sided, e.g. a single rank DIMM build from x4 DRAM devices is actually double-sided. It is also common practice to distribute the 9 devices of an x8 DIMM between both sides of the DIMM to enhance the thermal performance of the module. The standard 4-slot DDR2 topology is limited to single rank DIMM due to loading constraints.
R/C-A	Raw Card A. A FB-DIMM module assembled with 9pc of the full size x8 DRAM packages. This raw card comes in single rank by 8 (SRx8) configuration. This is a planar FB-DIMM module.
R/C-B	Raw Card B. A FB-DIMM module assembled with 18pc of the full size x8 DRAM packages. This raw card comes in dual rank by 8 (DRx8) configuration. This is a planar FB-DIMM module.
R/C-C	Raw Card C. A FB-DIMM module assembled with 18pc of the full size x4 DRAM packages. This raw card comes in single rank by 4 (SRx4) configuration. This is a planar FB-DIMM module.
R/C-D	Raw Card D. A FB-DIMM module assembled with 36pc of the full size x4 DRAM packages. This raw card comes in dual rank by 4 (DRx4) configuration. This is a stacked FB-DIMM module.
R/C-E	Raw Card E. A FB-DIMM module assembled with 36pc of the reduced size x4 DRAM packages. This raw card comes in dual rank by 4 (DRx4) configuration. This is a planar FB-DIMM module.
R/C-H	Raw Card H. A FB-DIMM module assembled with 36pc of the reduced size x4 DRAM packages. This raw card comes in dual rank by 4 (DRx4) configuration. This is a planar FB-DIMM module.
R/C-J	Raw Card J. A FB-DIMM module assembled with 18pc of the thicker size DRAM packages with two x4 die in each. This raw card comes in dual rank by 4 (DRx4) configuration. This is a planar FB-DIMM module.
$T_{case\_max\_GB}$	Maximum die temperature allowed on the Intel 6400/6402 Advanced Memory Buffer. This temperature is measured at the geometric center of the top of the package die.
$T_{case\_min\_GB}$	Minimum die temperature allowed on the Intel 6400/6402 Advanced Memory Buffer. This temperature is measured at the geometric center of the top of the package die.
$T_{case\_max\_DRAM}$	Maximum case temperature allowed on the DRAM. This temperature is measured at the geometric center of the top of the DRAM package.
$T_{case\_min\_DRAM}$	Minimum case temperature allowed on the DRAM. This temperature is measured at the geometric center of the top of the DRAM package.

$T_{j\_\_max\_GB}$	Maximum die junction temperature allowed. This temperature is reported by the thermal sensor within the Intel 6400/6402 Advanced Memory Buffer.
$T_{heatspreader\_max\_FB-DIMM}$	Maximum heatspreader temperature allowed on the FB-DIMM module without exceeding . This temperature is measured at the geometric center of the top of the DRAM package.
T_{LA_DIMM}	Air temperature entering memory DIMM channel (°C).
TDP	Thermal design power. Thermal solutions should be designed to dissipate this target power level. TDP is not the maximum power that the chipset can dissipate.
TEMP	Temperature A/D. A 8-bit register within the Intel 6400/6402 AMB that outputs its current die temperature . Its output range is between 0 to 127 degrees C and its resolution if 0.5 degree C.
TIM	Thermal Interface Material.
TTK	Thermal Test Kit. A test setup enabled by Intel for the FB-DIMM industry to spec a $T_{heatspreader\_max\_FB-DIMM}$ value that corresponds to $T_{case\_max\_GB}$.

1.3 Reference Documents

The reader of this specification should also be familiar with material and concepts presented in the following documents:

- *Intel® 6400/6402 Advanced Memory Buffer Datasheet.*
- *Intel® 6400/6402 Advanced Memory Buffer Specification Update.*
- *Intel® 5000P/5000V/5000Z Chipset Memory Controller Hub (MCH) Datasheet.*
- *Intel® 5000X Chipset Memory Controller Hub (MCH) Datasheet.*
- *Intel® 5000 Series Chipset Memory Controller Hub (MCH) Specification Update.*
- *Intel® 631xESB/632xESB I/O Controller Hub Datasheet.*
- *Intel® 631xESB/632xESB I/O Controller Hub Specification Update.*
- *Advanced Memory Buffer Component Specification-Supplier Edition.*
- *FB-DIMM Architecture and Protocol Specification.*
- *FB4300/5300/6400 DDR2 Fully Buffered DIMM Design Specification.*
- *JEDEC DDR2 SDRAM Specification, JC 42.3.*
- *Intel® 6700PXH 64-bit Hub (PXH) Thermal/Mechanical Design Guidelines.*
- *Intel® 6700PXH 64-bit PCI Hub (PXH) Datasheet.*
- *BGA/OLGA Assembly Development Guide.*
- Various system thermal design suggestions (http://www.formfactors.org).

Note: Unless otherwise specified, these documents are available through your Intel field sales representative. Some documents may not be available at this time.

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2 Packaging Technology

The Intel 6400/6402 Advanced Memory Buffer uses a 24.5 mm x 19.5 mm, 6-layer FC-BGA package (see Figure 2-1, Figure 2-2 and Figure 2-3).

Figure 2-1. Intel® 6400/6402 Advanced Memory Buffer Package Dimensions (Top View)

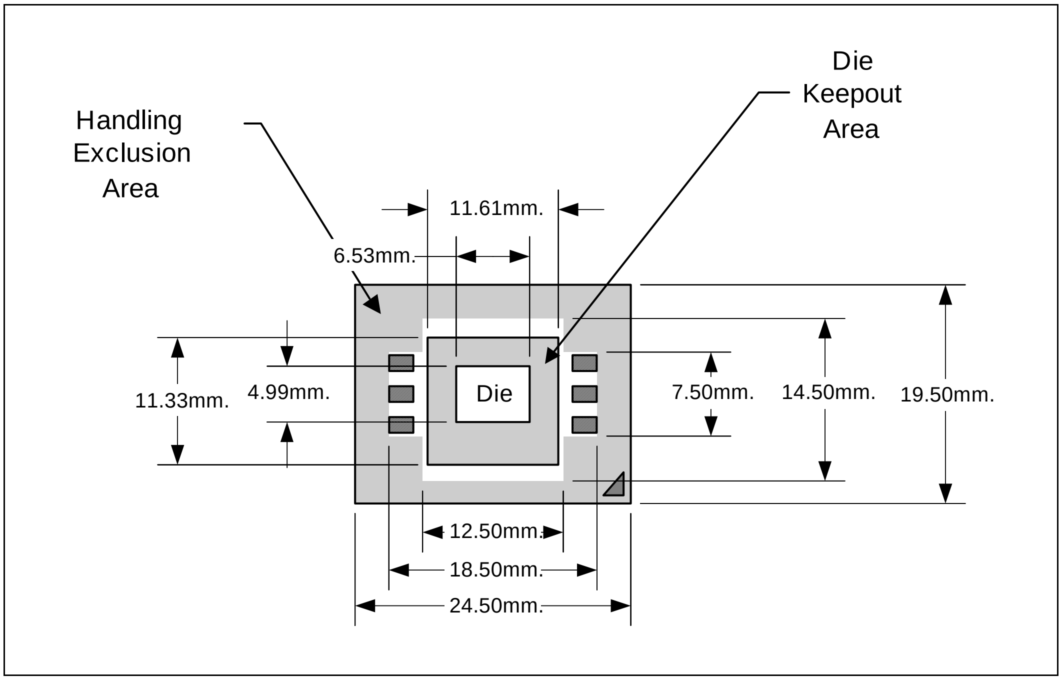
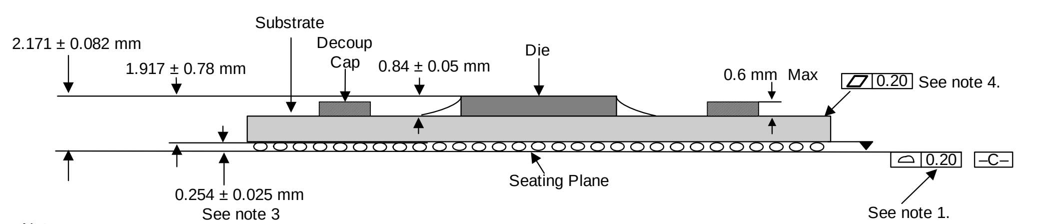
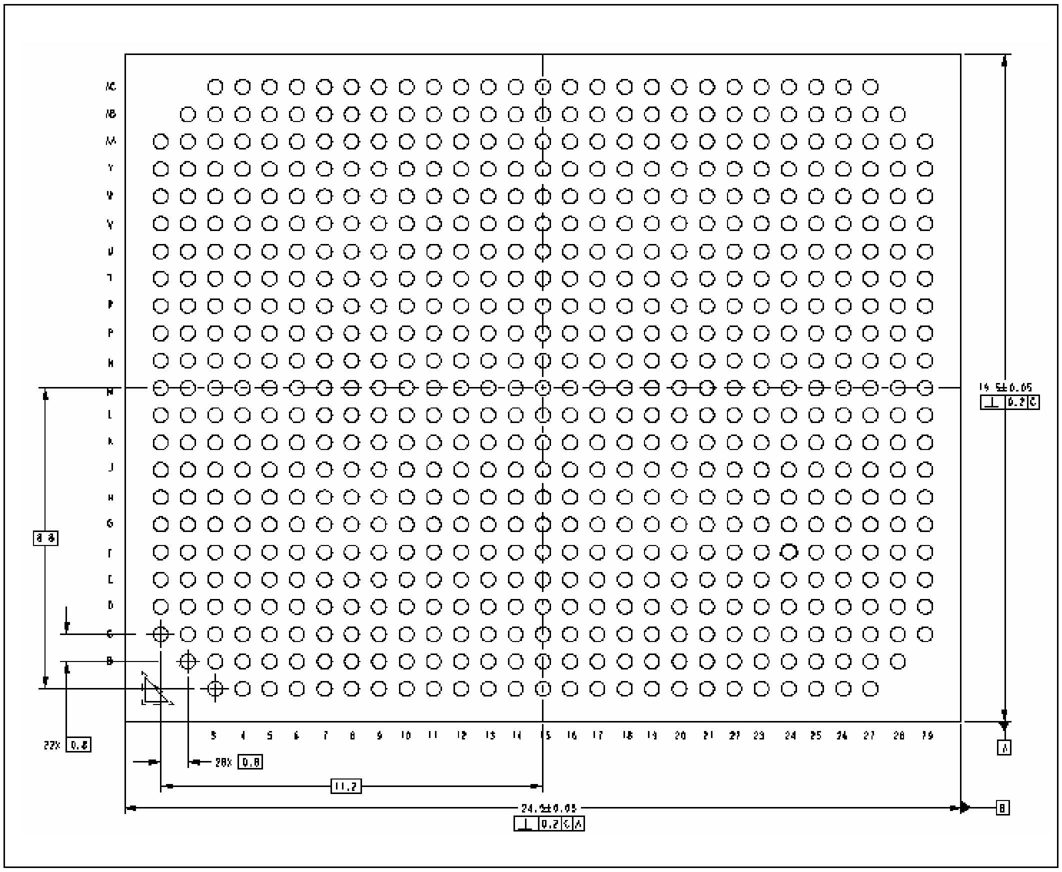


Figure 2-2. Intel 6400/6402 Advanced Memory Buffer Package Dimensions (Side View)



Notes:
1. Primary datum -C- and seating plan are defined by the spherical crowns of the solder balls (shown before motherboard attach)
2. All dimensions and tolerances conform to ANSI Y14.5M-1994
3. BGA has a pre-SMT height of 0.401 - 0.411mm and post-SMT height of 0.229 - 0.279mm
4. Shown before motherboard attach; FCBGA has a convex (dome shaped) orientation before reflow and is expected to have a slightly concave (bowl shaped) orientation after reflow

Figure 2-3. Intel 6400/6402 Advanced Memory Buffer Package Dimensions (Btm View)



Notes:
1. All dimensions are in millimeters.
2. All dimensions and tolerances conform to ANSI Y14.5M-1994.

2.1 Package Mechanical Requirements

The Intel 6400/6402 Advanced Memory Buffer package has an exposed bare die which is capable of sustaining a maximum static normal load of 15-lbf. The package is NOT capable of sustaining a dynamic or static compressive load applied to any edge of the bare die. These mechanical load limits must not be exceeded during heatsink installation, mechanical stress testing, standard shipping conditions and/or any other use condition.

Note:

1. The heatsink attach solutions must not include continuous stress onto the chipset package with the exception of a uniform load to maintain the heatsink-to-package thermal interface.
2. These specifications apply to uniform compressive loading in a direction perpendicular to the bare die/IHS top surface.
3. These specifications are based on limited testing for design characterization. Loading limits are for the package only.

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3 Thermal Specifications

3.1 Thermal Design Power (TDP)

Analysis indicates that real applications are unlikely to cause the Intel 6400/6402 Advanced Memory Buffer to consume maximum power dissipation for sustained time periods. Therefore, in order to arrive at a more realistic power level for thermal design purposes, Intel characterized power consumption based on know platform benchmark applications. The result power consumption is referred as the Thermal Design Power (TDP). TDP is the target power level that the thermal solutions should be designed to. TDP is not the maximum power that the Intel 6400/6402 Advanced Memory Buffer can dissipate.

For Intel 6400/6402 Advanced Memory Buffer TDP specifications, see Table 3-1 for the Intel® 5000P chipset-based platforms, Table 3-2 for the Intel® 5000V chipset-based platforms, and Table 3-3 to Table 3-6 for the Intel® 5000X chipset-based platforms. FC-BGA packages have poor heat transfer capability into the board and have minimal thermal capability without a thermal solution. Intel recommends that system designers plan for a heat dissipation device when using the Intel 6400/6402 Advanced Memory Buffer.

For reference FB-DIMM TDP guidance (including Intel 6400/6402 Advanced Memory Buffer power consumptions), see Table 3-7 for the Intel 5000P chipset-based platform, Table 3-8 for the Intel 5000V chipset-based platform, and Table 3-9 to Table 3-12 for the Intel 5000X chipset-based platform. Systems not designed to sufficiently cool the TDP values described below may exceed FB-DIMM temperature limit or experience reduced performance if memory throttling is enabled.

3.2 Die Temperature Specifications

To ensure proper operation and reliability of the Intel 6400/6402 Advanced Memory Buffer, the die temperatures must be at or between the maximum/minimum operating temperature ranges as specified in Table 3-1 to Table 3-6. System and/or component level thermal solutions are required to maintain these temperature specifications. Refer to Chapter 5 for guidelines on accurately measuring package die temperatures.

Table 3-1. Intel 5000P Chipset-Based Platform: Intel 6400/6402 Advanced Memory Buffer Thermal Specifications (Sheet 1 of 2)

	DIMM Type	DIMM 0 Intel 6400/6402 Advanced Memory Buffer TDP	DIMM 1 Intel 6400/6402 Advanced Memory Buffer TDP	DIMM 2 Intel 6400/6402 Advanced Memory Buffer TDP	DIMM 3 Intel 6400/6402 Advanced Memory Buffer TDP	Intel 6400/6402 Advanced Memory Buffer T_{case_max}	Intel 6400/6402 Advanced Memory Buffer T_{case_min}
1 DIMM per Channel (4 DIMMs Total) (1.95GB/sec/DIMM)	DRx8	5.1 watts				110°C	5°C
	DRx4	5.4 watts				110°C	5°C

Table 3-1. Intel 5000P Chipset-Based Platform: Intel 6400/6402 Advanced Memory Buffer Thermal Specifications (Sheet 2 of 2)

	DIMM Type	DIMM 0 Intel 6400/6402 Advanced Memory Buffer TDP	DIMM 1 Intel 6400/6402 Advanced Memory Buffer TDP	DIMM 2 Intel 6400/6402 Advanced Memory Buffer TDP	DIMM 3 Intel 6400/6402 Advanced Memory Buffer TDP	Intel 6400/6402 Advanced Memory Buffer T_{case_max}	Intel 6400/6402 Advanced Memory Buffer T_{case_min}
2 DIMM per Channel (8 DIMMs Total) (0.98GB/sec/DIMM)	DRx8	5.7 watts	4.5 watts			110°C	5°C
	DRx4	6.0 watts	4.9 watts			110°C	5°C
3 DIMM per Channel (12 DIMMs Total) (0.65GB/sec/DIMM)	DRx8	5.5 watts	5.4 watts	4.4 watts		110°C	5°C
	DRx4	5.9 watts	5.7 watts	4.7 watts		110°C	5°C
4 DIMM per Channel (16 DIMMs Total) (0.49GB/sec/DIMM)	DRx8	5.5 watts	5.3 watts	5.2 watts	4.3 watts	110°C	5°C
	DRx4	5.8 watts	5.6 watts	5.6 watts	4.6 watts	110°C	5°C

Note: These specifications are based on silicon characterization with identical size FB-DIMMs within entire memory subsystem; however, they may be updated as further data becomes available.

Table 3-2. Intel 5000V Chipset-Based Platform: Intel 6400/6402 Advanced Memory Buffer Thermal Specifications (Sheet 1 of 2)

	DIMM Type	DIMM 0 Intel 6400/6402 Advanced Memory Buffer TDP	DIMM 1 Intel 6400/6402 Advanced Memory Buffer TDP	DIMM 2 Intel 6400/6402 Advanced Memory Buffer TDP	DIMM 3 Intel 6400/6402 Advanced Memory Buffer TDP	Intel 6400/6402 Advanced Memory Buffer T_{case_max}	Intel 6400/6402 Advanced Memory Buffer T_{case_min}
1 DIMM per Channel (4 DIMMs Total) (2.4GB/sec/DIMM)	**DRx8**	5.3 watts				110°C	5°C
	DRx4	5.7 watts				110°C	5°C
2 DIMM per Channel (8 DIMMs Total) (1.7GB/sec/DIMM)	**DRx8**	6.1 watts	4.9 watts			110°C	5°C
	DRx4	6.5 watts	5.3 watts			110°C	5°C

Table 3-2. Intel 5000V Chipset-Based Platform: Intel 6400/6402 Advanced Memory Buffer Thermal Specifications (Sheet 2 of 2)

	DIMM Type	DIMM 0 Intel 6400/6402 Advanced Memory Buffer TDP	DIMM 1 Intel 6400/6402 Advanced Memory Buffer TDP	DIMM 2 Intel 6400/6402 Advanced Memory Buffer TDP	DIMM 3 Intel 6400/6402 Advanced Memory Buffer TDP	Intel 6400/6402 Advanced Memory Buffer T_{case_max}	Intel 6400/6402 Advanced Memory Buffer T_{case_min}
3 DIMM per Channel (12 DIMMs Total) (1.1GB/sec/DIMM)	DRx8	5.8 watts	5.6 watts	4.6 watts		110°C	5°C
	DRx4	6.2 watts	6.0 watts	4.9 watts		110°C	5°C
4 DIMM per Channel (16 DIMMs Total) (0.85GB/sec/DIMM)	DRx8	5.7 watts	5.5 watts	5.5 watts	4.5 watts	110°C	5°C
	DRx4	6.1 watts	5.9 watts	5.8 watts	4.8 watts	110°C	5°C

Note: These specifications are based on silicon characterization with identical size FB-DIMMs within entire memory subsystem; however, they may be updated as further data becomes available.

Table 3-3. 4 DIMMs Total (1 DIMM/CH) Intel 5000X Chipset-Based Platform: Intel 6400/6402 Advanced Memory Buffer Thermal Specifications

PCIe Lanes With Heavy Traffic	DIMM Type	DIMM 0 Intel 6400/6402 Advanced Memory Buffer TDP	Intel 6400/6402 Advanced Memory Buffer T_{case_max}	Intel 6400/6402 Advanced Memory Buffer T_{case_min}
x16 from MCH x8 from ESB2 x4 from ESB2 (2.25GB/sec/DIMM)	DRx8	5.2 watts	110°C	5°C
	DRx4	5.6 watts	110°C	5°C
x16 from MCH x8 from ESB2 (2.25GB/sec/DIMM)	DRx8	5.2 watts	110°C	5°C
	DRx4	5.6 watts	110°C	5°C
x16 from MCH (2.2GB/sec/DIMM)	DRx8	5.2 watts	110°C	5°C
	DRx4	5.6 watts	110°C	5°C
x8 from ESB2 x4 from ESB2 (2.1GB/sec/DIMM)	DRx8	5.1 watts	110°C	5°C
	DRx4	5.5 watts	110°C	5°C
x8 from ESB2 (2.05GB/sec/DIMM)	DRx8	5.1 watts	110°C	5°C
	DRx4	5.5 watts	110°C	5°C
x4 from ESB2 (1.9GB/sec/DIMM)	DRx8	5.0 watts	110°C	5°C
	DRx4	5.4 watts	110°C	5°C
none (1.78GB/sec/DIMM)	DRx8	5.0 watts	110°C	5°C
	DRx4	5.3 watts	110°C	5°C

Note: These specifications are based on silicon characterization with identical size FB-DIMMs within entire memory subsystem; however, they may be updated as further data becomes available.

Table 3-4. 8 DIMMs Total (2 DIMMs/CH) Intel 5000X Chipset-Based Platform: Intel 6400/6402 Advanced Memory Buffer Thermal Specifications

PCIe Lanes With Heavy Traffic	DIMM Type	DIMM 0 Intel 6400/6402 Advanced Memory Buffer TDP	DIMM 1 Intel 6400/6402 Advanced Memory Buffer TDP	Intel 6400/6402 Advanced Memory Buffer T_{case_max}	Intel 6400/6402 Advanced Memory Buffer T_{case_min}
x16 from MCH x8 from ESB2 x4 from ESB2 (1.25GB/sec/DIMM)	DRx8	5.9 watts	4.7 watts	110°C	5°C
	DRx4	6.2 watts	5.0 watts	110°C	5°C
x16 from MCH x8 from ESB2 (1.25GB/sec/DIMM)	DRx8	5.9 watts	4.7 watts	110°C	5°C
	DRx4	6.2 watts	5.0 watts	110°C	5°C
x16 from MCH (1.23GB/sec/DIMM)	DRx8	5.8 watts	4.7 watts	110°C	5°C
	DRx4	6.2 watts	5.0 watts	110°C	5°C
x8 from ESB2 x4 from ESB2 (1.2GB/sec/DIMM)	DRx8	5.8 watts	4.7 watts	110°C	5°C
	DRx4	6.2 watts	5.0 watts	110°C	5°C
x8 from ESB2 (1.15GB/sec./DIMM)	DRx8	5.8 watts	4.6 watts	110°C	5°C
	DRx4	6.2 watts	5.0 watts	110°C	5°C
x4 from ESB2 (1.10GB/sec/DIMM)	DRx8	5.8 watts	4.6 watts	110°C	5°C
	DRx4	6.1 watts	4.9 watts	110°C	5°C
none (1.05GB/sec/DIMM)	DRx8	5.7 watts	4.6 watts	110°C	5°C
	DRx4	6.1 watts	4.9 watts	110°C	5°C

Note: These specifications are based on silicon characterization with identical size FB-DIMMs within entire memory subsystem; however, they may be updated as further data becomes available.

Table 3-5. 12 DIMMs Total (3 DIMMs/CH) Intel 5000X Chipset-Based Platform: Intel 6400/6402 Advanced Memory Buffer Thermal Specifications

PCIe Lanes With Heavy Traffic	DIMM Type	DIMM 0 Intel 6400/6402 Advanced Memory Buffer TDP	DIMM 1 Intel 6400/6402 Advanced Memory Buffer TDP	DIMM 2 Intel 6400/6402 Advanced Memory Buffer TDP	Intel 6400/6402 Advanced Memory Buffer T_{case_max}	Intel 6400/6402 Advanced Memory Buffer T_{case_min}
x16 from MCH x8 from ESB2 x4 from ESB2 (0.83GB/sec/DIMM)	DRx8	5.6 watts	5.5 watts	4.5 watts	110°C	5°C
	DRx4	6.0 watts	5.8 watts	4.8 watts	110°C	5°C
x16 from MCH x8 from ESB2 (0.83GB/sec/DIMM)	DRx8	5.6 watts	5.5 watts	4.5 watts	110°C	5°C
	DRx4	6.0 watts	5.8 watts	4.8 watts	110°C	5°C
x16 from MCH (0.82GB/sec/DIMM)	DRx8	5.6 watts	5.5 watts	4.5 watts	110°C	5°C
	DRx4	6.0 watts	5.8 watts	4.8 watts	110°C	5°C
x8 from ESB2 x4 from ESB2 (0.8GB/sec/DIMM)	DRx8	5.6 watts	5.4 watts	4.4 watts	110°C	5°C
	DRx4	6.0 watts	5.8 watts	4.8 watts	110°C	5°C
x8 from ESB2 (0.77GB/sec/DIMM)	DRx8	5.6 watts	5.4 watts	4.4 watts	110°C	5°C
	DRx4	6.0 watts	5.8 watts	4.8 watts	110°C	5°C
x4 from ESB2 (0.73GB/sec/DIMM)	DRx8	5.6 watts	5.4 watts	4.4 watts	110°C	5°C
	DRx4	5.9 watts	5.7 watts	4.7 watts	110°C	5°C
none (0.7GB/sec/DIMM)	DRx8	5.6 watts	5.4 watts	4.4 watts	110°C	5°C
	DRx4	5.9 watts	5.7 watts	4.7 watts	110°C	5°C

Note: These specifications are based on silicon characterization with identical size FB-DIMMs within entire memory subsystem; however, they may be updated as further data becomes available.

Table 3-6. 16 DIMMs Total (4 DIMMs/CH) Intel 5000X Chipset-Based Platform: Intel 6400/6402 Advanced Memory Buffer Thermal Specifications

PCIe Lanes With Heavy Traffic	DIMM Type	DIMM 0 Intel 6400/6402 Advanced Memory Buffer TDP	DIMM 1 Intel 6400/6402 Advanced Memory Buffer TDP	DIMM 2 Intel 6400/6402 Advanced Memory Buffer TDP	DIMM 3 Intel 6400/6402 Advanced Memory Buffer TDP	Intel 6400/6402 Advanced Memory Buffer T_{case_max}	Intel 6400/6402 Advanced Memory Buffer T_{case_min}
x16 from MCH x8 from ESB2 x4 from ESB2 (0.63GB/sec/DIMM)	DRx8	5.6 watts	5.4 watts	5.3 watts	4.3 watts	110°C	5°C
	DRx4	5.9 watts	5.7 watts	5.7 watts	4.7 watts	110°C	5°C
x16 from MCH x8 from ESB2 (0.63GB/sec/DIMM)	DRx8	5.6 watts	5.4 watts	5.3 watts	4.3 watts	110°C	5°C
	DRx4	5.9 watts	5.7 watts	5.7 watts	4.7 watts	110°C	5°C
x16 from MCH (0.61GB/sec/DIMM)	DRx8	5.5 watts	5.4 watts	5.3 watts	4.3 watts	110°C	5°C
	DRx4	5.9 watts	5.7 watts	5.7 watts	4.7 watts	110°C	5°C
x8 from ESB2 x4 from ESB2 (0.60GB/sec/DIMM)	DRx8	5.5 watts	5.4 watts	5.3 watts	4.3 watts	110°C	5°C
	DRx4	5.9 watts	5.7 watts	5.7 watts	4.7 watts	110°C	5°C
x8 from ESB2 (0.58GB/sec/DIMM)	DRx8	5.5 watts	5.3 watts	5.3 watts	4.3 watts	110°C	5°C
	DRx4	5.9 watts	5.7 watts	5.6 watts	4.6 watts	110°C	5°C
x4 from ESB2 (0.55GB/sec/DIMM)	DRx8	5.5 watts	5.3 watts	5.3 watts	4.3 watts	110°C	5°C
	DRx4	5.8 watts	5.7 watts	5.6 watts	4.6 watts	110°C	5°C
none (0.53GB/sec/DIMM)	DRx8	5.5 watts	5.3 watts	5.3 watts	4.3 watts	110°C	5°C
	DRx4	5.8 watts	5.6 watts	5.6 watts	4.6 watts	110°C	5°C

Note: These specifications are based on silicon characterization with identical size FB-DIMMs within entire memory subsystem; however, they may be updated as further data becomes available.

Table 3-7. Intel 5000P Chipset-Based Platform: Reference FB-DIMM Total TDP

	DIMM Type	DIMM 0 Total TDP	DIMM 1 Total TDP	DIMM 2 Total TDP	DIMM 3 Total TDP
1 DIMM per Channel (4 DIMMs Total) (1.95GB/sec/DIMM)	DRx8	11.0 watts			
	DRx4	16.2 watts			
2 DIMM per Channel (8 DIMMs Total) (0.98GB/sec/DIMM)	DRx8	10.1 watts	8.9 watts		
	DRx4	14.0 watts	12.8 watts		
3 DIMM per Channel (12 DIMMs Total) (0.65GB/sec/DIMM)	DRx8	9.3 watts	9.1 watts	8.1 watts	
	DRx4	12.8 watts	12.6 watts	11.6 watts	
4 DIMM per Channel (16 DIMMs Total) (0.49GB/sec/DIMM)	DRx8	8.9 watts	8.8 watts	8.7 watts	7.8 watts
	DRx4	12.2 watts	12.0 watts	12.0 watts	11.0 watts

Note: The above Total TDPs are provided as guidance and for reference only. These reference TDP values are based on the assumption of identical size FB-DIMMs within the entire memory subsystem. They are not inclusive of every DRAM technologies. Users are advised to conduct their own FB-DIMM power measurement as part of their system thermal evaluation.

Table 3-8. Intel 5000V Chipset-Based Platform: Reference FB-DIMM Total TDP

	DIMM Type	DIMM 0 Total TDP	DIMM 1 Total TDP	DIMM 2 Total TDP	DIMM 3 Total TDP
1 DIMM per Channel (4 DIMMs Total) (2.4GB/sec/DIMM)	DRx8	12.0 watts			
	DRx4	17.7 watts			
2 DIMM per Channel (8 DIMMs Total) (1.7GB/sec/DIMM)	DRx8	11.7 watts	10.5 watts		
	DRx4	16.6 watts	15.4 watts		
3 DIMM per Channel (12 DIMMs Total) (1.1GB/sec/DIMM)	DRx8	10.4 watts	10.2 watts	9.2 watts	
	DRx4	14.5 watts	14.3 watts	13.3 watts	
4 DIMM per Channel (16 DIMMs Total) (0.85GB/sec/DIMM)	DRx8	9.8 watts	9.6 watts	9.6 watts	8.6 watts
	DRx4	13.6 watts	13.4 watts	13.3 watts	12.3 watts

Note: The above Total TDPs are provided as guidance and for reference only. These reference TDP values are based on the assumption of identical size FB-DIMMs within the entire memory subsystem. They are not inclusive of every DRAM technologies. Users are advised to conduct their own FB-DIMM power measurement as part of their system thermal evaluation.

Table 3-9. 4 DIMMs Total (1 DIMM/CH) Intel 5000X Chipset-Based Platform: Reference FB-DIMM Total TDP

PCIe Lanes With Heavy Traffic	DIMM Type	DIMM 0 Total TDP
x16 from MCH x8 from ESB2 x4 from ESB2 (2.25GB/sec/DIMM)	DRx8	11.7 watts
	DRx4	17.2 watts
x16 from MCH x8 from ESB2 (2.25GB/sec/DIMM)	DRx8	11.7 watts
	DRx4	17.2 watts
x16 from MCH (2.2GB/sec/DIMM)	DRx8	11.6 watts
	DRx4	17.1 watts
x8 from ESB2 x4 from ESB2 (2.1GB/sec/DIMM)	DRx8	11.4 watts
	DRx4	16.7 watts
x8 from ESB2 (2.05GB/sec/DIMM)	DRx8	11.3 watts
	DRx4	16.6 watts
x4 from ESB2 (1.9GB/sec/DIMM)	DRx8	10.9 watts
	DRx4	16.1 watts
none (1.78GB/sec/DIMM)	DRx8	10.7 watts
	DRx4	15.7 watts

Note: The above Total TDPs are provided as guidance and for reference only. These reference TDP values are based on the assumption of identical size FB-DIMMs within the entire memory subsystem. They are not inclusive of every DRAM technologies. Users are advised to conduct their own FB-DIMM power measurement as part of their system thermal evaluation.

Table 3-10. 8 DIMMs Total (2 DIMMs/CH) Intel 5000X Chipset-Based Platform: Reference FB-DIMM Total TDP

PCIe Lanes With Heavy Traffic	DIMM Type	DIMM 0 Total TDP	DIMM 1 Total TDP
x16 from MCH x8 from ESB2 x4 from ESB2 (1.25GB/sec/DIMM)	DRx8	10.7 watts	9.5 watts
	DRx4	15.0 watts	13.8 watts
x16 from MCH x8 from ESB2 (1.25GB/sec/DIMM)	DRx8	10.7 watts	9.5 watts
	DRx4	15.0 watts	13.8 watts
x16 from MCH (1.23GB/sec/DIMM)	DRx8	10.6 watts	9.5 watts
	DRx4	14.9 watts	13.8 watts
x8 from ESB2 x4 from ESB2 (1.20GB/sec/DIMM)	DRx8	10.6 watts	9.4 watts
	DRx4	14.8 watts	13.6 watts
x8 from ESB2 (1.15GB/sec/DIMM)	DRx8	10.5 watts	9.3 watts
	DRx4	14.6 watts	13.5 watts
x4 from ESB2 (1.1GB/sec/DIMM)	DRx8	10.3 watts	9.2 watts
	DRx4	14.4 watts	13.3 watts
none (1.05GB/sec/DIMM)	DRx8	10.2 watts	9.1 watts
	DRx4	14.3 watts	13.1 watts

Note: The above Total TDPs are provided as guidance and for reference only. These reference TDP values are based on the assumption of identical size FB-DIMMs within the entire memory subsystem. They are not inclusive of every DRAM technologies. Users are advised to conduct their own FB-DIMM power measurement as part of their system thermal evaluation.

Table 3-11. 12 DIMMs Total (3 DIMMs/CH) Intel 5000X Chipset-Based Platform: Reference FB-DIMM Total TDP

PCIe Lanes With Heavy Traffic	DIMM Type	DIMM 0 Total TDP	DIMM 1 Total TDP	DIMM 2 Total TDP
x16 from MCH x8 from ESB2 x4 from ESB2 (0.83GB/sec/DIMM)	**DRx8**	9.7 watts	9.5 watts	8.5 watts
	DRx4	13.5 watts	13.6 watts	12.2 watts
x16 from MCH x8 from ESB2 (0.83GB/sec/DIMM)	**DRx8**	9.7 watts	9.5 watts	8.5 watts
	DRx4	13.5 watts	13.6 watts	12.2 watts
x16 from MCH (0.82GB/sec/DIMM)	**DRx8**	9.7 watts	9.5 watts	8.5 watts
	DRx4	13.4 watts	13.2 watts	12.2 watts
x8 from ESB2 x4 from ESB2 (0.80GB/sec/DIMM)	**DRx8**	9.7 watts	9.5 watts	8.5 watts
	DRx4	13.4 watts	13.1 watts	12.1 watts
x8 from ESB2 (0.77GB/sec/DIMM)	**DRx8**	9.6 watts	9.4 watts	8.4 watts
	DRx4	13.2 watts	13.0 watts	12.0 watts
x4 from ESB2 (0.73GB/sec/DIMM)	**DRx8**	9.5 watts	9.3 watts	8.3 watts
	DRx4	13.1 watts	12.9 watts	11.9 watts
none (0.70GB/sec/DIMM)	**DRx8**	9.4 watts	9.2 watts	8.2 watts
	DRx4	13.0 watts	12.8 watts	11.8 watts

Note: The above Total TDPs are provided as guidance and for reference only. These reference TDP values are based on the assumption of identical size FB-DIMMs within the entire memory subsystem. They are not inclusive of every DRAM technologies. Users are advised to conduct their own FB-DIMM power measurement as part of their system thermal evaluation.

Table 3-12. 16 DIMMs Total (4 DIMMs/CH) Intel 5000X Chipset-Based Platform: Reference FB-DIMM Total TDP

PCIe Lanes With Heavy Traffic	DIMM Type	DIMM 0 Total TDP	DIMM 1 Total TDP	DIMM 2 Total TDP	DIMM 3 Total TDP
x16 from MCH x8 from ESB2 x4 from ESB2 (0.63GB/sec/DIMM)	**DRx8**	9.3 watts	9.1 watts	9.1 watts	8.1 watts
	DRx4	12.7 watts	12.5 watts	12.5 watts	11.5 watts
x16 from MCH x8 from ESB2 (0.63GB/sec/DIMM)	**DRx8**	9.3 watts	9.1 watts	9.1 watts	8.1 watts
	DRx4	12.7 watts	12.5 watts	12.5 watts	11.5 watts
x16 from MCH (0.61GB/sec/DIMM)	**DRx8**	9.2 watts	9.1 watts	9.0 watts	8.0 watts
	DRx4	12.7 watts	12.5 watts	12.4 watts	11.4 watts
x8 from ESB2 x4 from ESB2 (0.60GB/sec/DIMM)	**DRx8**	9.2 watts	9.0 watts	9.0 watts	8.0 watts
	DRx4	12.6 watts	12.4 watts	12.4 watts	11.4 watts
x8 from ESB2 (0.58GB/sec/DIMM)	**DRx8**	9.2 watts	9.0 watts	9.0 watts	8.0 watts
	DRx4	12.5 watts	12.3 watts	12.3 watts	11.3 watts
x4 from ESB2 (0.55GB/sec/DIMM)	**DRx8**	9.1 watts	8.9 watts	8.9 watts	7.9 watts
	DRx4	12.4 watts	12.2 watts	12.2 watts	11.2 watts
none (0.53GB/sec/DIMM)	**DRx8**	9.0 watts	8.9 watts	8.8 watts	7.8 watts
	DRx4	12.3 watts	12.2 watts	12.1 watts	11.1 watts

Note: The above Total TDPs are provided as guidance and for reference only. These reference TDP values are based on the assumption of identical size FB-DIMMs within the entire memory subsystem. They are not inclusive of every DRAM technologies. Users are advised to conduct their own FB-DIMM power measurement as part of their system thermal evaluation.

3.3 Thermal Sensor

The Intel® 6400/6402 Advanced Memory Buffer includes an on-die temperature sensor. This thermal sensor measured from 0 to 127 degrees C measured in 0.5 degree increments. Current temperature reading of the die is stored on a 8-bit register named TEMP. Overall accuracy of this thermal sensor with respect to GB Tcase are the following:

- 40'C < Tcase < 54.5'C : +10/-15°C
- 55'C < Tcase < 89.5'C : ±10°C
- 90'C < Tcase < 110'C : ±6°C
- 110.5'C < Tcase < 124'C : ±10°C

For example, if GB Tcase is currently at 95°C, the TEMP register will output a temperature value between 89°C and 101°C. This TEMP register will then be used to determine the following thermal sensor status registers' values

- TEMPSTAT.INCREASING
- TEMPSTAT.OVERTEMPHI
- TEMPSTAT.OVERTEMPMID
- TEMPSTAT.OVERTEMPLO

For additional details on these thermal sensor related registers, refer to Section 14.5.3.5 and 14.5.3.6 in the *Intel® 6400/6402 Advanced Memory Buffer Datasheet*

3.3.1 Overtemp Shutdown Protection Setting

Each Intel 6400/6402 Advanced Memory Buffer is programmed with a TEMPHI register value of 124°C. This corresponds to:

$$114°C < Tcase < 134°C$$

If the TEMP register values exceeds TEMPHI, errors are logged. And if the TEMPHIENABLE bit in the TEMPSTAT register is set, DDR shutdown occurs and FBD links go into electrical idle mode. This over TEMPHI behavior also applies when in LAI mode. See section 6.1.4 in the *Intel® 6400/6402 Advanced Memory Buffer Datasheet* for a more complete description of chip behavior when TEMPHI is exceeded.

For additional details on this feature, refer to Section 4.7.1, 14.5.3.3 and 14.5.3.5 in the *Intel® 6400/6402 Advanced Memory Buffer Datasheet* as well.

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4 Thermal Simulation

Intel provides a tool called *FB-DIMM System Thermal Calculator for the Intel® 5000P/5000V/5000X Chipset-Based Platforms* to aid system designers in simulating, analyzing, and optimizing their system-level thermal solutions in an integrated, system-level environment. The data generated from this are all based on reference thermal solutions described in later chapters of this document. Contact your Intel field sales representative to order this tool.

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5 Thermal Metrology

The system designer must make temperature measurements to accurately determine the thermal performance of the system. Intel has established guidelines for proper techniques to measure the Intel 6400/6402 Advanced Memory Buffer die temperatures. Section 5.1 to Section 5.5 provide guidelines on how to accurately measure the Intel 6400/6402 Advanced Memory Buffer die temperature and the DRAM case temperature. Section 5.7 contains information on running an application program that will emulate anticipated maximum thermal design power.

5.1 FB-DIMM Module Temperature Measurements

To ensure functionality and reliability, the Tcase of the Intel 6400/6402 Advanced Memory Buffer must be maintained at or between the maximum/minimum operating range of the temperature specifications as noted in Table 3-1, Table 3-2 and Table 3-3. The Tcase of the DRAM must be maintained below respective manufacturers' datasheet Tcase_max specification. The surface temperature at the geometric center of the die corresponds to Tcase. Measuring Tcase requires special care to ensure an accurate temperature measurement.

Temperature differences between the temperature of a surface and the surrounding local ambient air can introduce errors in the measurements. The measurement errors could be due to a poor thermal contact between the thermocouple junction and the surface of the package, heat loss by radiation and/or convection, conduction through thermocouple leads, and/or contact between the thermocouple cement and the heatspreader based (if a heatspreader is used). For maximum measurement accuracy, on the 0^{o} thermocouple attach approach is recommended.

5.2 Thermocouple Attachment Methodology for AMB-Only Heatspreader FB-DIMM

Steps to attach the thermocouple to monitor both the AMB Tcase temperature *directly* and DRAM Tcase temperature *directly* are the following:

1. If applicable, remove and discard the thermal solution that came with the FB-DIMM Module to be evaluated.

   Note: We recommend using isopropyl alcohol to remove all remaining TIM residue.

2. Drill a 2.6 mm diameter hole through a new AMB Heatspreader at a location corresponding to the geometric center of the AMB die.

   Note: When drilling holes, either have no TIM or be sure that the TIM is not disturbed. Ensure that the metal from the heatspreader or TC attach is not degrading TIM performance (increase in BLT).

3. Run the only AMB thermocouple (36 gauge or smaller calibrated T-type) bead from the heatspreader's non-TIM side to heatspreader's TIM side.
4. Attach this AMB thermocouple bead to the center of the top surface of the AMB die using a high thermal conductivity cement.
5. Attach the DRAM thermocouple(s) bead to the center of the top surface of the DRAM case using a high thermal conductivity cement.
6. Assemble the newly modified AMB only heatspreader onto the FB-DIMM module.

5.3 Alternative Attachment Methodology for AMB Only Heatspreader FB-DIMM

Intel is in the process of enabling all the DIMM vendors with a TTK setup methodology to specify a $T_{\_heatspreader\_max\_FB\text{-}DIMM}$ value that corresponds to the $T_{\_case\_max\_GB}$ value as noted in Table 3-1 through Table 3-3. If the AMB only heatspreader FB-DIMMs under test are specified with this $T_{\_heatspreader\_max\_FB\text{-}DIMM}$ value. Steps to attach thermocouple to monitor both the AMB Tcase temperature indirectly and DRAM Tcase temperature directly are the following:

1. Attach the AMB thermocouple bead to the center of the surface of the AMB heatspreader using a high thermal conductivity cement.
2. Attach the DRAM thermocouple(s) bead to the center of the top surface of the DRAM case using a high thermal conductivity cement.

5.4 Thermocouple Attachment Methodology for FDHS FB-DIMM

Steps to attach thermocouples to monitor both the AMB Tcase temperature *directly* and DRAM Tcase temperature *directly* are the following:

1. If applicable, remove and discard the thermal solution that came with the FB-DIMM Module to be evaluated

   Note: We recommend using isopropyl alcohol to remove all remaining TIM residue.

2. Drill a 2.6 mm diameter hole through a new FDHS at a location corresponding to the geometric center of the AMB die.

   Note: When drilling holes, either have no TIM or be sure that the TIM is not disturbed. Ensure that the metal from the heatspreader or TC attach is not degrading TIM performance (increase in BLT).

3. Drill any number of 2.6 mm diameter holes through the same new FDHS at locations corresponding to the geometric center of the DRAM package.

   Note: When drilling holes, either have no TIM or be sure that the TIM is not disturbed. Ensure that the metal from the heatspreader or TC attach is not degrading TIM performance (increase in BLT).

4. For DRAM whose package's geometric center is overshadowed by the FDHS clip, system developer will also need to drill the corresponding 3.0mm diameter holes through a new set of FDHS clips at location indicated in Figure 5-1 in order for the thermocouple wire to pass through the FDHS clip (Figure 5-3)

   Note: Care must be taken to ensure drilling of the FDHS clip will not alter the spring force of the FDHS clip.

5. Run both the AMB and DRAM thermocouple (36 gauge or smaller calibrated T-type) beads from the heatspreader's non-TIM side to heatspreader's TIM side.
6. Attach the AMB thermocouple bead to the center of the top surface of the AMB die using a high thermal conductivity cement.
7. Attach the DRAM thermocouple(s) bead to the center of the top surface of the DRAM case using a high thermal conductivity cement.
8. Assemble the newly modified FDHS assembly onto the FB-DIMM module.

5.5 Alternative Attachment Methodology for FDHS FB-DIMM

Intel is in the process of enabling all the DIMM vendors with a TTK setup methodology to specify a $T_{\_heatspreader\_max\_FB\text{-}DIMM}$ value that corresponds to $T_{\_case\_max\_GB}$ value as noted in Table 3-1 through Table 3-3. If the FDHS heatspreader FB-DIMMs under test are specified with this $T_{\_heatspreader\_max\_FB\text{-}DIMM}$ value. Steps to attach thermocouple to monitor both the AMB Tcase temperature indirectly and DRAM Tcase temperature directly are the following:

1. If applicable, remove and discard the thermal solution that came with the FB-DIMM Module to be evaluated.

   Note: We recommend using isopropyl alcohol to remove all remaining TIM residue.

2. Drill any number of 2.6 mm diameter holes through a new FDHS at locations corresponding to the geometric center of the DRAM package (Figure 5-1).

   Note: When drilling holes, either have no TIM or be sure that the TIM is not disturbed. Ensure that the metal from the heatspreader or TC attach is not degrading TIM performance (increase in BLT).

3. For DRAM whose package's geometric center is overshadowed by the FDHS clip, system developer will also need to drill the corresponding 3.0mm diameter holes through a new set of FDHS clips at location indicated in Figure 5-1 in order for the thermocouple wire to pass through the FDHS clip (Figure 5-3)

   Note: Care must be taken to ensure drilling of the FDHS clip will not alter the spring force of the FDHS clip.

4. Run the DRAM thermocouple (36 gauge or smaller calibrated T-type) beads from the heatspreader's non-TIM side to heatspreader's TIM side (Figure 5-2).
5. Attach the AMB thermocouple bead to the center of the surface of the FDHS using a high thermal conductivity cement (Figure 5-3).
6. Attach the DRAM thermocouple(s) bead to the center of the top surface of the DRAM case using a high thermal conductivity cement (Figure 5-2).
7. Assemble the newly modified FDHS assembly onto the FB-DIMM module (Figure 5-3).

Figure 5-1. FDHS DRAM Thermocouple Drill Locations

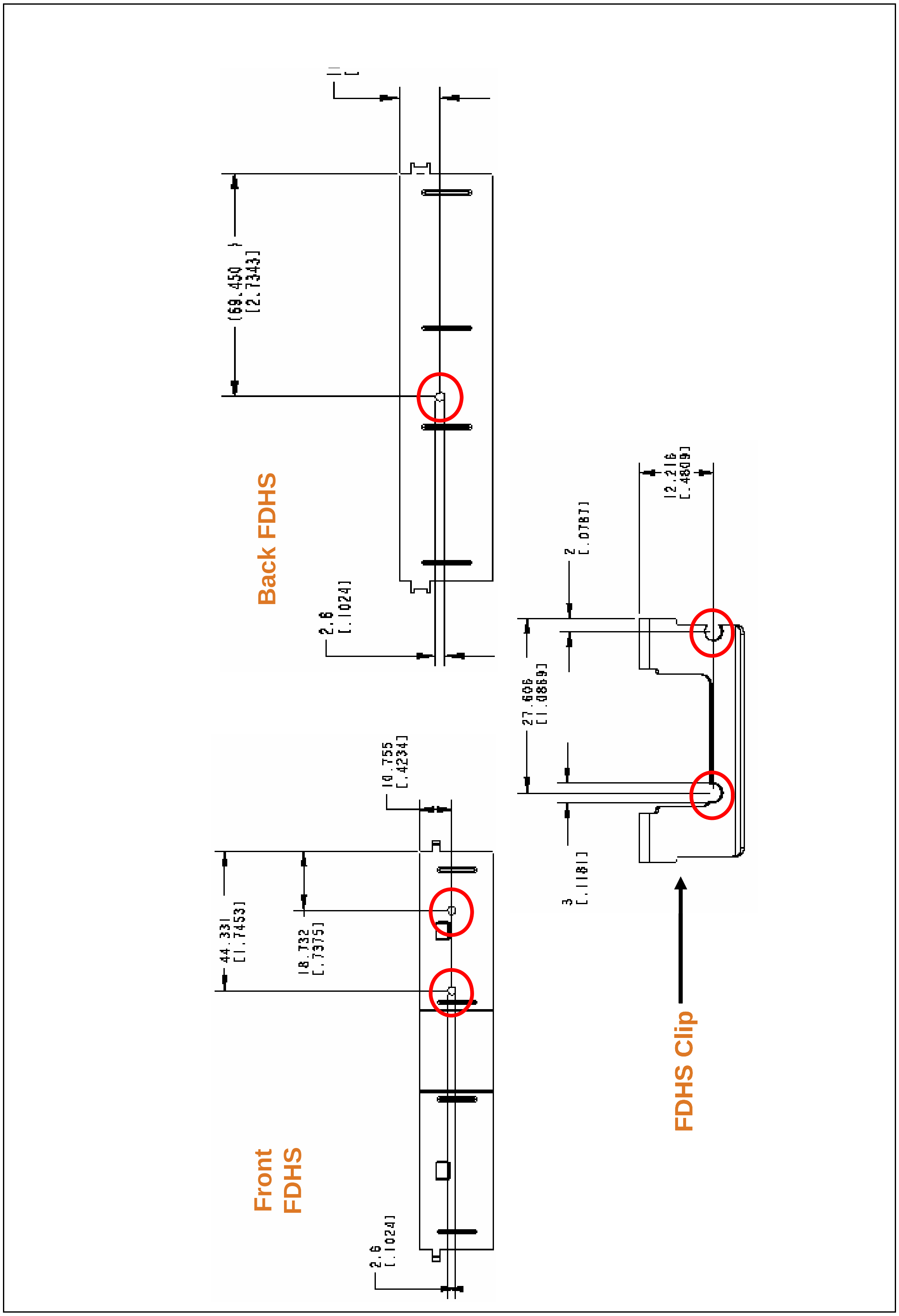
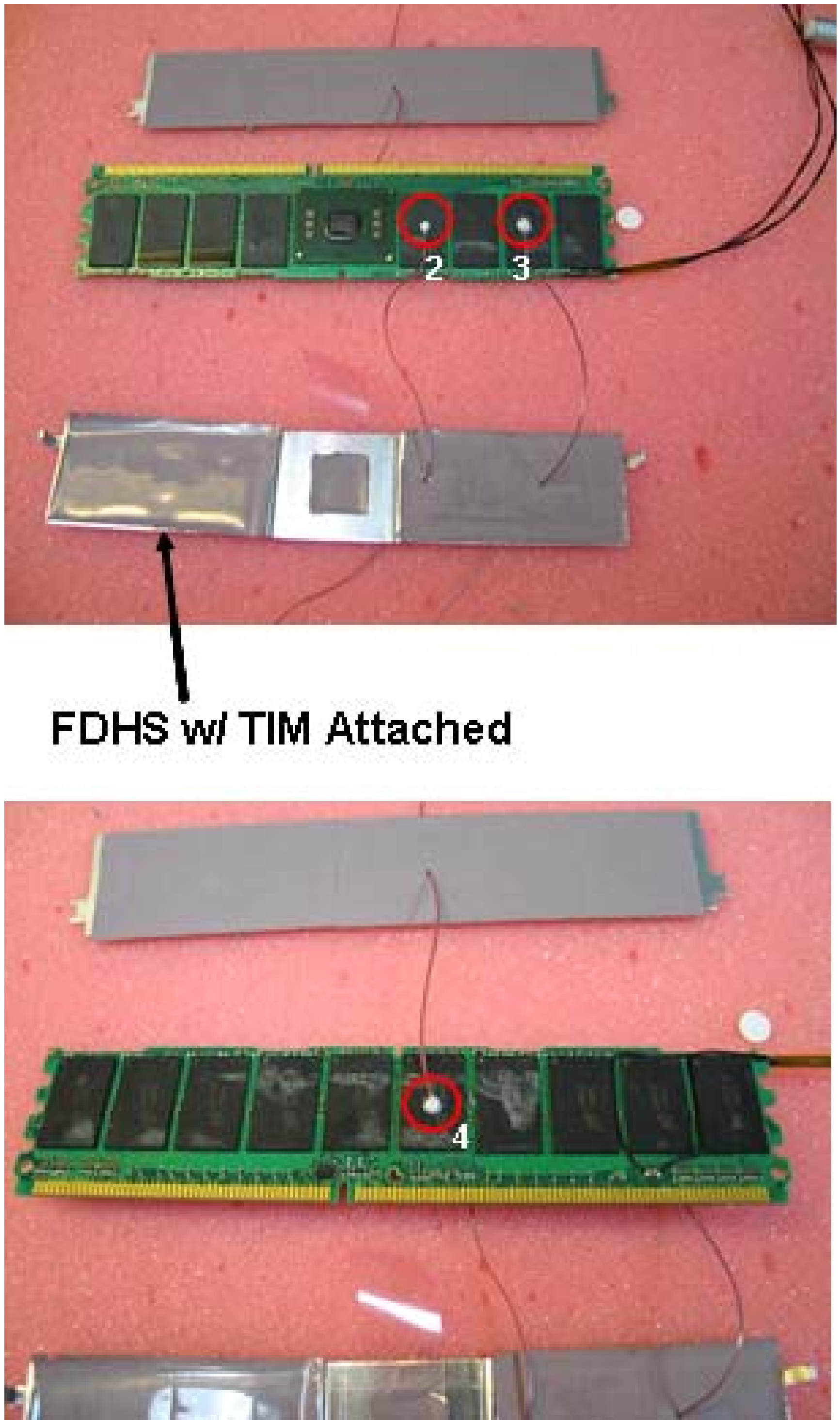
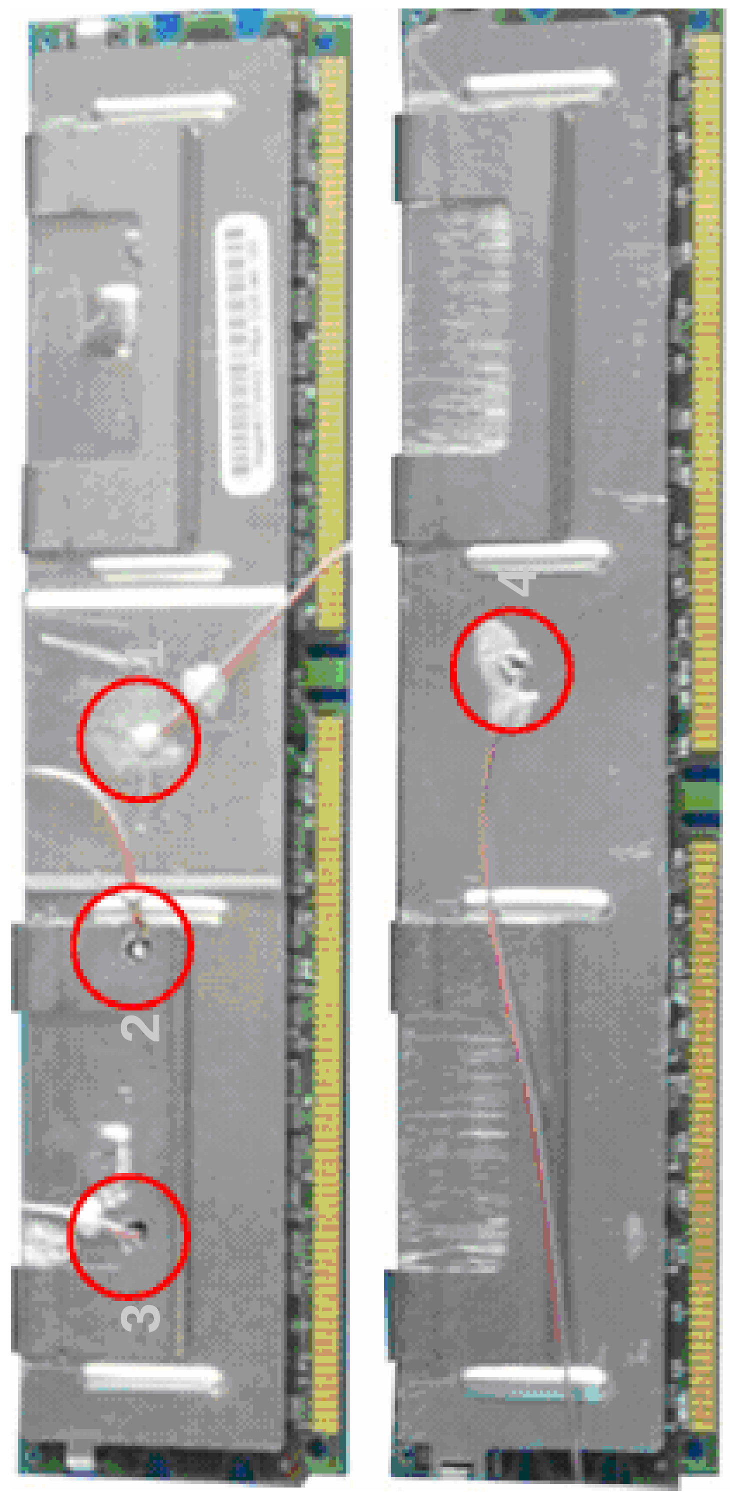


Figure 5-2. FDHS FB-DIMM with AMB/DRAM Thermocouples Attached (Pre-Assembly)



Note: Please refer to Chapter 8 and Appendix B for actual details on the Intel reference FDHS. The above illustration does not depict actual Intel reference FDHS.

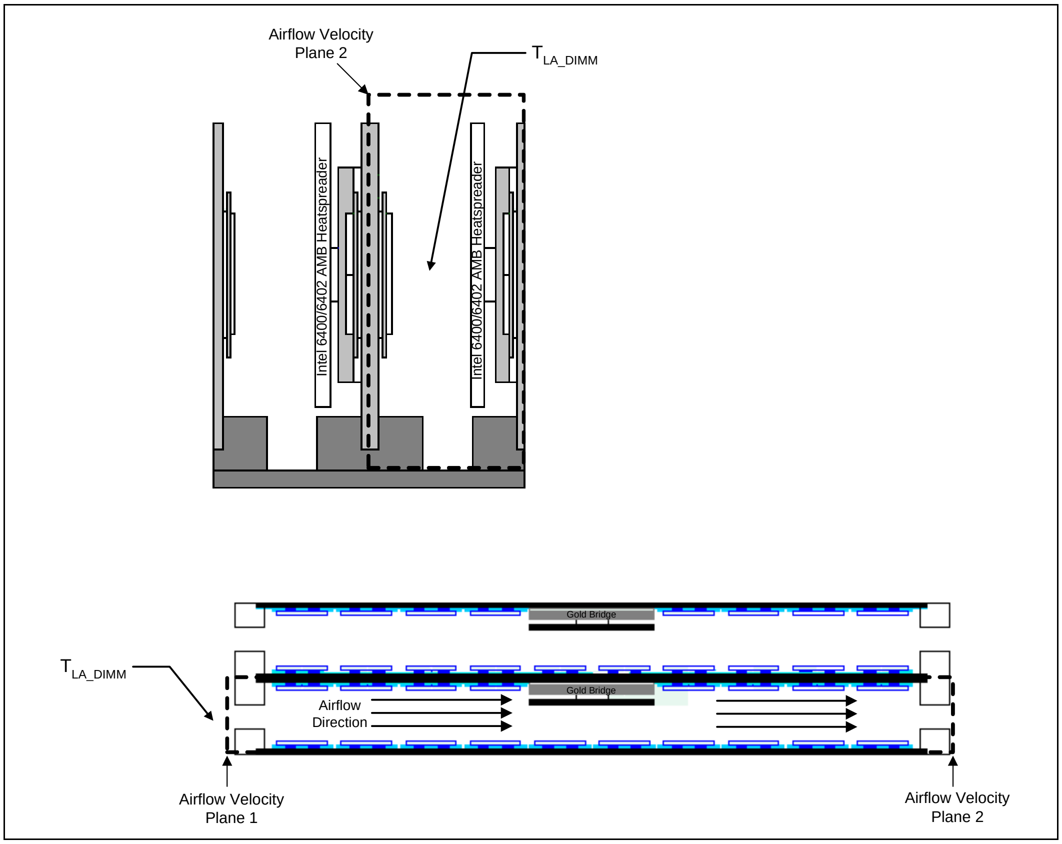
Figure 5-3. FDHS FB-DIMM with AMB/DRAM Thermocouples Attached (Post-Assembly)



5.6 Airflow Characterization

Figure 5-4 describes the recommended location for air temperature measurements relative to the FB-DIMM.

Figure 5-4. Airflow Temperature/Velocity Measurement Illustration



5.7 Power Simulation Software

The power simulation software is a utility designed to dissipate the thermal design power on an Intel 6400/6402 Advanced Memory Buffer when used in conjunction with the Intel 5000P/5000V/5000X chipset-based platforms. The combination of the above mentioned memory technology and the higher bandwidth capability of the Intel 5000P/5000V/5000X chipsets enable higher levels of system performance. To assess the thermal performance of the Intel 6400/6402 Advanced Memory Buffer thermal solution under “worst-case realistic application” conditions, Intel has developed a software utility that operates the advanced memory buffer at near worst-case thermal power dissipation.

The power simulation software being developed should only be used to test thermal solutions at or near the thermal design power. Real world applications may exceed the thermal design power limit for transient time periods. For power supply current requirements under these transient conditions, please refer to teach component’s datasheet for the ICC (Max Power Supply Current) specification. Contact your Intel field sales representative to order the power utility software and user’s guide.

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6 Reference Thermal Solution 1

Intel has developed three reference thermal solutions to meet the cooling need of the Intel 6400/6402 Advanced Memory Buffer under operating environments and specifications defined in this document. This chapter describes the overall requirements for the Intel 6400/6402 Advanced Memory Buffer only wire clip heatspreader reference thermal solution including critical-to-function dimensions, operating environment, and validation criteria.

This reference thermal solutions consists of the following:

- Front Plate (1pc).
- Wire-Clip (1pc).

This particular reference thermal solution is compatible with all FB-DIMM rawcard configurations.

6.1 Operating Environment

Since each Intel 5000P/5000V/5000X chipset-based platform's FB-DIMM subsystem thermal dissipation is based on the following variables:

- Number of memory channel utilized.
- Number of FB-DIMMs installed on each memory channel.
- Type of FB-DIMMs installed on each memory channel.
- Size of the FB-DIMMs installed on each memory channel.
- Memory refresh rate.
- Thermal solution on the FB-DIMM.

When this reference thermal solution is assembled on a raw card D (DRx4) configuration FB-DIMM, the *FB-DIMM System Thermal Calculator for the Intel® 5000P/5000V/5000X Chipset-Based Platforms* Tool can be used to determine if this reference thermal solution can deliver the thermal performance needed for your respective memory subsystem.

6.2 Heatspreader Performance

The thermal performance of the Intel 6400/6402 Advanced Memory Buffer reference thermal solution is dependant on the following:

T_{j_GB}	Intel 6400/6402 Advanced Memory Buffer junction temperature (°C).
$T_{j\_max\_GB}$	Maximum Intel 6400/6402 Advanced Memory Buffer die junction temperature allowed (°C).
T_{case_GB}	Temperature measured at the geometric center of the top of the Intel 6400/6402 Advanced Memory Buffer package die (°C).
$T_{case\_max\_GB}$	Maximum die temperature allowed on the Intel 6400/6402 Advanced Memory Buffer. This temperature is measured at the geometric center of the top of the package die (°C).
T_{case_DRAM}	Hottest DRAM case Temperature (°C).

$T_{case\_max\_DRAM}$	Maximum DRAM case temperature allowed (°C).
T_{LA_DIMM}	Air temperature entering memory DIMM channel (°C).
T_{j_AMB}	AMB junction Temperature (°C).
P_{GB}	Intel 6400/6402 Advanced Memory Buffer power dissipation (W).
P_{AMB}	AMB power dissipation (W).
P_{DRAM}	Total power of DRAMs (W).
Ψ_{AMB}	AMB Thermal Resistance from junction to air at a given flow velocity (°C/W).
Ψ_{AD}	Thermal Resistance of DRAM from AMB heating at a given flow velocity (°C/W).
Ψ_{DA}	Thermal Resistance of AMB from DRAM heating at a given flow velocity (°C/W).
Ψ_{Adj_AMB}	Thermal Resistance of AMB from Adjacent DIMM heating at a given flow velocity (°C/W).
Ψ_{Adj_DRAM}	Thermal Resistance of DRAM from Adjacent DIMM heating at a given flow velocity (°C/W).
Ψ_{DRAM}	Hottest DRAM thermal resistance from case to air at a given flow velocity (°C/W).
P_{adj_DIMM}	Total power dissipation of adjacent DIMM (W).

The overall thermal performance of this reference thermal solution is determine by the following two criteria:

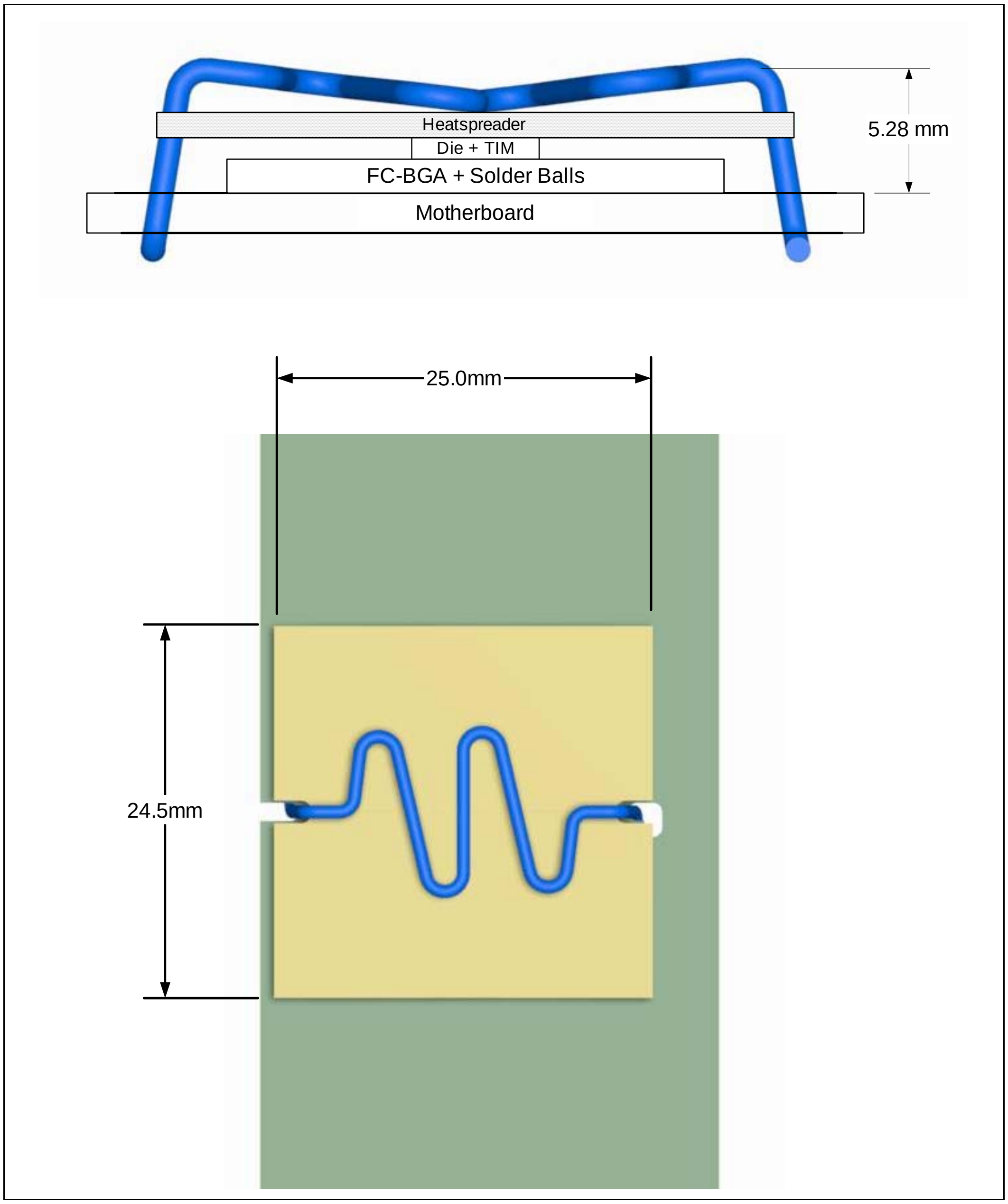
$$T_{j\_max\_GB} < T_{j\_AMB} = T_{LA\_DIMM} + \Psi_{AMB} P_{AMB} + \Psi_{DA} P_{DRAM} + \Psi_{Adj\_AMB} P_{Adj\_DIMM}$$

$$T_{case\_max\_dram} < T_{case\_DRAM} = T_{LA\_DIMM} + \Psi_{AD} P_{AMB} + \Psi_{DRAM} P_{DRAM} + \Psi_{Adj\_DRAM} P_{Adj\_DIMM}$$

6.3 Mechanical Design Envelope

While each design may have unique mechanical volume and height restrictions or implementation requirements, the height, width, and depth constraints typically placed on the Intel 6400/6402 Advanced Memory Buffer thermal solution are shown in Figure 6-1.

Figure 6-1. Wire Clip Heatspreader Volumetric Envelope for the Intel 6400/6402 Advanced Memory Buffer



6.4 Board-Level Components Keepout Dimensions

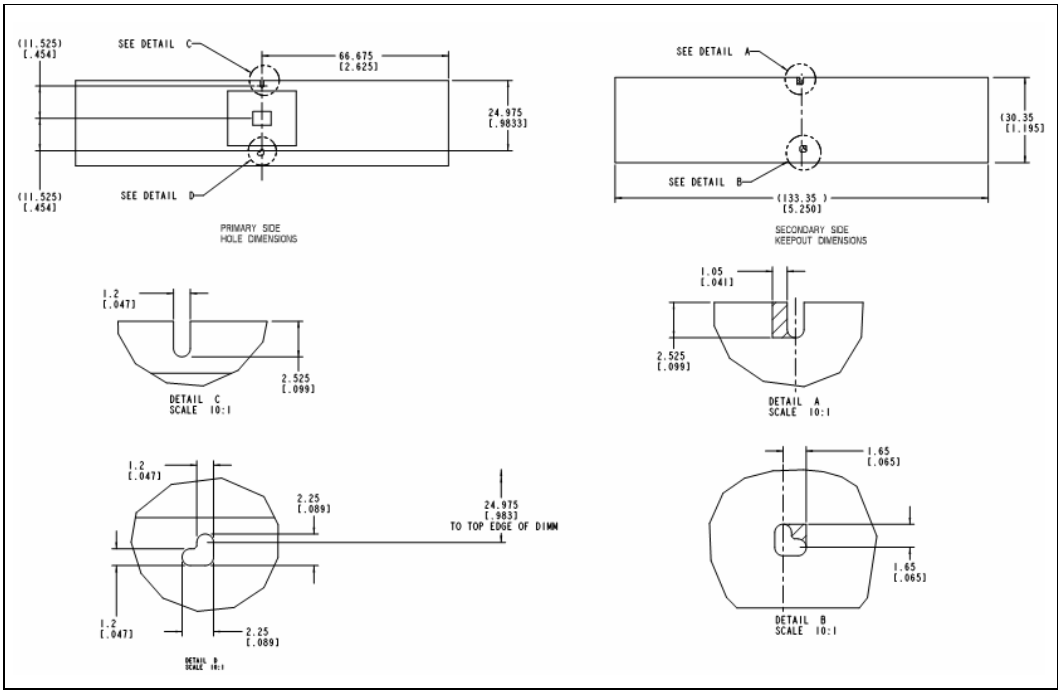
The location of hole patterns and keepout zones for the reference thermal solution are shown in Figure 6-2.

6.5 Wire Clip Heatspreader Thermal Solution Assembly

The reference thermal solution for the chipset Intel 6400/6402 Advanced Memory Buffer is a passive stamped heatspreader with thermal interface. The wire clip is latched through two non-grounded through holes on the DIMM. Figure 6-3 shows the reference thermal solution assembly and associated components.

Full mechanical drawings of the thermal solution assembly and the wire clip are provided in Appendix B. Appendix A contains vendor information for each thermal solution component.

Figure 6-2. Wire Clip Heatspreader Board Component Keepout

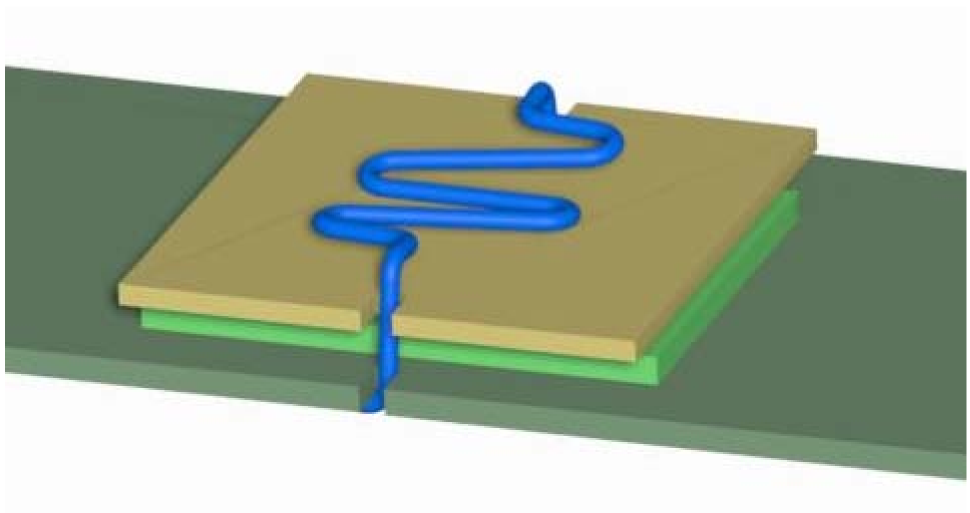


Note: All dimensions are in millimeters.

6.5.1 Heatspreader Orientation

This reference thermal solution should be aligned with the mounting holes on the FB-DIMM as defined in the JEDEC MO-256 Specification.

Figure 6-3. Wire Clip Heatspreader Assembly



6.5.2 Heatspreader Profiles

The reference wire clip heatspreader uses a stamped copper heatspreader for cooling the Intel 6400/6402 Advanced Memory Buffer. Figure 6-4 shows the spreader profile. Appendix A lists a supplier for this stamped heatspreader. Other heatspreaders with similar dimensions and increased thermal performance may be available. Currently available full mechanical drawing of this heatspreader is provided in Appendix B.

6.5.3 Mechanical Interface Material

There is no mechanical interface material associated with this reference solution.

6.5.4 Thermal Interface Material

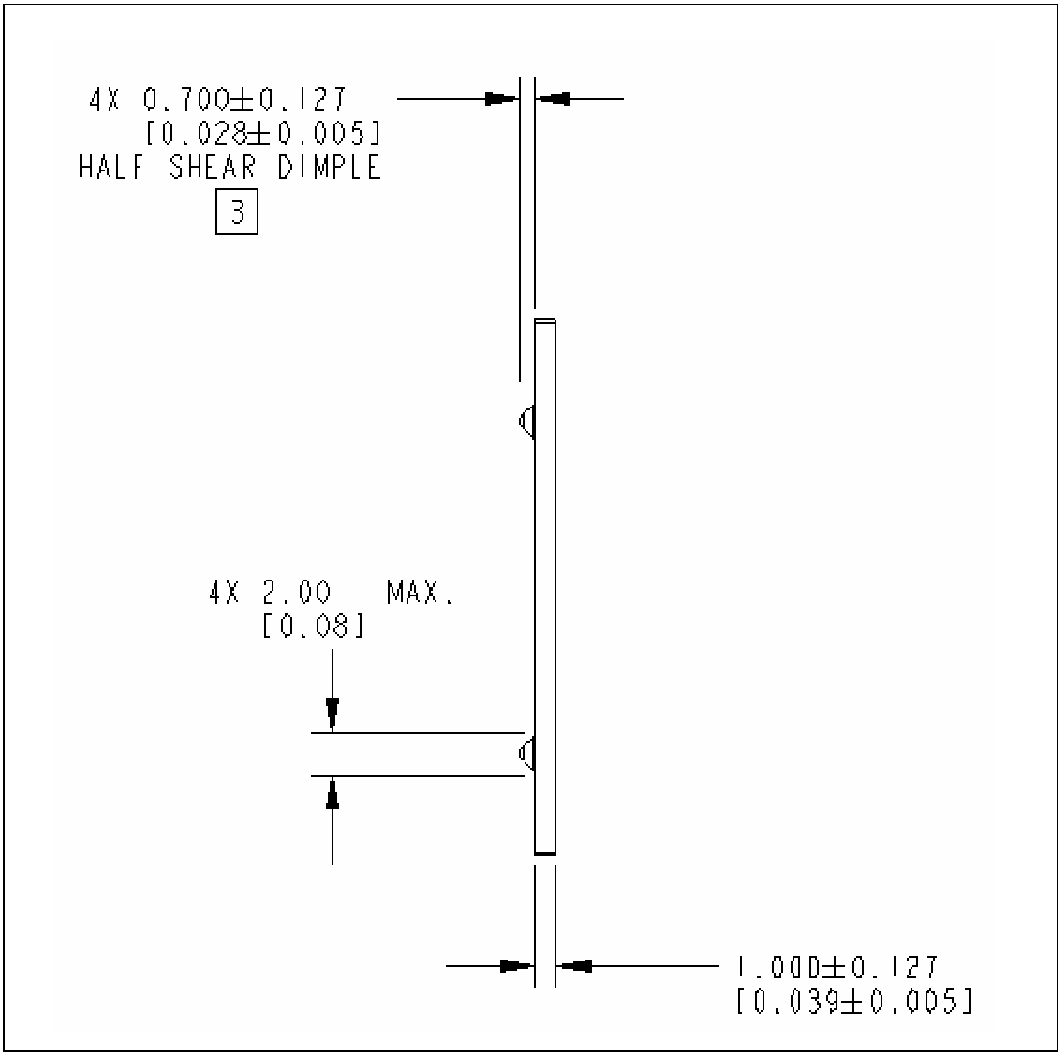
A TIM provides improved conductivity between the die and heatspreader. The reference thermal solution uses Honeywell PCM45F, 0.25 mm (0.010 in.) thick, 8 mm x 8 mm (0.315 in. x 0.315 in.) square.

Note: Unflowed or “dry” Honeywell PCM-45F* has a material thickness of 0.010 inch. The flowed or “wet” Honeywell PCM-45F has a material thickness of ~0.003 inch after it reaches its phase change temperature.

6.5.5 Heatspreader Clip

The reference solution uses a single wire clip which is latched through two non-grounded through holes on the DIMM. See Appendix B for a mechanical drawing of the clip.

Figure 6-4. Wire Clip Heatspreader Stamp Profile



6.5.6 Clip Retention Anchors

There are no motherboard clip retention anchors associated with this reference solution.

6.6 Reliability Guidelines

Each motherboard, heatspreader and attach combination may vary the mechanical loading of the component. Based on the end user environment, the user should define the appropriate reliability test criteria and carefully evaluate the completed assembly prior to use in high volume. Some general recommendations are shown in Table 6-1.

Table 6-1. Reliability Guidelines

Test (1)	Requirement	Pass/Fail Criteria (2)
Mechanical Shock	50 g, board level, 11 msec, 3 shocks/axis	Visual Check and Electrical Functional Test
Random Vibration	7.3 g, board level, 45 min/axis, 50 Hz to 2000 Hz	Visual Check and Electrical Functional Test
Temperature Life	85°C, 2000 hours total, checkpoints at 168, 500, 1000, and 2000 hours	Visual Check
Thermal Cycling	–5°C to +70°C, 500 cycles	Visual Check
Humidity	85% relative humidity, 55°C, 1000 hours	Visual Check

Notes:
1. It is recommended that the above tests be performed on a sample size of at least twelve assemblies from three lots of material.
2. Additional pass/fail criteria may be added at the discretion of the user.

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7 Reference Thermal Solution 2

Intel has developed three reference thermal solutions to meet the cooling need of the Intel 6400/6402 Advanced Memory Buffer under operating environments and specifications defined in this document. This chapter describes the overall requirements for the Intel 6400/6402 Advanced Memory Buffer only c-clip heatspreader reference thermal solution including critical-to-function dimensions, operating environment, and validation criteria.

This reference thermal solutions consists of the following:

- Front Plate (1pc).
- Back Plate (1pc).
- C-Clip (1pc).

This particular reference thermal solution is compatible with FB-DIMM rawcard configurations A/B/C/E/H.

7.1 Operating Environment

Since each Intel 5000P/5000V/5000X chipset-based platform's FB-DIMM subsystem thermal dissipation is based on the following variables:

- Number of memory channel utilized.
- Number of FB-DIMMs installed on each memory channel.
- Type of FB-DIMMs installed on each memory channel.
- Size of the FB-DIMMs installed on each memory channel.
- Memory refresh rate.
- Thermal solution on the FB-DIMM.

When this reference thermal solution is assembled on a raw card B (DRx8) configuration FB-DIMM, the *FB-DIMM System Thermal Calculator for the Intel® 5000P/5000V/5000X Chipset-Based Platforms* Tool can be used to determine if this reference thermal solution can deliver the thermal performance needed for your respective memory subsystem.

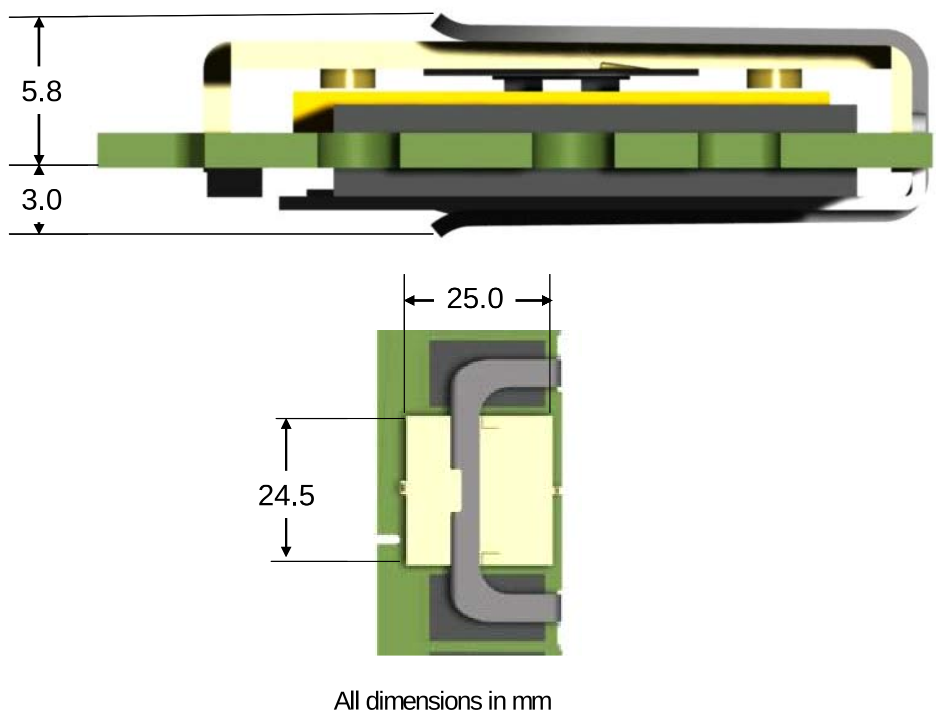
7.2 Heatspreader Performance

Please refer to Section 6.2 for details.

7.3 Mechanical Design Envelope

While each design may have unique mechanical volume and height restrictions or implementation requirements, the height, width, and depth constraints typically placed on the Intel 6400/6402 Advanced Memory Buffer thermal solution are shown in Figure 7-1.

Figure 7-1. C-Clip Heatspreader Volumetric Envelope for the Intel 6400/6402 Advanced Memory Buffer



7.4 Board-Level Components Keepout Dimensions

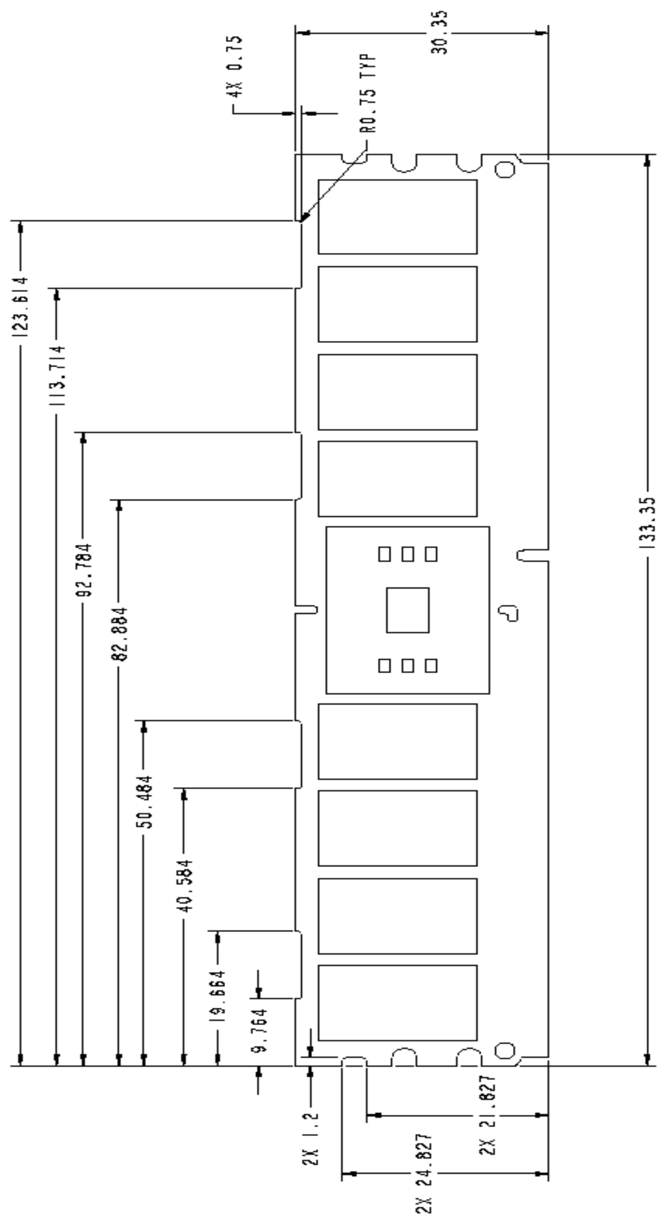
The location of hole patterns and keepout zones for the reference thermal solution are shown in Figure 7-2.

7.5 C-Clip Heatspreader Thermal Solution Assembly

The reference thermal solution for the chipset Intel 6400/6402 Advanced Memory Buffer is a passive stamped heatspreader with thermal interface. The c-clip is latched through two non-grounded notches on the DIMM. Figure 7-3 shows the reference thermal solution assembly and associated components.

Full mechanical drawings of the thermal solution assembly and the c-clip are provided in Appendix B. Appendix A contains vendor information for each thermal solution component.

Figure 7-2. C Clip Heatspreader Board Component Keepout

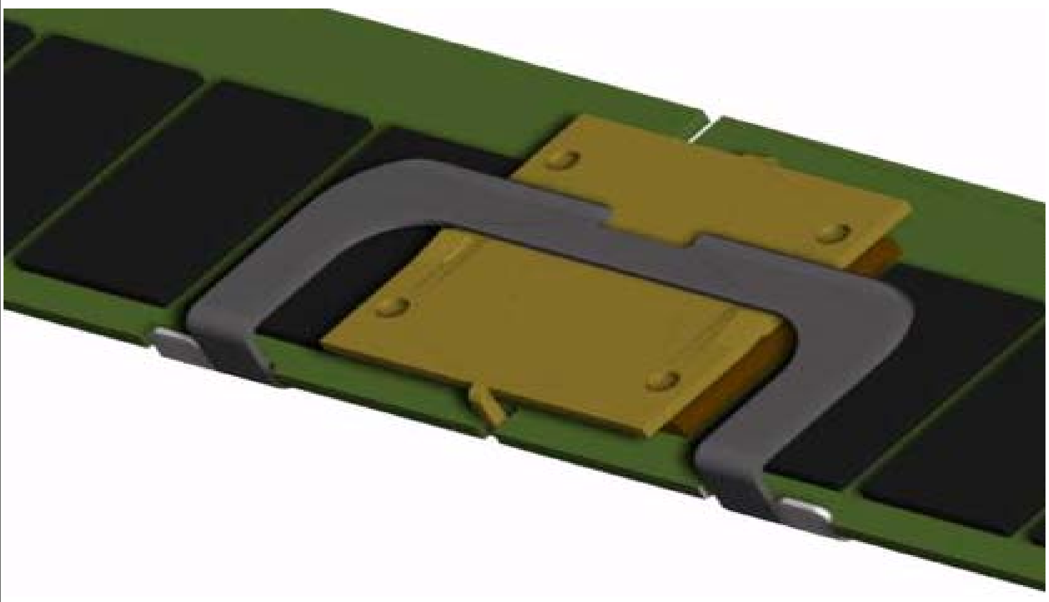


Note: All dimensions are in millimeters.

7.5.1 Heatspreader Orientation

This reference thermal solution should be aligned with the mounting holes on the FB-DIMM as defined in the JEDEC MO-256 Specification.

Figure 7-3. C Clip Heatspreader Assembly



7.5.2 Heatspreader Profiles

The reference c-clip heatspreader uses a stamped copper heatspreader for cooling the Intel 6400/6402 Advanced Memory Buffer. Figure 7-1 shows the spreader profile. Appendix A lists a supplier for this stamped heatspreader. Other heatspreaders with similar dimensions and increased thermal performance may be available. Currently available full mechanical drawing of this heatspreader is provided in Appendix B.

7.5.3 Mechanical Interface Material

There is no mechanical interface material associated with this reference solution.

7.5.4 Thermal Interface Material

A TIM provides improved conductivity between the die and heatspreader. The reference thermal solution uses Honeywell PCM45F, 0.25 mm (0.010 in.) thick, 15mm x 15mm (0.59 in. x 0.59in.) square.

Note: Unflowed or “dry” Honeywell PCM-45F* has a material thickness of 0.010 inch. The flowed or “wet” Honeywell PCM-45F has a material thickness of ~0.003 inch after it reaches its phase change temperature.

7.5.5 Heatspreader Clip

The reference solution uses a single c-clip which is latched through two non-grounded through notches on the DIMM. See Appendix B for a mechanical drawing of the clip.

7.5.6 Clip Retention Anchors

There are no motherboard clip retention anchors associated with this reference solution.

7.6 Reliability Guidelines

Please refer to Section 6.6 for details.

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8 Reference Thermal Solution 3

Intel has developed three reference thermal solutions to meet the cooling need of the Intel 6400/6402 Advanced Memory Buffer under operating environments and specifications defined in this document. This chapter describes the overall requirements for the full DIMM heatspreader reference thermal solution including critical-to-function dimensions, operating environment, and validation criteria.

This reference thermal solutions consists of the following:

- Front Plate Assembly (1 pc).
- Back Plate Assembly (1 pc).
- C-Clip (2 pc).

This particular reference thermal solution is compatible with FB-DIMM rawcard configurations A/B/C/E/H.

8.1 Operating Environment

Since each Intel 5000P/5000V/5000X chipset-based platform's FB-DIMM subsystem thermal dissipation is based on the following variables:

- Number of memory channel utilized.
- Number of FB-DIMMs installed on each memory channel.
- Type of FB-DIMMs installed on each memory channel.
- Size of the FB-DIMMs installed on each memory channel.
- Memory refresh rate.
- Thermal solution on the FB-DIMM.

When this reference thermal solution is assembled on a raw card B (DRx8) or E (DRx4) configuration FB-DIMM, the *FB-DIMM System Thermal Calculator for the Intel® 5000P/5000V/5000X Chipset-Based Platforms* Tool can be used to determine if this reference thermal solution can deliver the thermal performance needed for your respective memory subsystem.

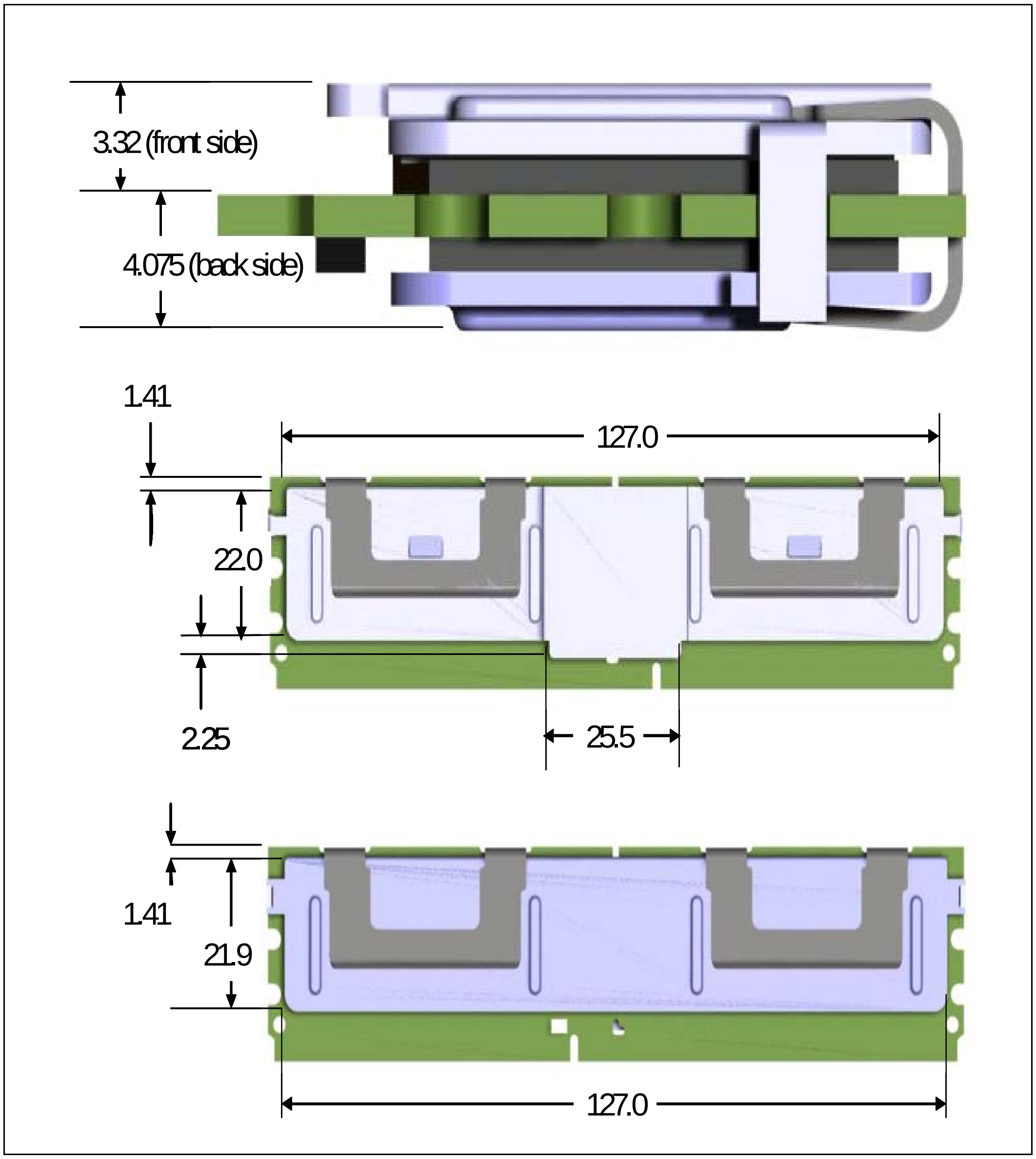
8.2 Heatspreader Performance

Please refer to Section 6.2 for details.

8.3 Mechanical Design Envelope

While each design may have unique mechanical volume and height restrictions or implementation requirements, the height, width, and depth constraints typically placed on the Intel 6400/6402 Advanced Memory Buffer thermal solution are shown in Figure 8-1.

Figure 8-1. 4 Piece Full DIMM Heatspreader Volumetric Envelope for the Intel 6400/6402 Advanced Memory Buffer



Note: All dimensions in mm.

8.4 Board-Level Components Keepout Dimensions

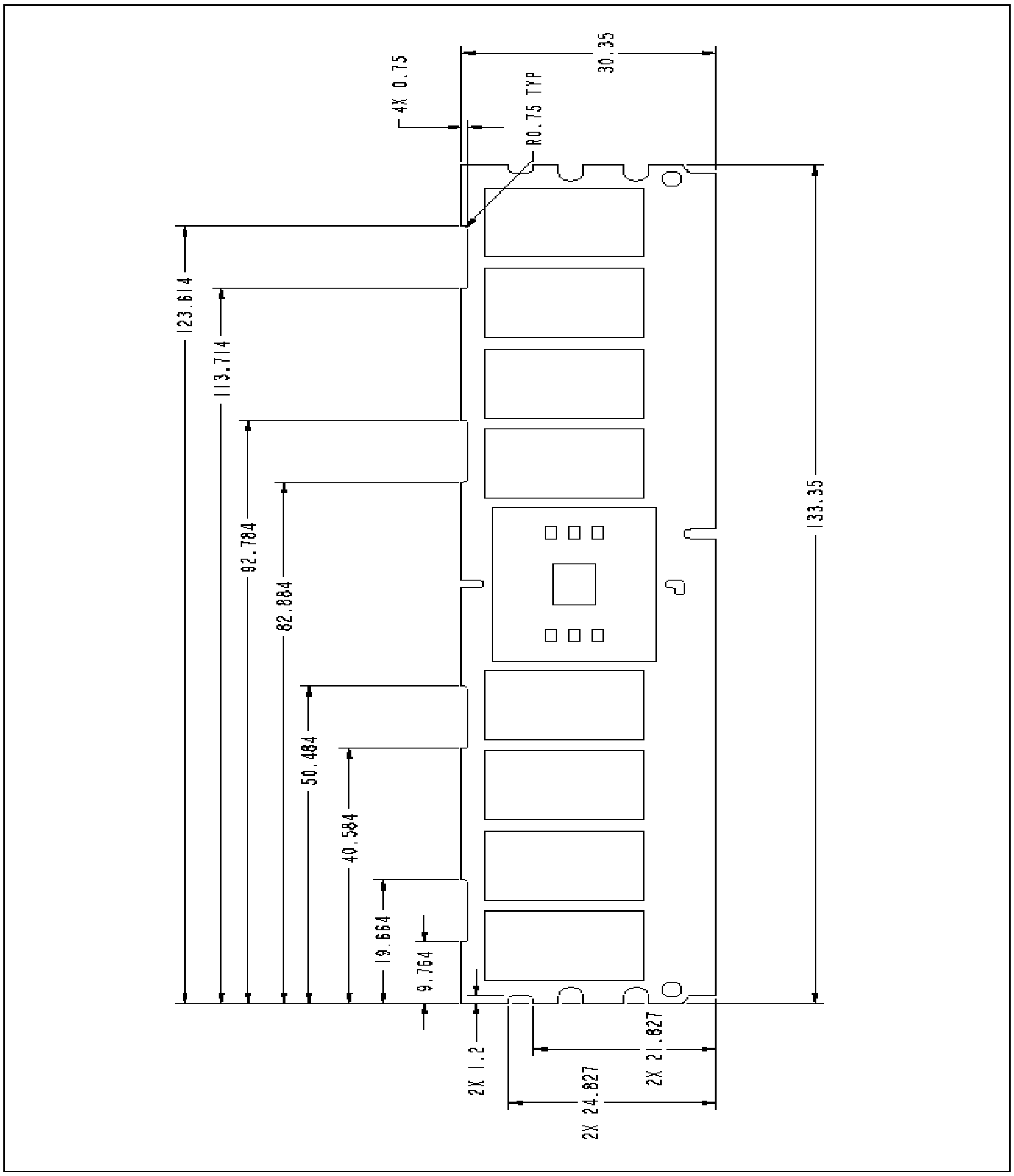
The location of hole patterns and keepout zones for the reference thermal solution are shown in Figure 8-2.

8.5 Full DIMM Heatspreader Thermal Solution Assembly

The reference thermal solution for the chipset Intel 6400/6402 Advanced Memory Buffer is a passive stamped heatspreader with thermal interface. The two c-clips are each latched through two non-grounded notches on the DIMM. Figure 8-3 shows the reference thermal solution assembly and associated components.

Full mechanical drawings of the thermal solution assembly and the strap clip are provided in Appendix B. Appendix A contains vendor information for each thermal solution component.

Figure 8-2. 4 Piece Full DIMM Heatspreader Board Component Keepout

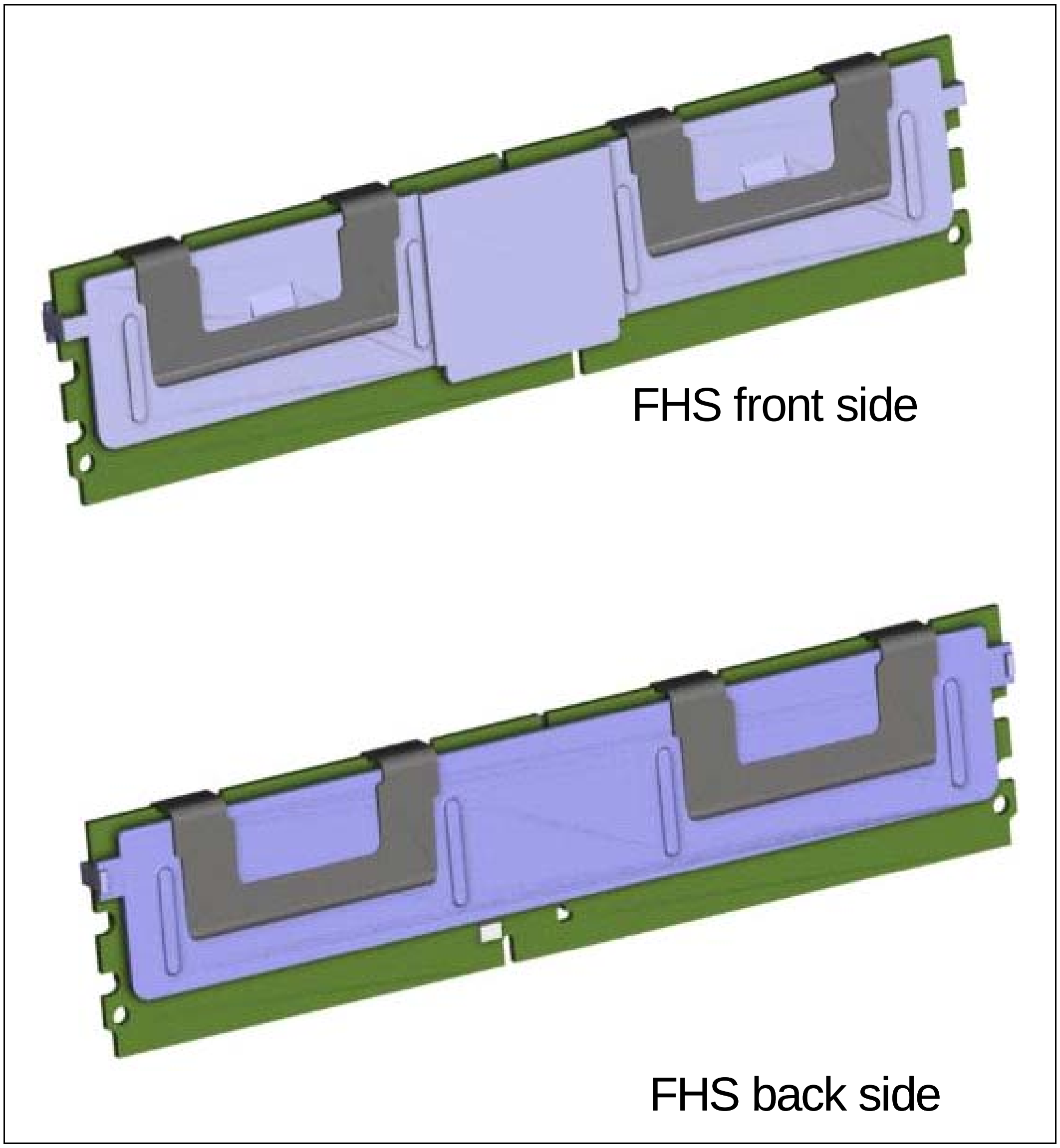


Note: All dimensions are in millimeters.

8.5.1 Heatspreader Orientation

This reference thermal solution should be aligned with the mounting holes on the FB-DIMM as defined in the JEDEC MO-256 Specification.

Figure 8-3. 4 Piece Full DIMM Heatspreader Assembly



8.5.2 Heatspreader Profiles

The reference full DIMM heatspreader uses a stamped full DIMM length aluminum heatspreader for cooling the Intel 6400/6402 Advanced Memory Buffer and the DRAMs. Figure 8-1 shows the spreader profile. Appendix A lists two suppliers for this stamped heatspreader. Other heatspreaders with similar dimensions and increased thermal performance may be available. Currently available full mechanical drawing of this heatspreader is provided in Appendix B.

8.5.3 Mechanical Interface Material

There is no mechanical interface material associated with this reference solution.

8.5.4 Thermal Interface Material

A TIM provides improved conductivity between the die and heatspreader. The reference thermal solution uses Honeywell PCM45F, 0.25 mm (0.010 in.) thick, 15mm x 15mm (0.59 in. x 0.59in.) square.

Note: Unflowed or "dry" Honeywell PCM-45F* has a material thickness of 0.010 inch. The flowed or "wet" Honeywell PCM-45F has a material thickness of ~0.003 inch after it reaches its phase change temperature.

8.5.5 Full DIMM Heatspreader Clip

The reference solution uses two c-clips (different from reference thermal solution from Chapter 7) which are latched through two non-grounded through notches on the DIMM. See Appendix B for a mechanical drawing of the clip.

8.5.6 Clip Retention Anchors

There are no motherboard clip retention anchors associated with this reference solution.

8.6 Reliability Guidelines

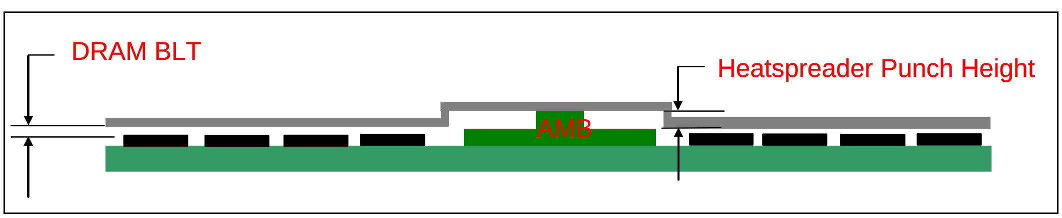
Please refer to Section 6.6 for details.

8.7 Heatspreader Punch Height Selection Procedure

This reference thermal solution comes in four different punch heights to accompany different height differences between the AMB and the DRAMs. Requirements to determine the correct heatspreader punch height are the following:

- Heatspreader should always be justified to the AMB such that a gap should always exist between the heatspreader and the DRAMs when the heatspreader bottoms out on the AMB. This gap will be taken up by the TIM.
- 0mm < DRAM BLT < 0.38mm (PCM45F TIM max thickness).

Figure 8-4. Heatsink Punch Height Representation

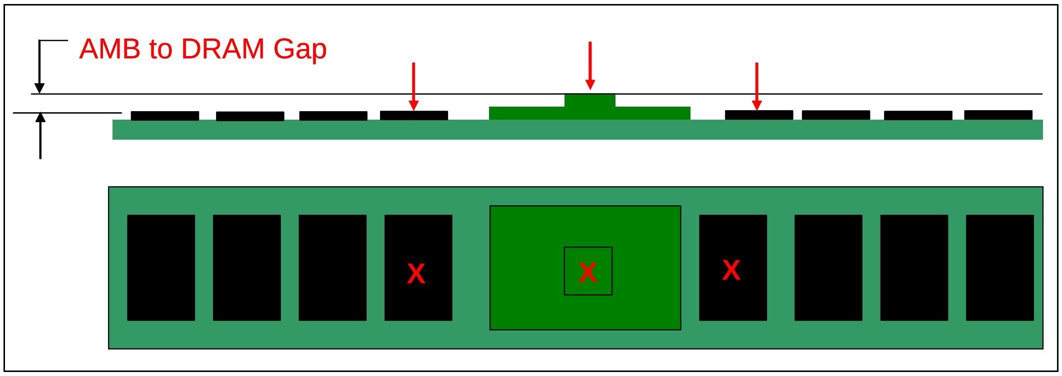


8.7.1 Steps to Determine Correct Punch Height

1. Collect AMB to DRAM height gap data from a minimum of five heatspreader manufacturing lots.

Note: Try to collect data from as many different lots and different runs as possible. Measure from the center of the AMB to the center of the nearest DRAMs. Use the smaller of the two gaps.

Figure 8-5. AMB to DRAM Gap Illustration



2. Determine following AMB to DRAM gap distances using the following formulas:
   — **Nominal AMB to DRAM Gap = Average (Max Measured AMB to DRAM Gap, Min Measured AMB to DRAM Gap**).
   — **AMB to DRAM Gap Tolerance = [(Max Measured AMB to DRAM Gap) - (Min Measured AMB to DRAM Gap)] / 2.**
3. Assume a given heatspreader punch height value.
4. Calculate both the minimum and maximum DRAM BLT using the following formulas:
   — Nominal DRAM BLT = (Heatspreader Nominal Punch Height) + (AMB TIM Nominal Height) - (Measured AMB to DRAM Nominal Gap).
   — 3 Sigma DRAM BLT = Root Sum Square of [(Heatspreader Punch Height Tolerance), (AMB TIM Height Tolerance), (Measured AMB to DRAM Height Tolerance)].
   — **Maximum DRAM BLT = (Nominal DRAM BLT) + (3 Sigma DRAM BLT**).
   — **Minimum DRAM BLT = (Nominal DRAM BLT) - (3 Sigma DRAM BLT**).
5. Iterate with a different heatspreader punch height value until the following conditions are met:
   — With heatspreader bottoms out on the AMB, minimum DRAM BLT > 0 mm at 3 sigma.
   — With heatspreader bottoms out on the AMB, maximum DRAM BLT < 0.38 mm at 3 sigma.

Example:

Heatspreader Nominal Punch Height: **1.13 mm** (per Appendix B).

Heatspreader Punch Height Tolerance: **0.12 mm** (per Appendix B).

AMB TIM Nominal Height: **0.075 mm** (Honeywell PCM45F reference value).

AMB TIM Height Tolerance: **0.05 mm** (Honeywell PCM45F reference value).

Maximum measured AMB to DRAM Gap: **1.07 mm** (example value per Figure 8-3).

Minimum measured AMB to DRAM Gap: **1.02 mm** (example value per Figure 8-3).

Figure 8-6. Sample AMB to DRAM Gap Data

	AMB-DRAM GAP lot 1	AMB-DRAM GAP lot 2	AMB-DRAM GAP lot 3	AMB-DRAM GAP lot 4
1	1.07	1.02	1.05	1.03
2	1.02	1.03	1.04	1.02
3	1.03	1.03	1.02	1.02
4	1.03	1.02	1.04	1.04
5	1.02	1.05	1.05	1.05
6	1.04	1.03	1.03	1.05
7	1.06	1.04	1.03	1.02
8	1.03	1.02	1.03	1.03
9	1.06	1.03	1.05	1.02
10	1.03	1.03	1.03	1.05
MAX	1.07	1.05	1.05	1.05
MIN	1.02	1.02	1.02	1.02

Nominal AMB to DRAM Gap = (1.07 mm + 1.02 mm)/2 = **1.045 mm.**

AMB to DRAM Gap Tolerance = (1.07 mm - 1.02 mm)/2 = **0.025 mm.**

Nominal DRAM BLT = 1.13mm + 0.075 mm - 1.045 mm = **0.16 mm.**

3 Sigma DRAM BLT = SQRT (0.12 mm^2 + 0.05 mm^2 + 0.025 mm^2) = **0.1324 mm.**

Maximum DRAM BLT = 0.16 mm + 0.1324 mm = **0.2924 mm.**

Minimum DRAM BLT = 0.16 mm - 0.1324 mm = **0.0276 mm.**

Conclusion: A heatspreader punch height of 1.13 mm is acceptable per success criteria in Section 8.7.

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A Thermal Solution Component Suppliers

A.1 Intel 6400/6402 AMB Only Wire Clip Heatspreader Thermal Solution

Table A-1. Wire Clip Heatspreader Thermal Solution Supplier

Part	Intel Part Number	Supplier (Part Number)	Contact Information
Heatspreader Assembly includes: • Stamped copper heatspreader • Thermal Interface Material • Strap Clip	C76512-001	Foxconn*	Julia Jiang (USA) 408-919-6178 Juliaj@foxconn.com
Copper Heatspreader (25.5 x 25 x 1 mm)	C76511-001	Foxconn	Julia Jiang (USA) 408-919-6178 Juliaj@foxconn.com
Thermal Interface (PCM45F)	C34795-001	Honeywell PCM45F	Scott Miller 509-252-2206 scott.miller4@honeywell.com
Heatspreader Attach Clip	C76509-001	Foxconn	Julia Jiang (USA) 408-919-6178 Juliaj@foxconn.com

Note: The enabled components may not be currently available from all suppliers. Contact the supplier directly to verify time of component availability.

A.2 Intel 6400/6402 AMB Only C-Clip Heatspreader Thermal Solution

Table A-2. Intel 6400/6402 Advanced Memory Buffer Only C-Clip Heatspreader Thermal Solution Supplier

Part	Intel Part Number	Supplier (Part Number)	Contact Information
Front Plate Assembly	D39182-001	PHI245C-10D2N	Julia Jiang (USA) 408-919-6178 Juliaj@foxconn.com
Back Plate Assembly	D39185-001	PHI515C-10D2N	Julia Jiang (USA) 408-919-6178 Juliaj@foxconn.com
Heatspreader Attach C-Clip Note: Need 1 per FB-DIMM	D39188-001	PHI430S-10D2C	Julia Jiang (USA) 408-919-6178 Juliaj@foxconn.com

Note: The enabled components may not be currently available from all suppliers. Contact the supplier directly to verify time of component availability.

A.3 Full DIMM Heatspreader Thermal Solution

Table A-3. Full DIMM Heatspreader Thermal Solution Suppliers

Part	Intel Part Number	Supplier (Part Number)	Contact Information
Front Plate Assembly • 0.96 mm Punch Depth • 1.02 mm Punch Depth • 1.08 mm Punch Depth • 1.13 mm Punch Depth Note: Punch Depth is the relative distance between top surface of the Intel 6400/6402 Advanced Memory Buffer and of the DRAM Note: Back Plate (D35171-001) and C-Clip (D35173-001) need to be purchased separately.	D35170-001 D35170-002 D35170-003 D35170-004	2ZR71-275 2ZR71-273 2ZR71-274 2ZR71-276	Foxconn Andrew LM Yang (APAC) andrew.LM.Yang@foxconn.com 886-2-2268-0970 x3348 Jack Chen (USA) jack.chen@foxconn.com 714-626-1233 Wanchi Chen (worldwide) wanchi.chen@foxconn.com
Back Plate Assembly	D35171-001	2ZR71-272	Foxconn Andrew LM Yang (APAC) andrew.LM.Yang@foxconn.com 886-2-2268-0970 x3348 Jack Chen (USA) jack.chen@foxconn.com 714-626-1233 Wanchi Chen (worldwide) wanchi.chen@foxconn.com
Heatspreader Attach C-Clip Note: Need 2per FB-DIMM	D35173-001	2ZR71-308	Foxconn Andrew LM Yang (APAC) andrew.LM.Yang@foxconn.com 886-2-2268-0970 x3348 Jack Chen (USA) jack.chen@foxconn.com 714-626-1233 Wanchi Chen (worldwide) wanchi.chen@foxconn.com
• 0.96 mm Punch Depth Complete Assembly* • 1.02 mm Punch Depth Complete Assembly* • 1.08 mm Punch Depth Complete Assembly* • 1.13 mm Punch Depth Complete Assembly* Note: Each complete assembly includes one front plate assembly (D35170-00x), one back plate assembly (D35171-001) and two c-clips (D35173-001)	N/A	S960200001 S960100001 S960300001 S960400001	AVC Jeff Brown (North America) jb@avcamerica.com 310-783-5442 Steve Huang (Taiwan, China) steve@avc.com.cn +886-930-875-986 +86-138-252-45215

Note: The enabled components may not be currently available from all suppliers. Contact the supplier directly to verify time of component availability.

§

B Mechanical Drawings

Table B-1 lists the mechanical drawings included in this appendix.

Table B-1. Mechanical Drawing List

Drawing Description	Figure Number
Intel 6400/6402 AMB Only "Wire Clip Heatspreader Assembly Drawing"	Figure B-1
Intel 6400/6402 AMB Only "Wire Clip Heatspreader Drawing"	Figure B-2
Intel 6400/6402 AMB Only "Wire Clip Drawing"	Figure B-3
Intel 6400/6402 AMB Only "C-Clip Heatspreader Drawing"	Figure B-4
Intel 6400/6402 AMB Only "C-Clip Back Plate Drawing"	Figure B-5
Intel 6400/6402 AMB Only "C-Clip Heatspreader Assembly Drawing"	Figure B-6
Intel 6400/6402 AMB Only "C-Clip Back Plate Assembly Drawing"	Figure B-7
Intel 6400/6402 AMB Only "C-Clip Drawing"	Figure B-8
"Full DIMM Front Heatspreader Drawing"	Figure B-9
"Full DIMM Back Heatspreader Drawing"	Figure B-10
"Full DIMM Heatspreader C-Clip Drawing"	Figure B-11
"Full DIMM Front Heatspreader Assembly Drawing"	Figure B-12
"Full DIMM Back Heatspreader Assembly Drawing"	Figure B-13
"Full DIMM Heatspreader Installation Drawing"	Figure B-14

Figure B-1. Wire Clip Heatspreader Assembly Drawing

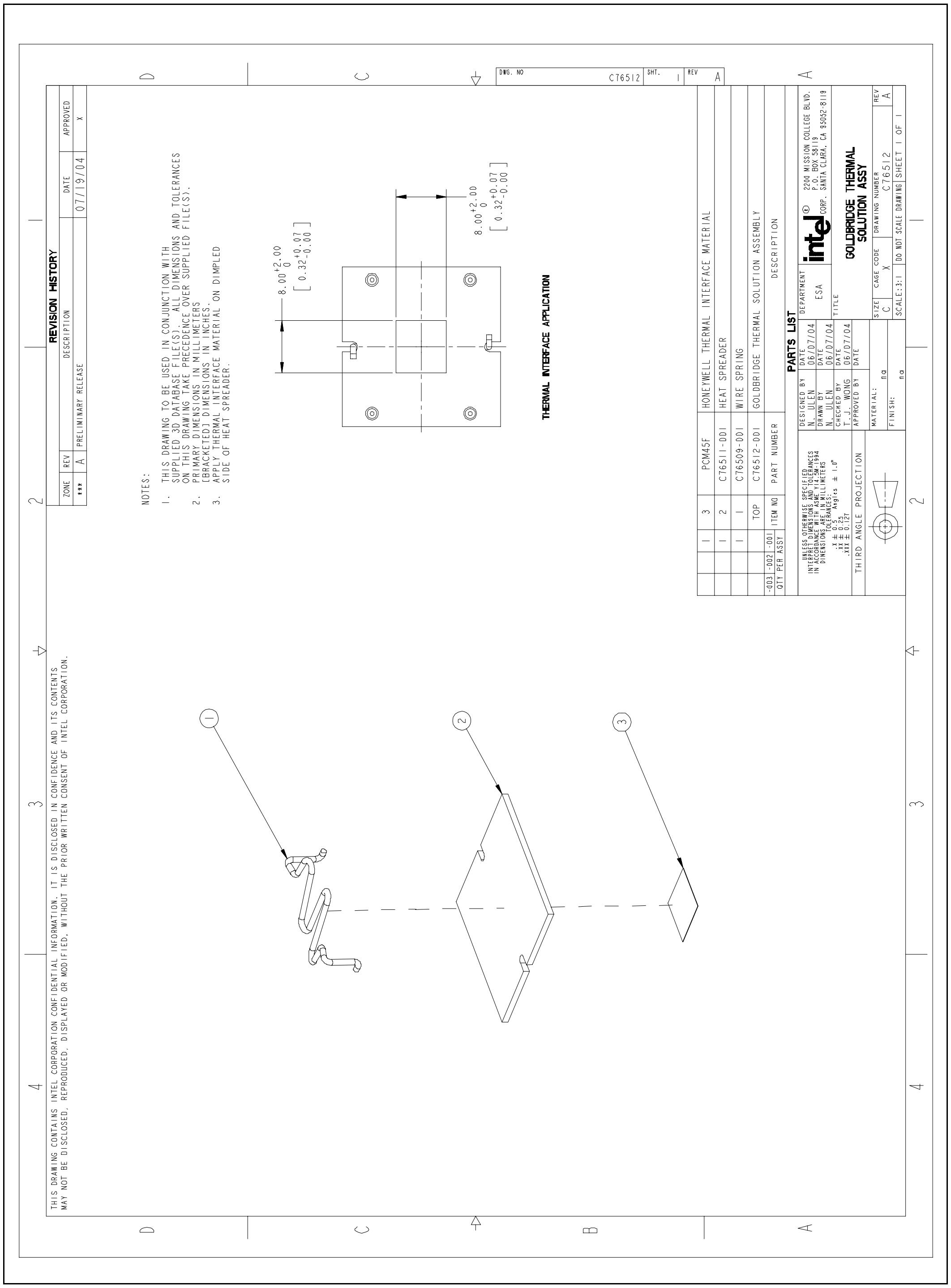


Figure B-2. Wire Clip Heatspreader Drawing

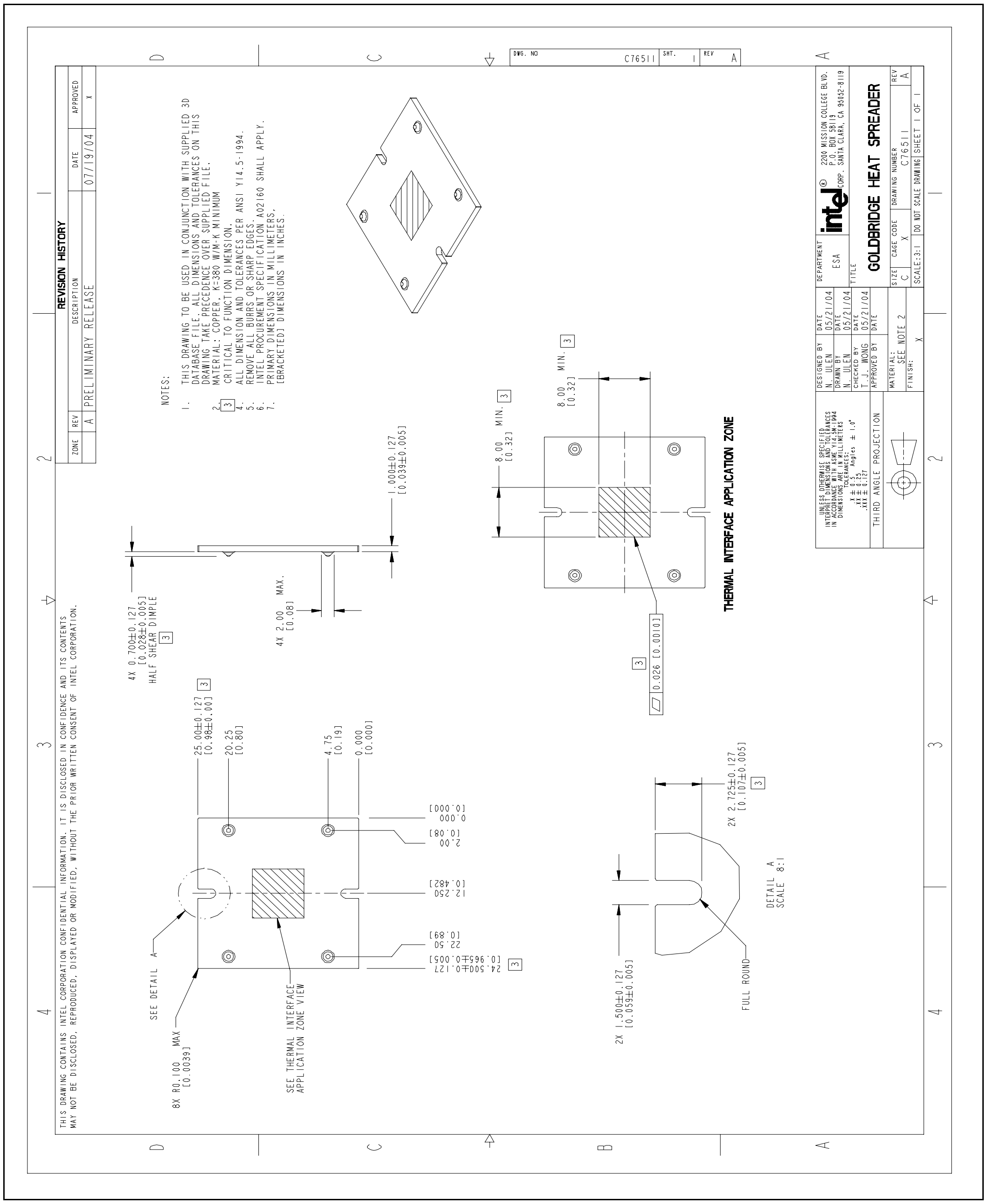


Figure B-3. Wire Clip Drawing

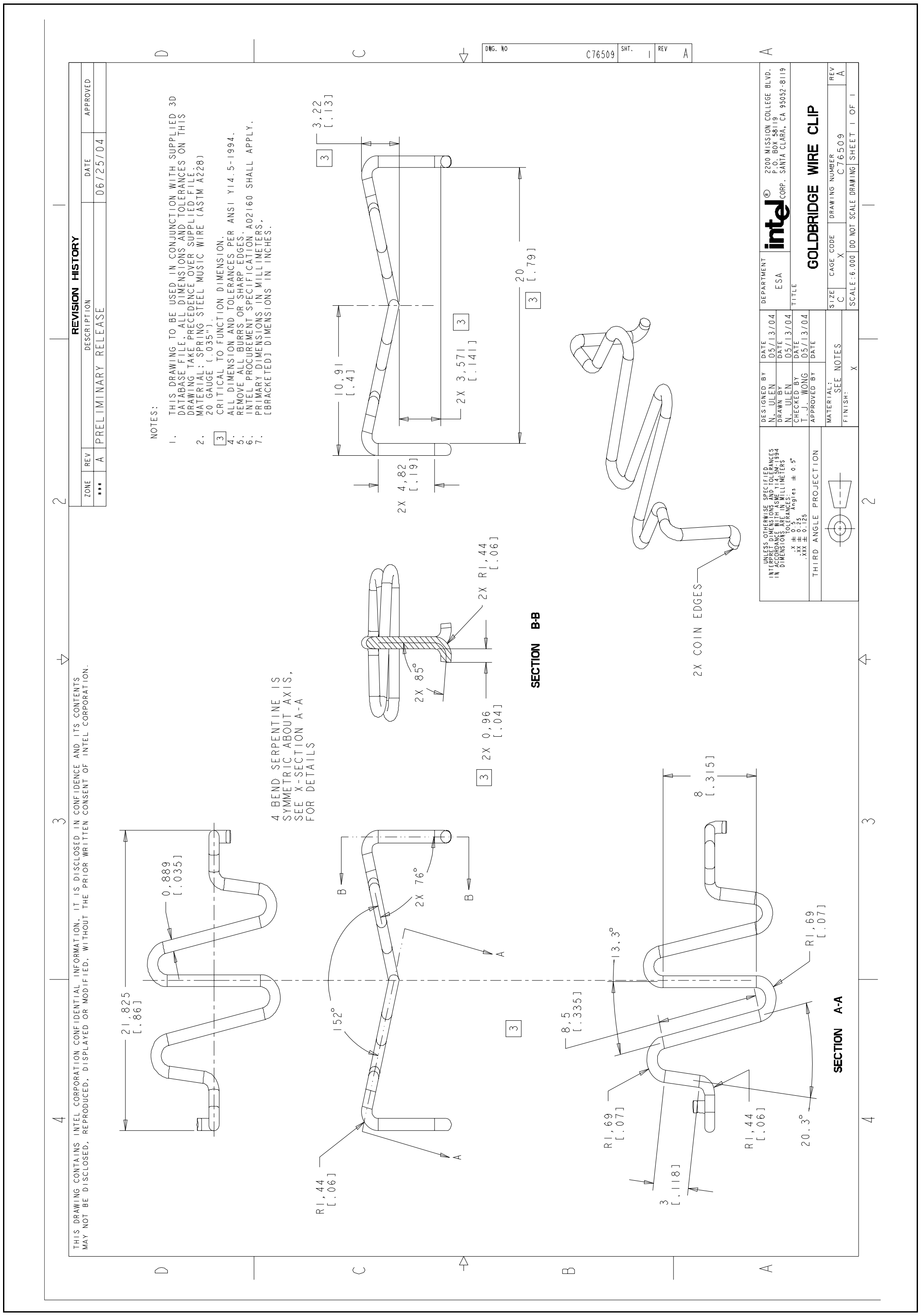


Figure B-4. C-Clip Heatspreader Drawing

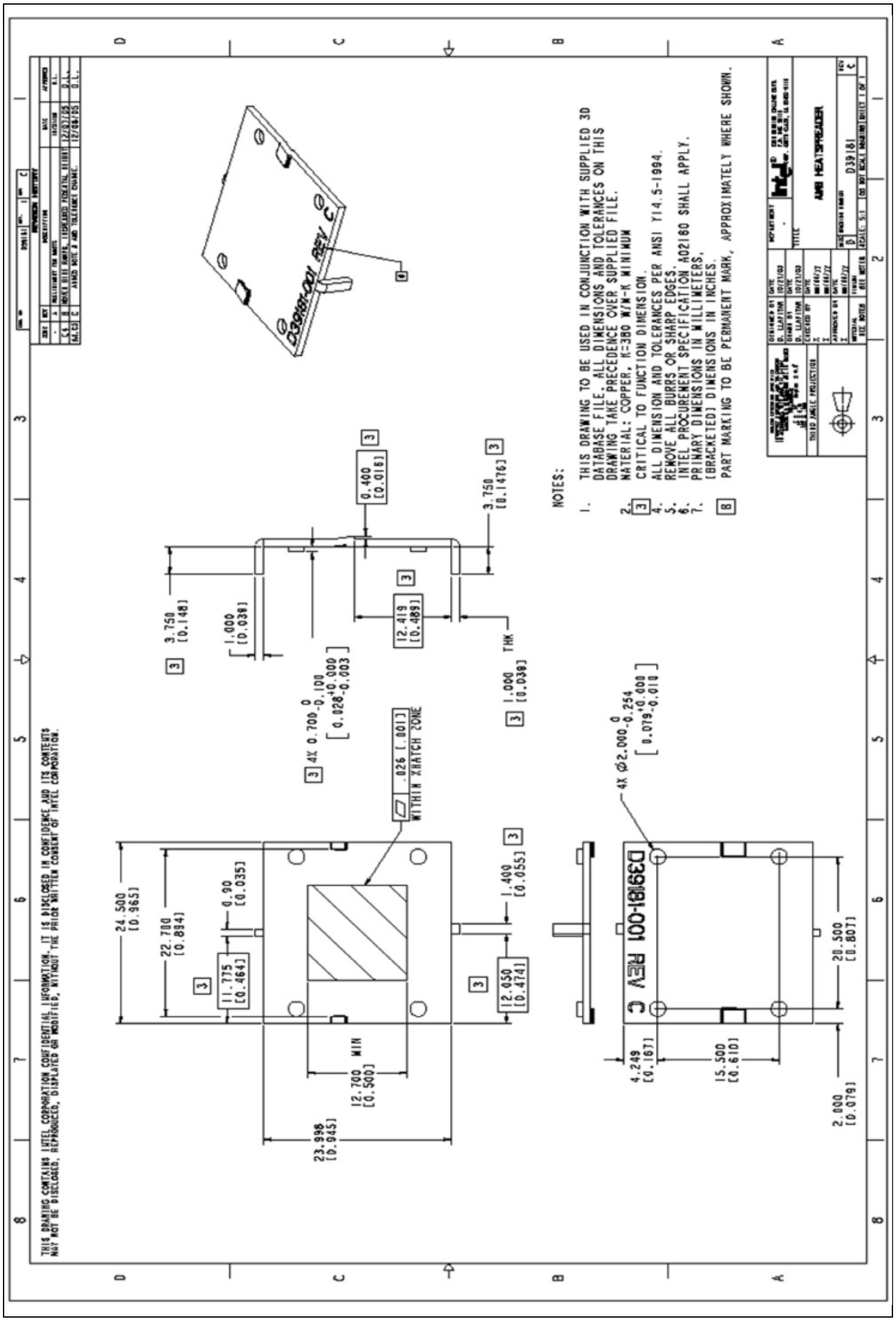


Figure B-5. C-Clip Back Plate Drawing

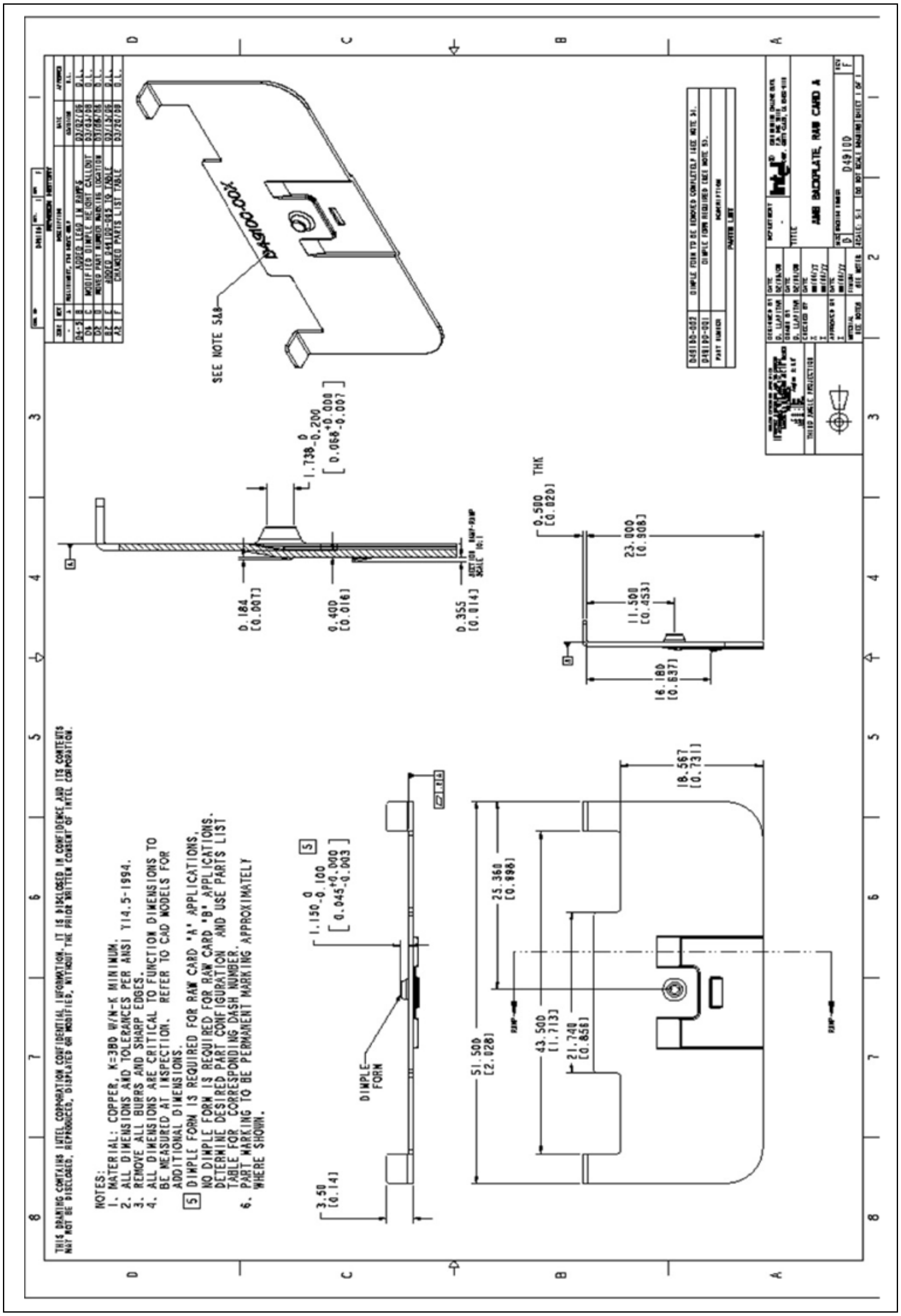


Figure B-6. C-Clip Heatspreader Assembly Drawing

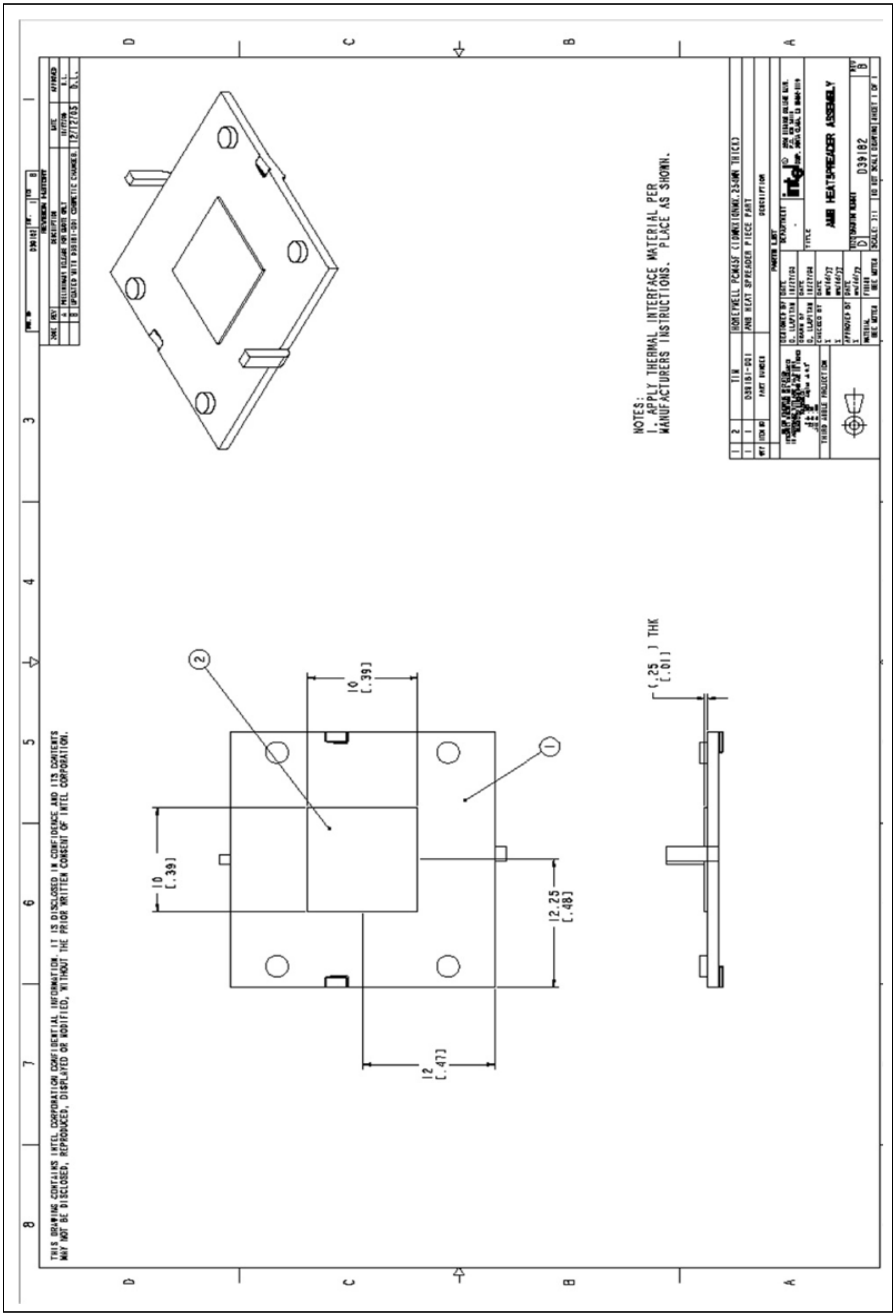


Figure B-7. C-Clip Back Plate Assembly Drawing

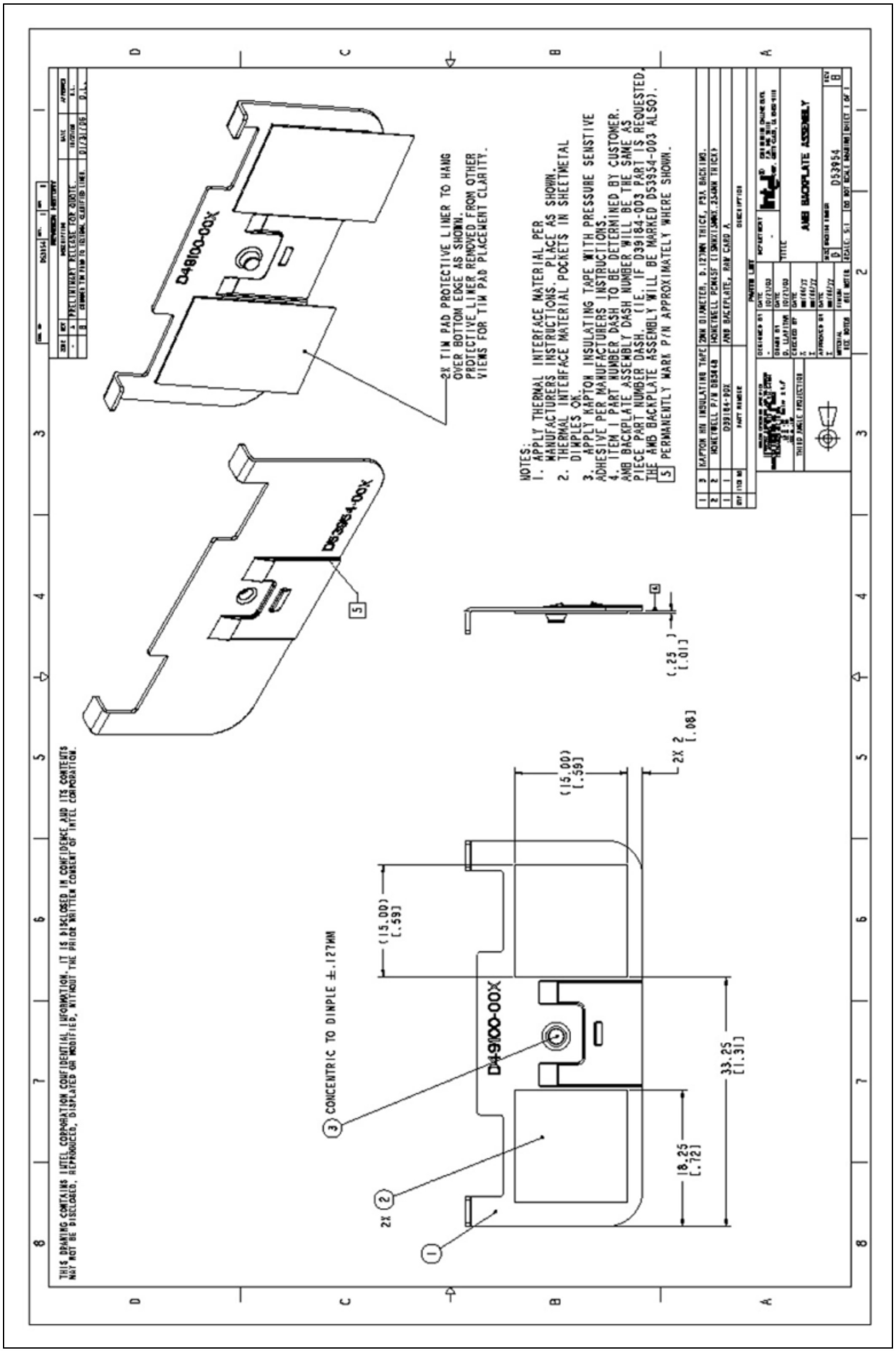


Figure B-8. C-Clip Drawing

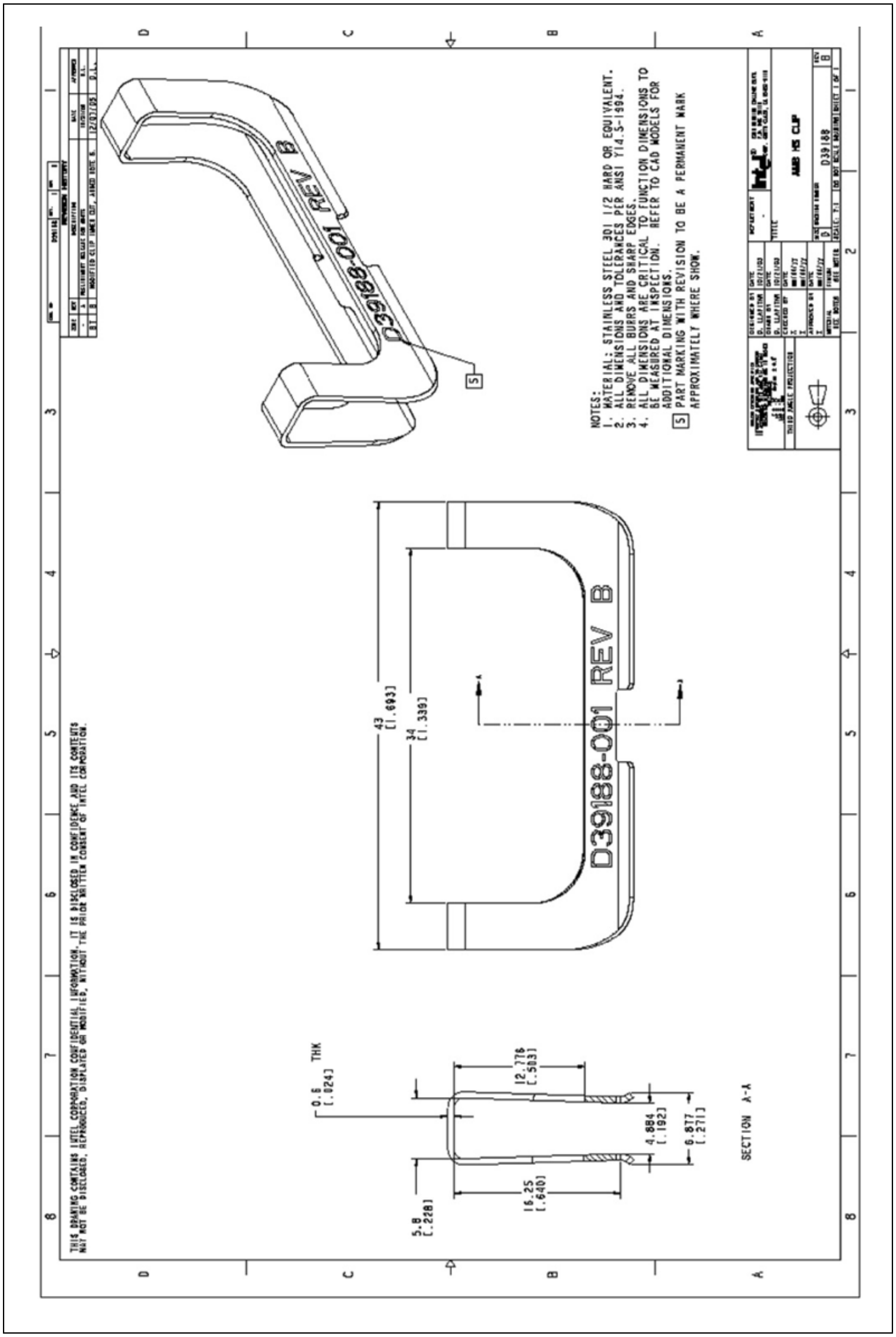


Figure B-9. Full DIMM Front Heatspreader Drawing

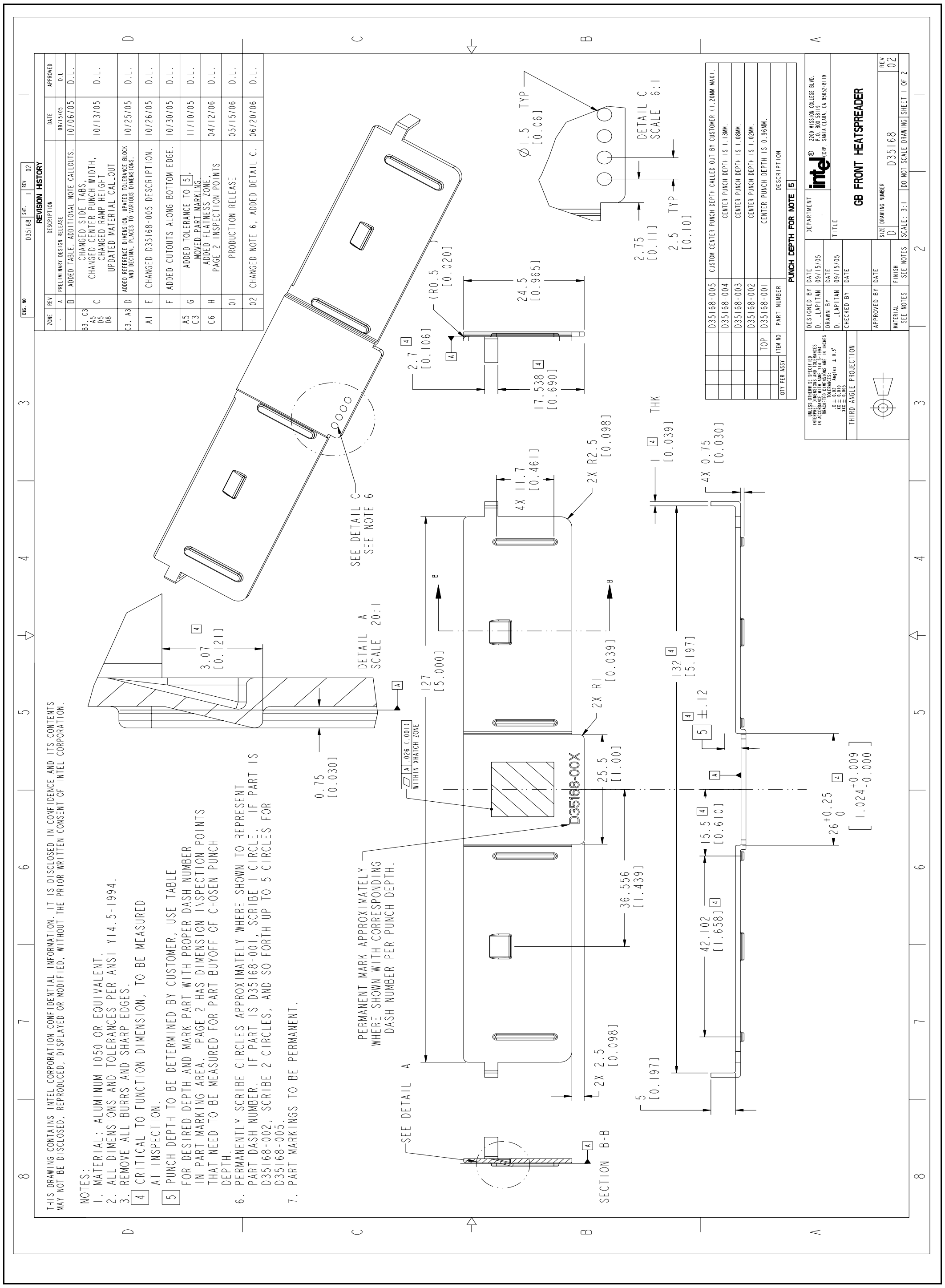


Figure B-10. Full DIMM Back Heatspreader Drawing

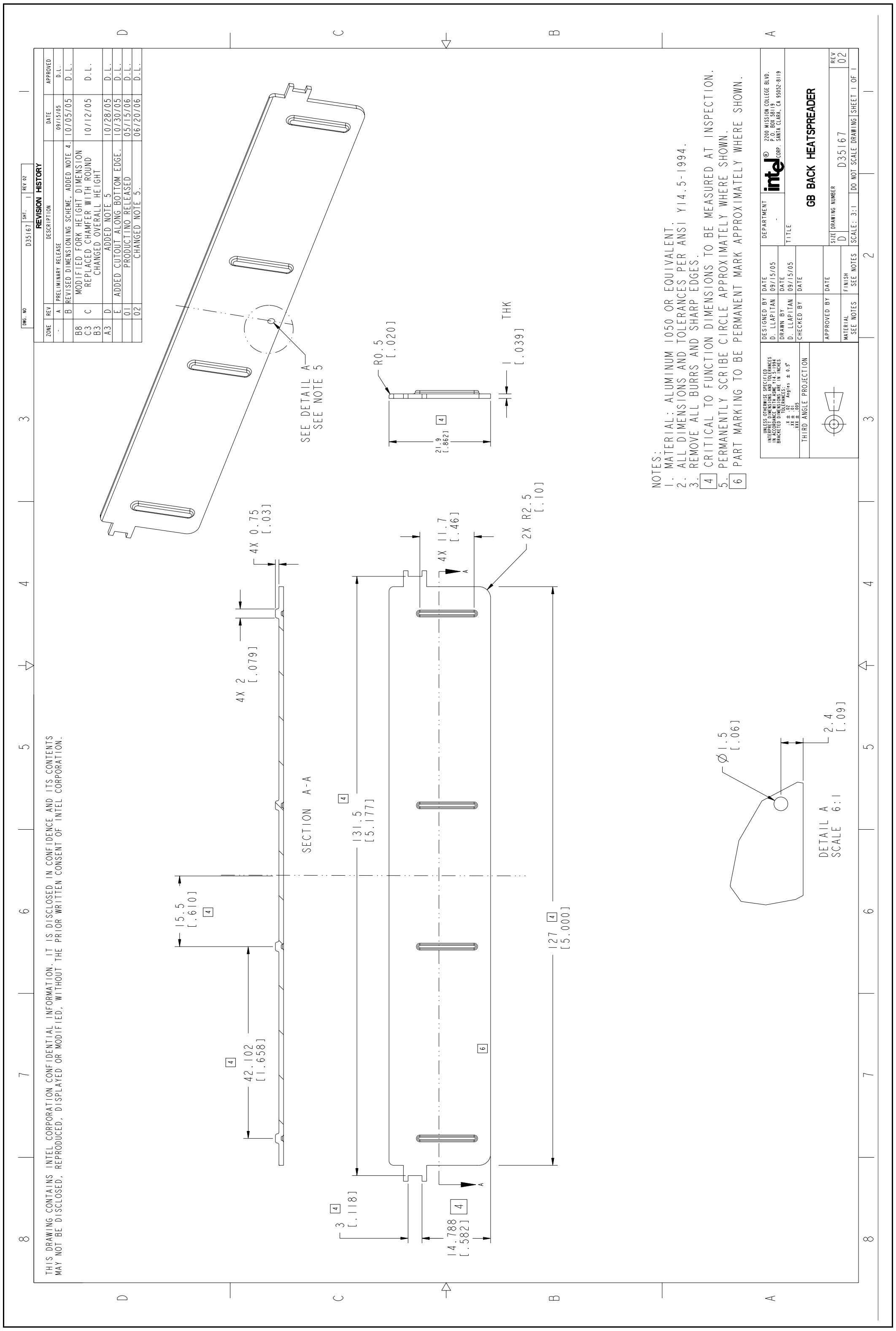


Figure B-11. Full DIMM Heatspreader C-Clip Drawing

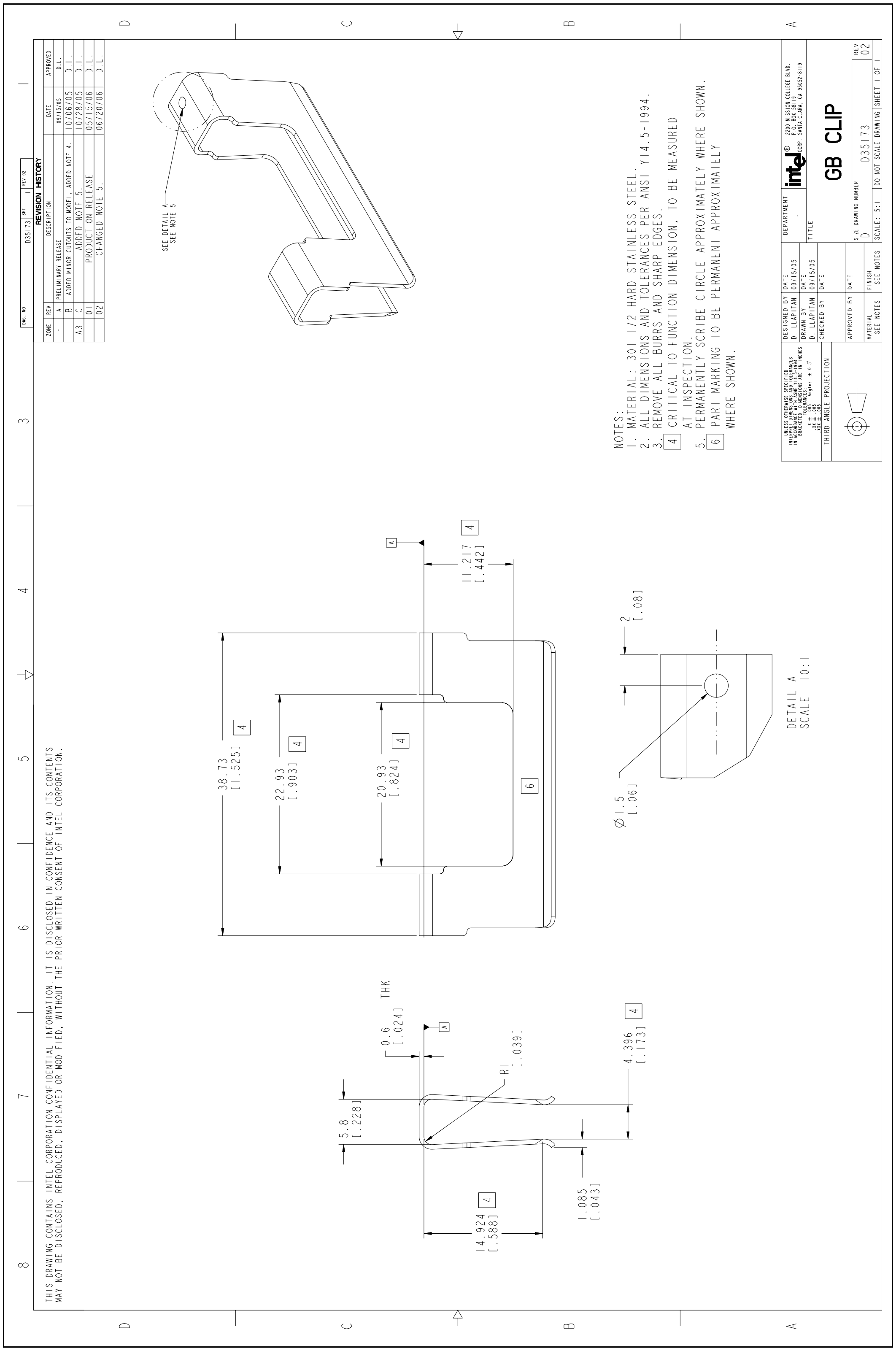


Figure B-12. Full DIMM Front Heatspreader Assembly Drawing

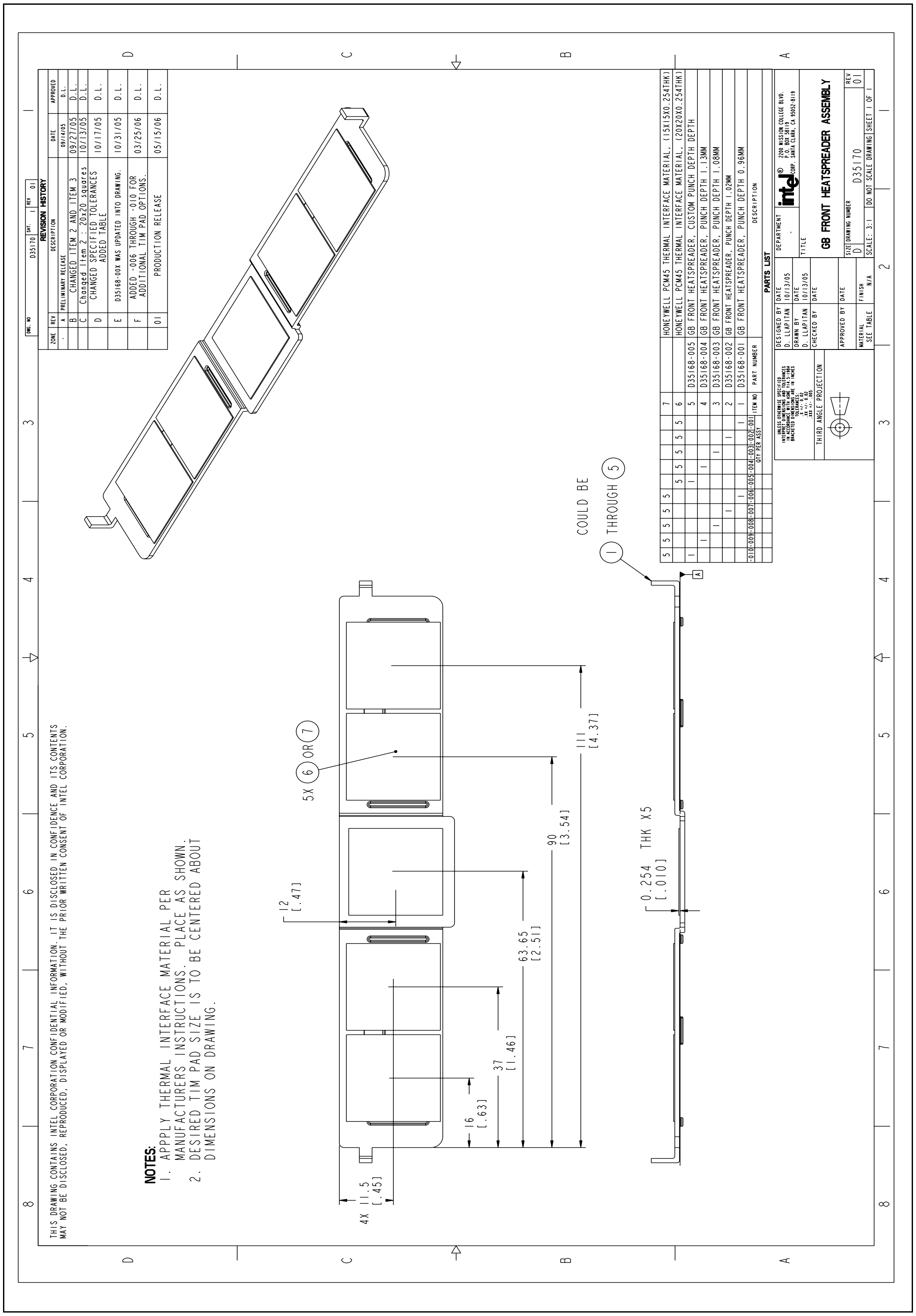


Figure B-13. Full DIMM Back Heatspreader Assembly Drawing

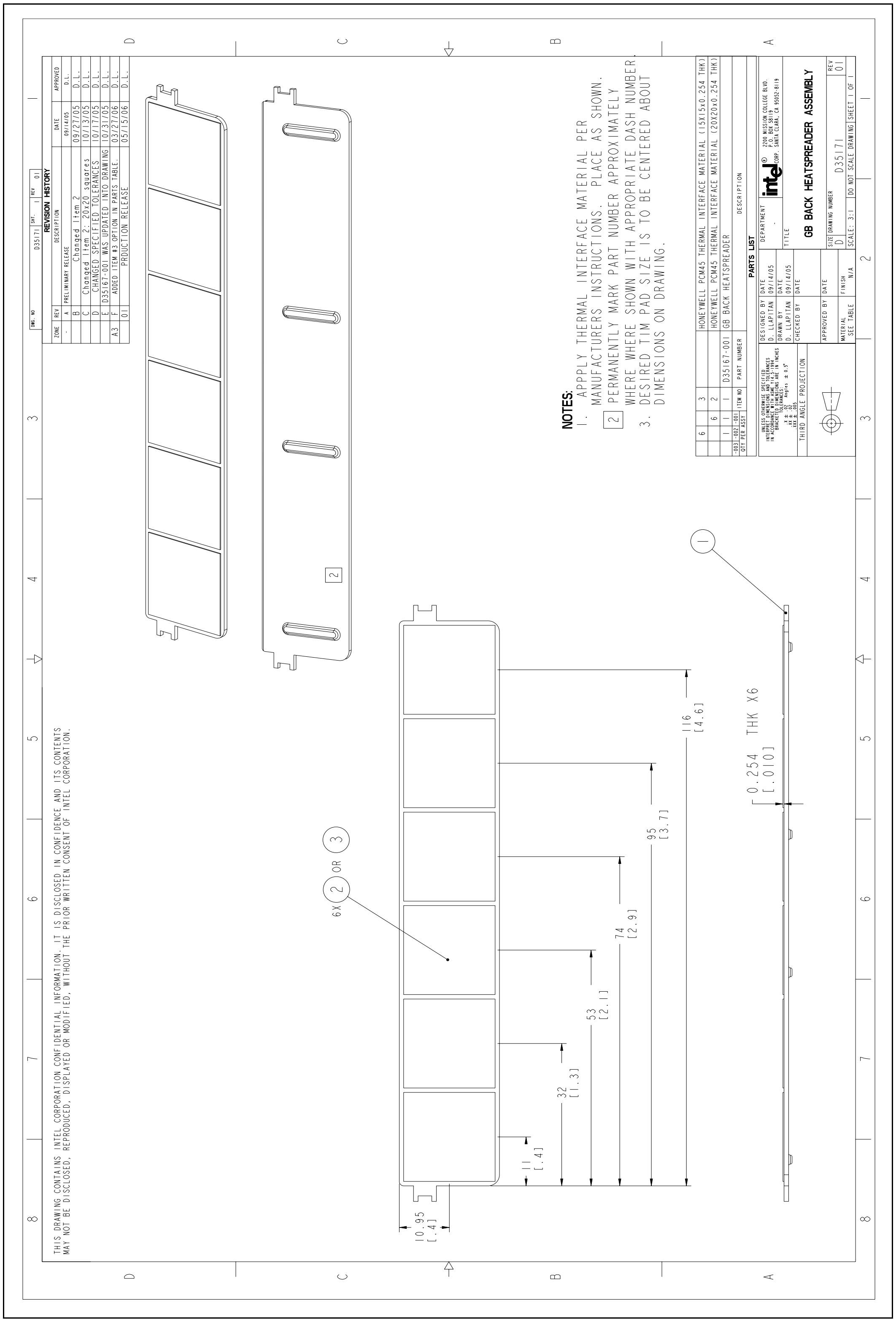
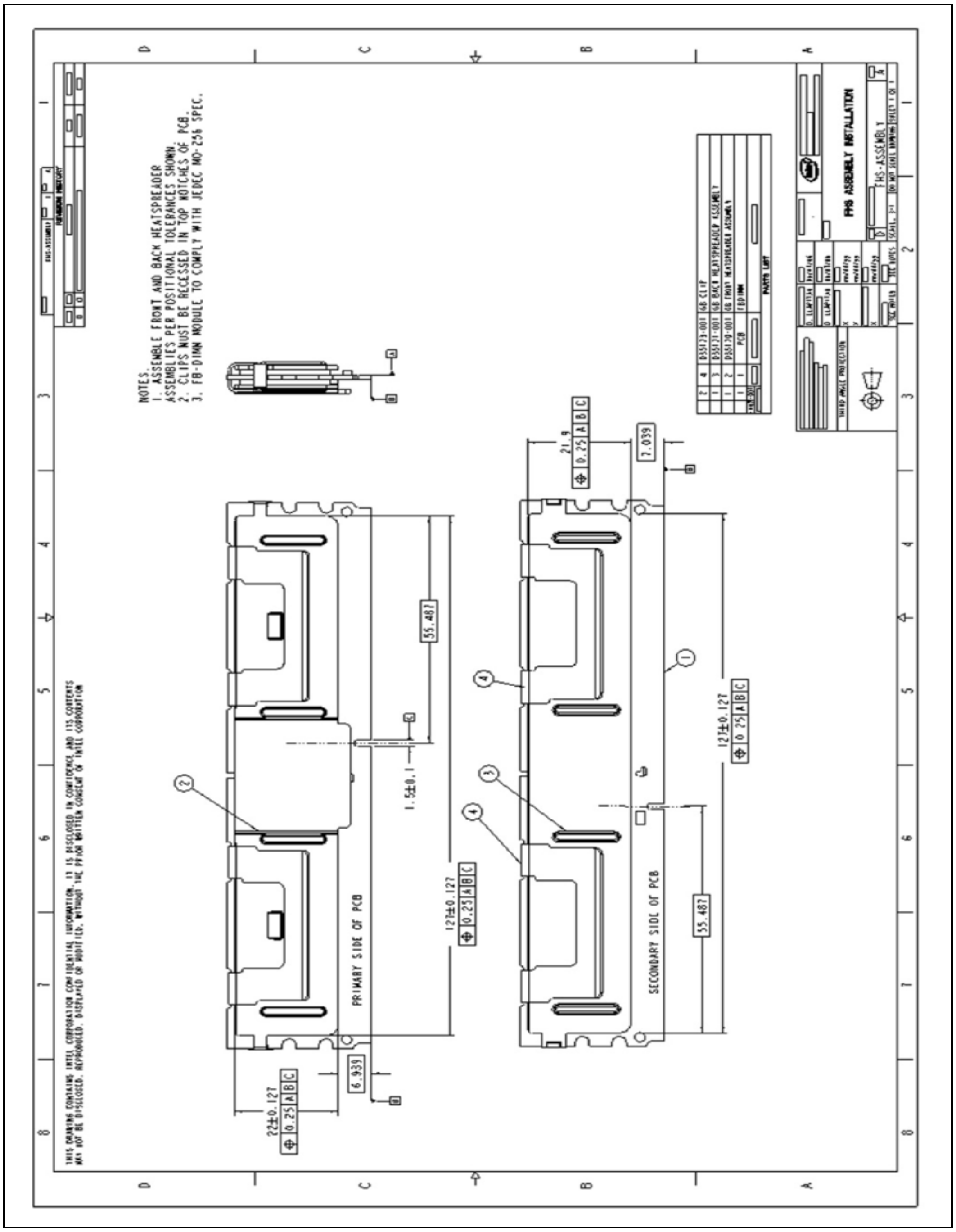


Figure B-14. Full DIMM Heatspreader Installation Drawing



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