Intel® I/O Controller Hub 6 (ICH6) Family

Thermal Design Guide

For the Intel® 82801FB ICH6 and 82801FR ICH6R I/O Controller Hubs

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Revision History

Rev. No.	Description	Date
-001	• Initial Release.	June 2004
-002	• Removed references to products no longer supported by Intel	January 2005

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1 Introduction

As the complexity of computer systems increases, so do power dissipation requirements. The additional power of next generation systems must be properly dissipated. Heat can be dissipated using improved system cooling, selective use of ducting, and/or passive heatsinks.

The objective of thermal management is to ensure that the temperature of all components in a system is maintained within functional limits. The functional temperature limit is the range within which the electrical circuits can be expected to meet specified performance requirements. Operation outside the functional limit can degrade system performance, cause logic errors, or cause component and/or system damage. Temperatures exceeding the maximum operating limits may result in irreversible changes in the operating characteristics of the component. The goal of this document is to provide an understanding of the operating limits of the Intel® ICH6 component.

The simplest and most cost-effective method is to improve the inherent system cooling characteristics of the ICH6 through careful 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 presents the conditions and requirements to properly design a cooling solution for systems that implement the ICH6 component. Properly designed solutions provide adequate cooling to maintain the Intel ICH6 component case temperature at or below thermal specifications. This is accomplished by providing a low local-ambient temperature, ensuring adequate local airflow, and minimizing the case to local-ambient thermal resistance. By maintaining the ICH6 component case temperature at or below maximum specifications, a system designer can ensure the proper functionality, performance, and reliability of this component.

Note: This document only applies to the desktop implementation of the ICH6 component. Unless otherwise specified the term ICH6 refers to the Intel® 82801FB ICH6 and 82801FR ICH6R I/O Controller Hubs.

1.1 Terminology

Term	Description
BGA	Ball Grid Array. A package type defined by a resin-fiber substrate where a die is mounted and bonded. The primary electrical interface is an array of solder balls attached to the substrate opposite the die and molding compound.
mBGA	Mini Ball Grid Array. A smaller version of the BGA with a ball pitch of 1.12 mm. Wirebonded package with die encased with a mold encapsulant.
T_C	The measured case temperature of a component. It is generally measured at the geometric center of the die or case, as specified in the component documentation.
$T_{C\text{-}MAX}$	The maximum case/die temperature.

Term	Description
$T_{C\text{-}MIN}$	The minimum case/die temperature.
TDP	Thermal Design Power is specified as the highest sustainable power level of most or all of the real applications expected to be run on the given product, based on extrapolations in both hardware and software technology over the life of the component. Thermal solutions should be designed to dissipate this target power level.
TIM	Thermal Interface Material: thermally conductive material installed between two surfaces to improve heat transfer and reduce interface contact resistance.
LFM	Linear Feet per Minute. Units of airflow velocity.
PTC	Package Thermal Capability. The power level at which at or below its value, the component does not require a heatsink

1.2 Reference Documents

Document	Document LInk
Intel® I/O Controller Hub 6 (ICH6) Family Datasheet	http://developer.intel.com/design/chipsets/datashts/301473.htm
Intel® Pentium® 4 Processor 560, 550, 540, 530 and 520[4] on 90 nm Process in the 775-Land LGA Package Datasheet	http://developer.intel.com//design/Pentium4/datashts/302351.htm
Intel® Pentium® 4 Processor 560, 550, 540, 530 and, and 520[4] on 90 nm Process in the 775-Land LGA Package Thermal Design Guidelines	http://developer.intel.com/design/Pentium4/guides/302553.htm
Various System Thermal Design Suggestions	http://www.formfactors.org

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2 Product Specifications

2.1 Package Description

The ICH6 component is available in a 609 ball, 31mm square mBGA package shown in Figure 6-1 (Appendix A).

2.2 Thermal Specifications

To ensure proper operation and reliability of the ICH6 component, the case temperature T_C must be at or below the maximum value $T_{C\text{-}MAX}$ specified in Table 2-1. If the temperature of the component exceeds the maximum temperature listed, system or component level thermal enhancements are required to dissipate the heat generated. The system designer must design a thermal solution for the ICH6such that it maintains T_C below $T_{C\text{-}MAX}$ for sustained power level equal to TDP. Chapter 3 provides the thermal metrology guidelines for case temperature measurements.

Chapter 4 provides information on the reference cooling solution.

The component should be operated above the minimum case temperature specification listed in Table 2-1.

Table 2-1 Intel® ICH6 Component Case Temperature Specifications

Parameter	Value
$T_{C\text{-}MAX}$ (Note 1 below)	No Heatsink Attached: 108 °C
	Heatsink Attached: 95 °C
$T_{C\text{-}MIN}$	0 °C
Storage Temperature	-10 °C to +45 °C

NOTES:

1. Without a heatsink, most of the heat dissipated by ICH6 goes through the PCB, acting as a heat spreader, and then into the ambient air. When a heatsink is installed on the package, more power is now being pulled through the case. As a result, the maximum case temperature must be maintained at lower level than without a heatsink to maintain the junction within specification.

2.3 Power Specifications

The ICH6 is estimated to dissipate the Thermal Design Power (TDP) value provided in Table 2-2. The TDP value is estimated based on various factors including: system configuration, industry stress applications, die temperature, and part-to-part variance. Based on Intel's reference boundary conditions of 60 °C inlet ambient temperature and 0.25 m/s [50 lfm] of airflow, the ICH6 package will not require a heatsink when power dissipation is at or below 2.9 W. This value is referred to as the Package Thermal Capability, or PTC. Note that the heatsink requirement power level will also change depending on system local operating ambient conditions as well as system configuration. For example, high power PCI Express* graphic cards may alter the local ambient temperature as well as airflow patterns in the vicinity of the chipset. Systems that have interface utilization less than that of the TDP configuration may be at power levels that may not require a heatsink. Complete your own power analysis if your system configuration varies from the ones listed below.

In conclusion, thermal validation should be performed in your anticipated system environment; in particular, measuring the ICH6 case temperature to ensure it meets its maximum case temperature specification. To evaluate the capability of your system for cooling the ICH6, the following system level tests are suggested to assess ICH6 case temperature compliancy:

- Shipping configuration(s) with expected end user add-in cards and I/O peripherals installed.
- All available slots on the board populated (only worst case if all I/O is fully populated including SATA, USB, etc.).

For completeness, both room ambient conditions (approximately 23 °C, to simulate impact of fan speed control) and worse case maximum external temperature (35 °C) conditions should be considered in the validation test suite. If the ICH6 case temperature is above the published Tcase-max, a heatsink is required.

If it is determined that the ICH6 package requires a heatsink in the system configuration, refer to Appendix A: Enabled Suppliers for the reference ICH6 heatsink vendor information.

Table 2-2. Intel® ICH6 Thermal Design Power Guidelines

Configuration	Devices(s)				
	USB (HS/FS)[1]	PCI Express*	SATA	PATA	PCI
TDP : 3.8W	6/2	4	3	Yes[2]	Yes

NOTES:
1. USB HS = USB 2.0 High Speed Device (480 Mb/s), USB FS = USB 2.0 Full Speed Device (12 Mb/s)
2. 'Yes' indicates a device is present

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3 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 of measuring chipset component case temperatures.

3.1 Case Temperature Measurements

To ensure functionality and reliability, the chipset component is specified for proper operation when T_C is maintained at or below the maximum temperature listed in Table 2-1. The surface temperature at the geometric center of the mold encapsulant corresponds to T_C. Measuring T_C requires special care to ensure an accurate temperature measurement.

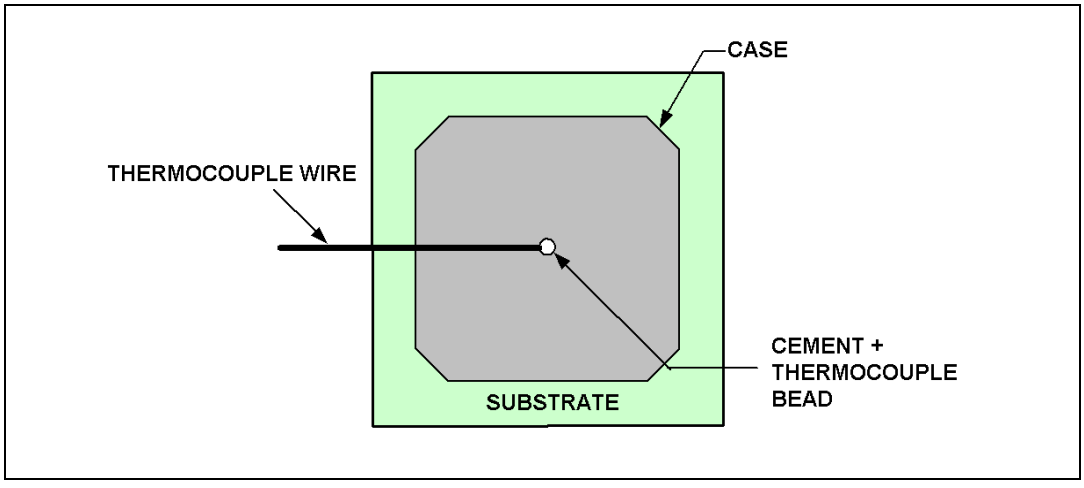
When no heatsink is attached to the ICH6, temperature differences between the temperature of a surface and the surrounding local ambient air can introduce error in the measurements. The measurement errors could be due to a poor thermal contact between the thermocouple junction and the surface of the package, heat loss by radiation and/or convection, and/or conduction through thermocouple leads. To minimize these measurement errors, the approach described in Section 0 is recommended for thermocouple attach.

This method will be updated for situations where a heatsink is attached to the ICH6.

0° Angle Attach Methodology

Attach a 36 gauge or smaller calibrated K-type thermocouple bead or junction to the center of the top surface of the case using a high thermal conductivity cement. **It is critical that the thermocouple bead makes contact with the case** (see Figure 3-1).

Figure 3-1. 0° Angle Attach Methodology (top view, not to scale)



Mechanical Test Vehicle

A Mechanical Test Vehicle (MTV) is available for early thermal testing prior to the availability of actual silicon. Please contact your Intel Field Sales Representative for more information on the Intel® ICH6 MTV.

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4 Reference Thermal Solution

The reference solution assumes a component local operating environment with a maximum local-ambient temperature of 60 °C and airflow of 0.25 m/s [50 lfm]. In these conditions, with the TDP projection given in Table 2-2, the ICH6 component requires an attached heatsink to meet thermal specifications. The local-ambient conditions are based on a 35 °C external-ambient temperature at sea level, where external-ambient refers to the environment external to the system. Refer to Appendix A: Enabled Suppliers for enabled suppliers for the ICH6 reference thermal solution, and Appendix B: Mechanical Drawings for reference thermal solution mechanical drawings. Refer to Figure 6-2 for reference ATX/µATX motherboard keep-out information. Heatsink can be tape-attached, or attached with a Z-clip. This motherboard keep-out allows a Z-clip heatsink attach.

4.1 Environmental Reliability Requirements

If an attached heatsink is implemented due to a severe component local operating environment, the reliability requirements in Table 4-1 are recommended. Each motherboard, heatsink, and attach combination may vary the mechanical loading of the component. Validation test plans should be defined by the user based on anticipated use conditions and resulting reliability requirements.

Table 4-1 Reference Thermal Solution Environmental Reliability Requirements

Test[1]	Requirement	Pass/Fail Criteria[2]
Mechanical Shock	• 3 drops for + and - directions in each of 3 perpendicular axes (i.e., total 18 drops). • Profile: 50 G trapezoidal waveform, 11 ms duration, 170 inches/sec minimum velocity change. • Setup: Mount sample board on test fixture.	Visual/Electrical Check
Random Vibration	• Duration: 10 min/axis, 3 axes • Frequency Range: 5 Hz to 500 Hz • Power Spectral Density (PSD) Profile: 3.13 g RMS	Visual/Electrical Check
Thermal Cycling	• -40 °C to +85 °C, 1000 cycles	Visual Check
Temperature Life	• 85 °C, 1000 hours total	Visual/Electrical Check
Unbiased Humidity	• 85 % relative humidity / 55 °C, 1000 hours	Visual Check

NOTES:
1. The above tests should be performed on a sample size of at least 12 assemblies from 3 different lots of material.
2. Additional Pass/Fail Criteria may be added at the discretion of the user.

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5 Appendix A: Enabled Suppliers

Enabled suppliers for the ICH6 Reference thermal solution are listed in Table 5-1 below.

Table 5-1. Enabled Suppliers for the Intel® ICH6 Reference Heatsink

Supplier	Intel Part Number	Vendor Part Number	Contact Information
CCI* (Chaun-Choung Technology Corp.)	C46655-001	00C855802B	Taiwan: Monica Chi Email: monica_chih@ccic.com.tw Tel: +886 - 2 2-995-2666 Ext 131 USA: Harry Lin Email: HLINACK@aol.com Tel: (714) 739-5797
Foxconn*	C46655-001	2Z802-009	USA: Jack Chen, PH.D Email: rongchechen@foxconn.com Tel: (714) 626-1233

Note: These vendors and devices are listed by Intel as a convenience to Intel's general customer base, but Intel does not make any representations or warranties whatsoever regarding quality, reliability, functionality, or compatibility of these devices. This list and/or these devices may be subject to change without notice.

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6 Appendix B: Mechanical Drawings

The following table lists the mechanical drawings available in this document:

Drawing Name	Page Number
Intel® ICH6 Component Package Drawing	16
Intel® ICH6 Motherboard Keep-Out	17
Intel® ICH6 Motherboard Keep-Out	17
Intel® ICH6 Heatsink Clip	19
Intel® ICH6 Heatsink Assembly	20

Figure 6-1. Intel® ICH6 Component Package Drawing

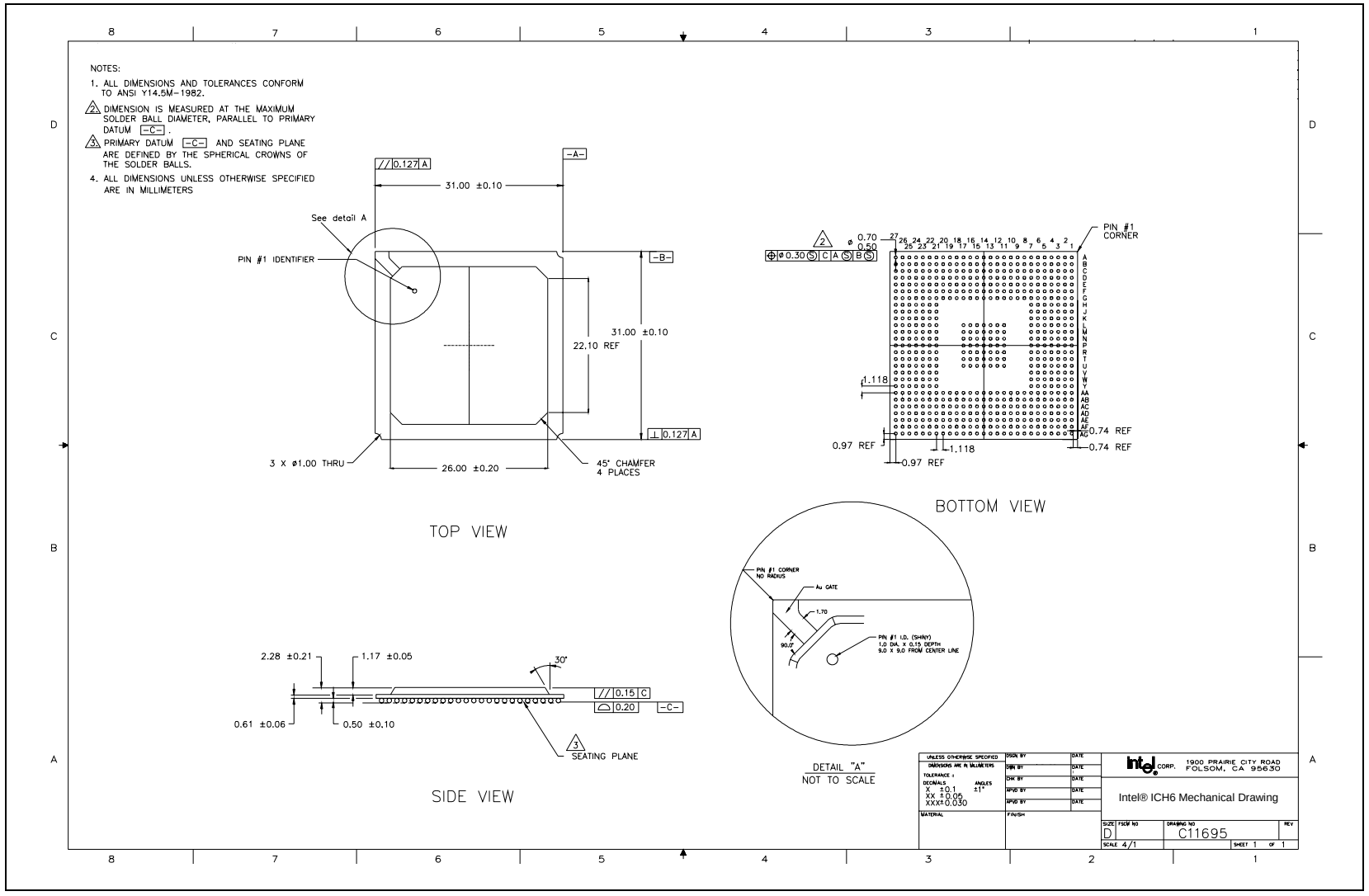

Figure 6-2. Intel® ICH6 Motherboard Keep-Out

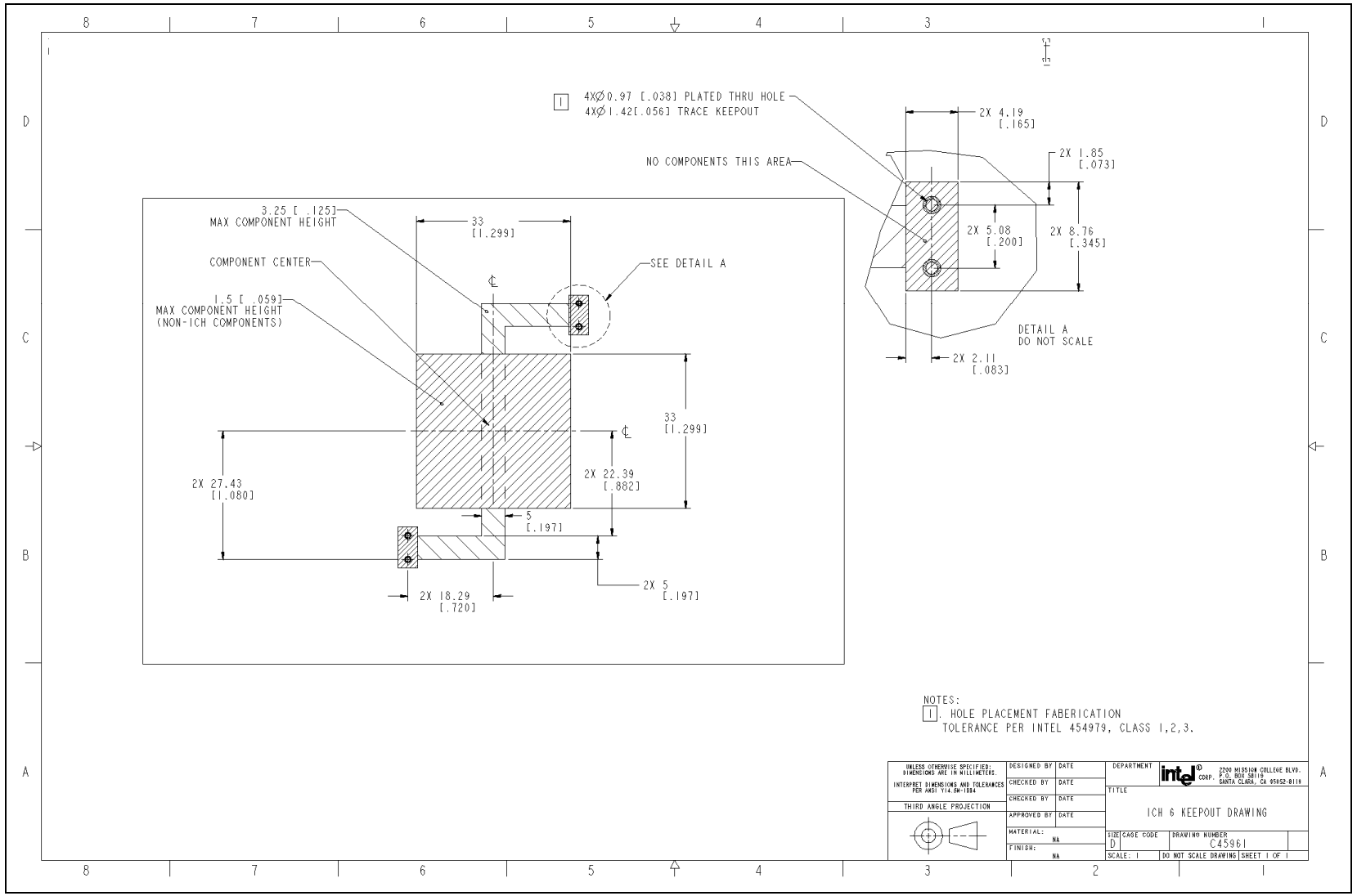

Figure 6-3. Intel® ICH6 Heatsink Extrusion

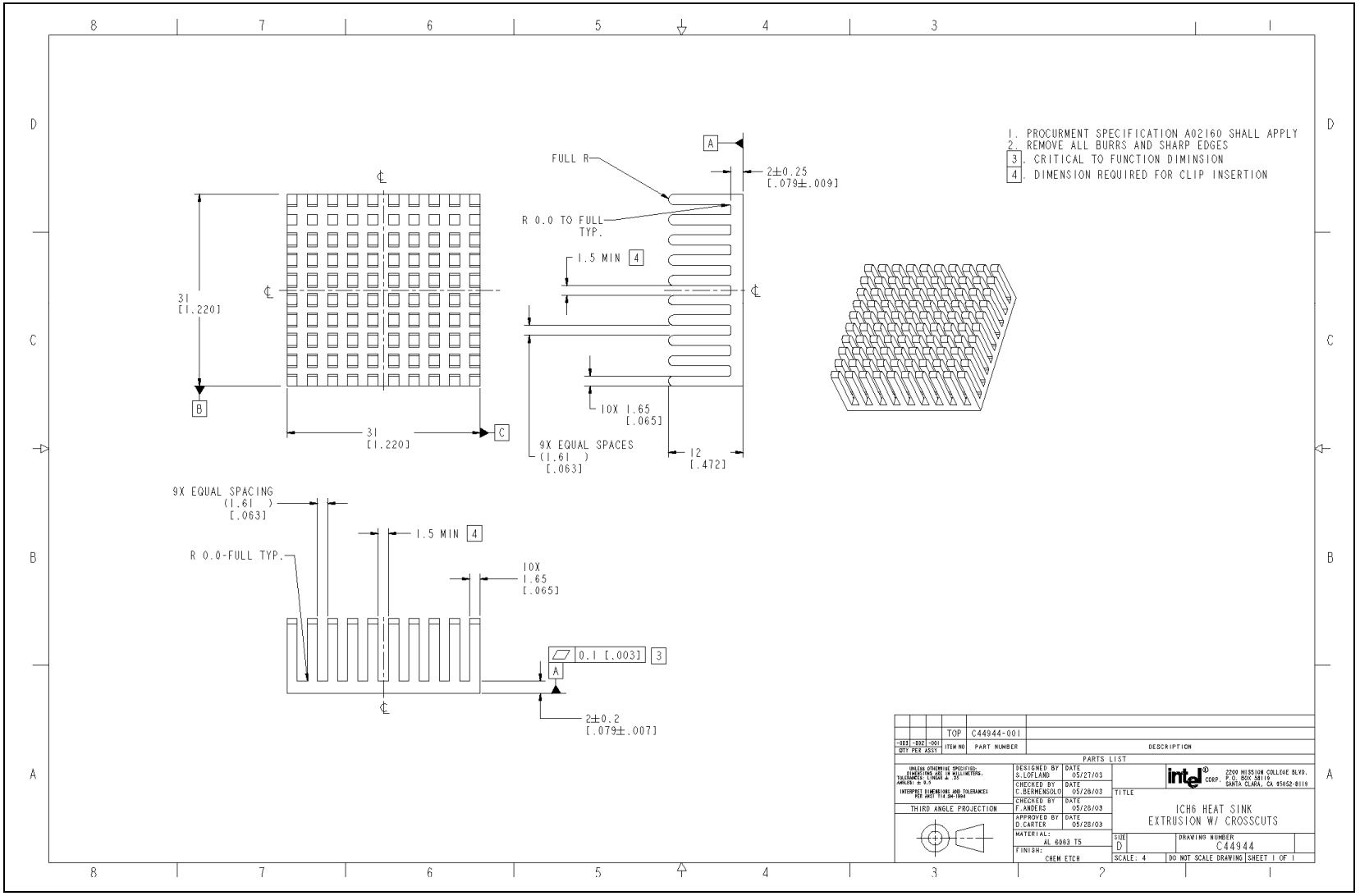

Figure 6-4. Intel® ICH6 Heatsink Clip

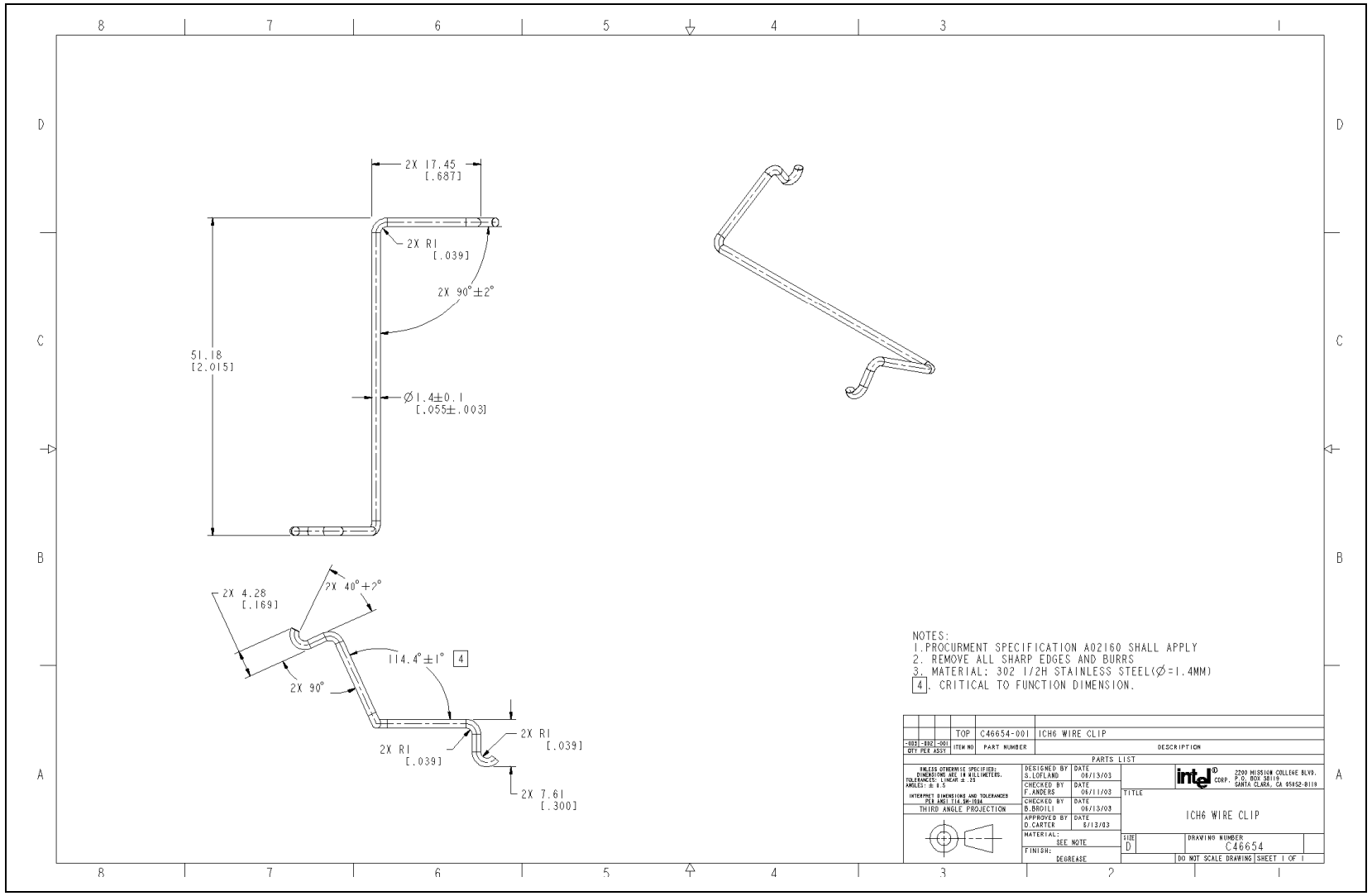

Figure 6-5. Intel® ICH6 Heatsink Assembly