Intel® X58 Express Chipset

Thermal and Mechanical Design Guide

November 2009

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Revision History

Revision Number	Description	Date
-001	- Initial release	November 2008
-002	- Updated idle power - Updated Reference Document link	March 2009
-003	- Updated idle power	November 2009

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1 Introduction

The goals of this document are to:

- Outline the thermal and mechanical operating limits and specifications for the Intel® X58 Express Chipset IOH.
- Describe reference thermal solutions that meet the specifications of the Intel® X58 Express Chipset IOH.

Properly designed thermal solutions provide adequate cooling to maintain the Intel® X58 Express Chipset IOH case temperatures 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 IOH case temperature at or below the specified limits, a system designer can ensure the proper functionality, performance, and reliability of the IOH. Operation outside the functional limits can cause data corruption or permanent damage to 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.

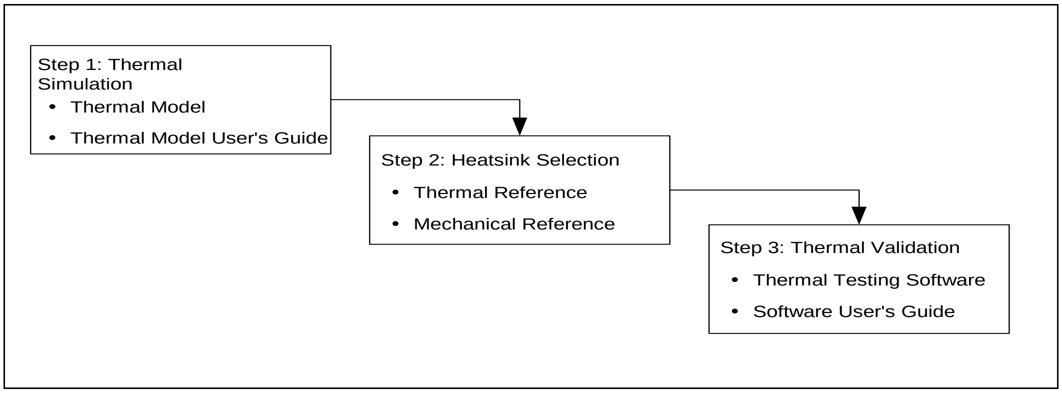
This document addresses thermal design and specifications for the Intel® X58 Express Chipset IOH component only. For thermal design information on other chipset components, refer to the respective component TMDG. For the ICH10, refer to the *Intel® I/O Controller Hub 10 (ICH10) Thermal and Mechanical Design Guidelines*.

Note: Unless otherwise specified, the term “IOH” refers to the Intel® X58 Express Chipset IOH.

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

Term	Description
FC-BGA	Flip Chip Ball Grid Array. A package type defined by a plastic substrate where a die is mounted using an underfill C4 (Controlled Collapse Chip Connection) attach style. The primary electrical interface is an array of solder balls attached to the substrate opposite the die. Note that the device arrives at the customer with solder balls attached.
BLT	Bond Line Thickness. Final settled thickness of the thermal interface material after installation of heatsink.
Intel® QuickPath Interconnect	The Physical layer of Intel® QuickPath interconnect is a link based interconnect specification for Intel processors, chipset and I/O bridge components.
IOH	Input Output Hub. The IO Controller Hub component that contains the Intel® QuickPath Interface to the processor, and PCI Express* interface. It communicates with the ICH10 over a proprietary interconnect called the Direct Media Interface (DMI).
Intel ICH10	I/O Controller Hub 10.
T_{case_max}	Die temperature allowed. This temperature is measured at the geometric center of the top of the die.
TDP	Thermal design power. Thermal solutions should be designed to dissipate this target power level. TDP is not the maximum power that the IOH can dissipate.

1.3 Reference Documents

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

Title	Location
Intel® X58 Express Chipset Datasheet	http://www.intel.com/Assets/PDF/datasheet/320839.pdf
Intel® I/O Controller Hub ICH10 Thermal Mechanical Design Guidelines	http://www.intel.com/design/chipsets/designex/319975.pdf

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2 Packaging Technology

The IOH uses a 37.5 mm, 8-layer flip chip ball grid array (FC-BGA) package (see Figure 2-1, Figure 2-2, and Figure 2-3). The complete package drawing can be found at Figure B-1. For information on the ICH10 package, refer to the *Intel® I/O Controller Hub 10 (ICH10) Family Thermal and Mechanical Design Guidelines*.

Figure 2-1. IOH Package Dimensions (Top View)

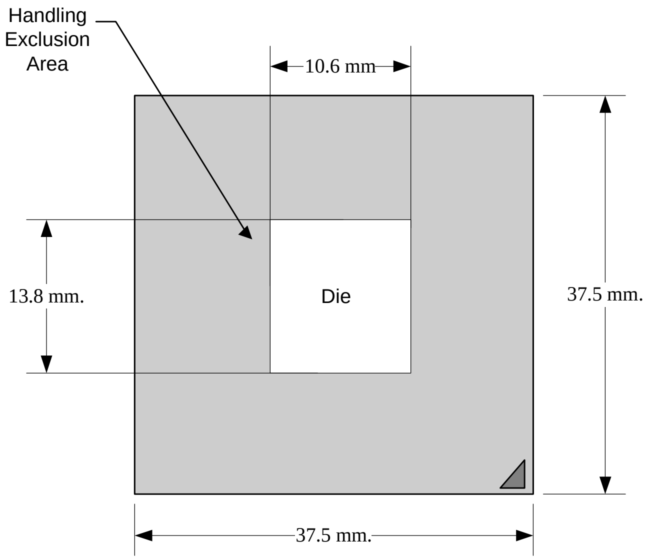
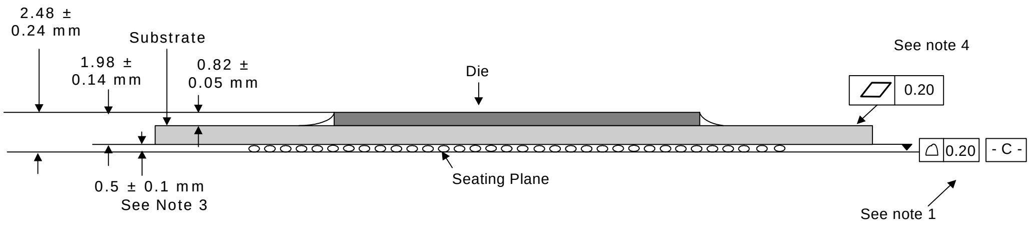


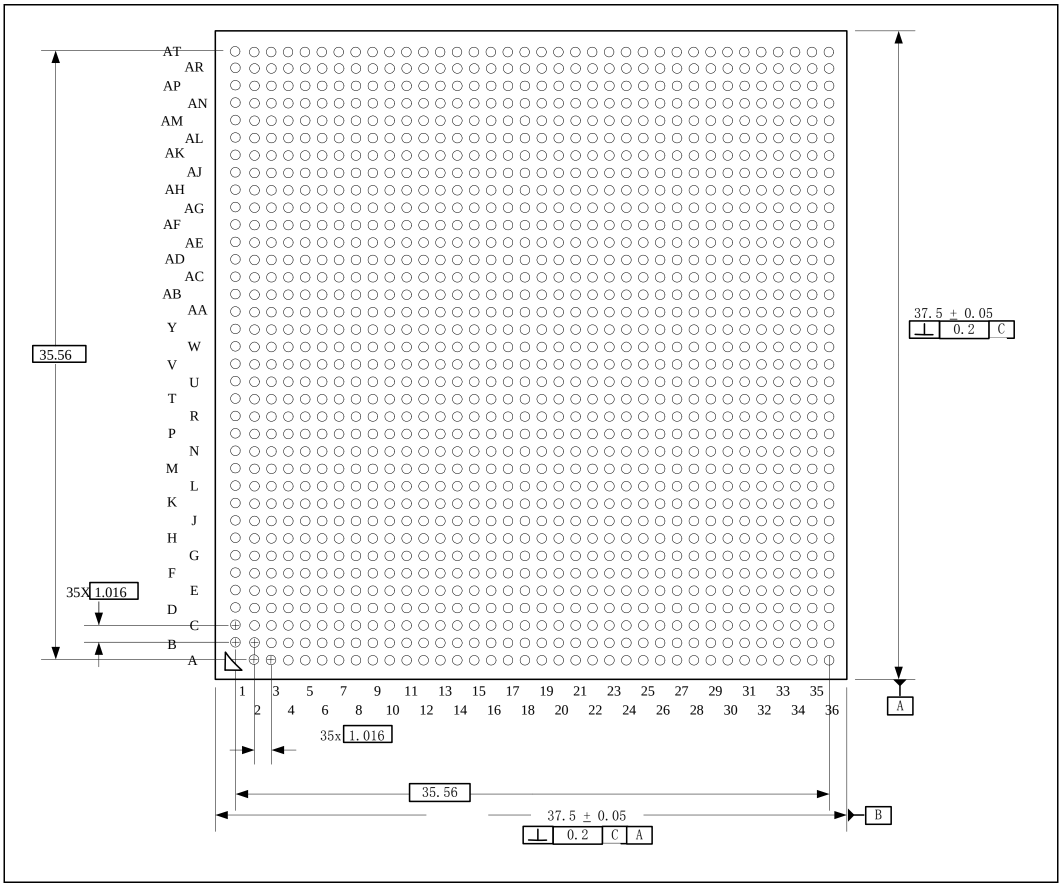
Figure 2-2. IOH Package Dimensions (Side View)



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 0.5±0.10 mm. Top of die above the motherboard after reflow is 2.36 ± 0.24 mm.
4. Shown before motherboard attach; FCBGA has a convex (dome shape) orientation before reflow and is expected to have a slightly concave (bowl shaped) orientation after reflow

Figure 2-3. IOH Package Dimensions (Bottom View)

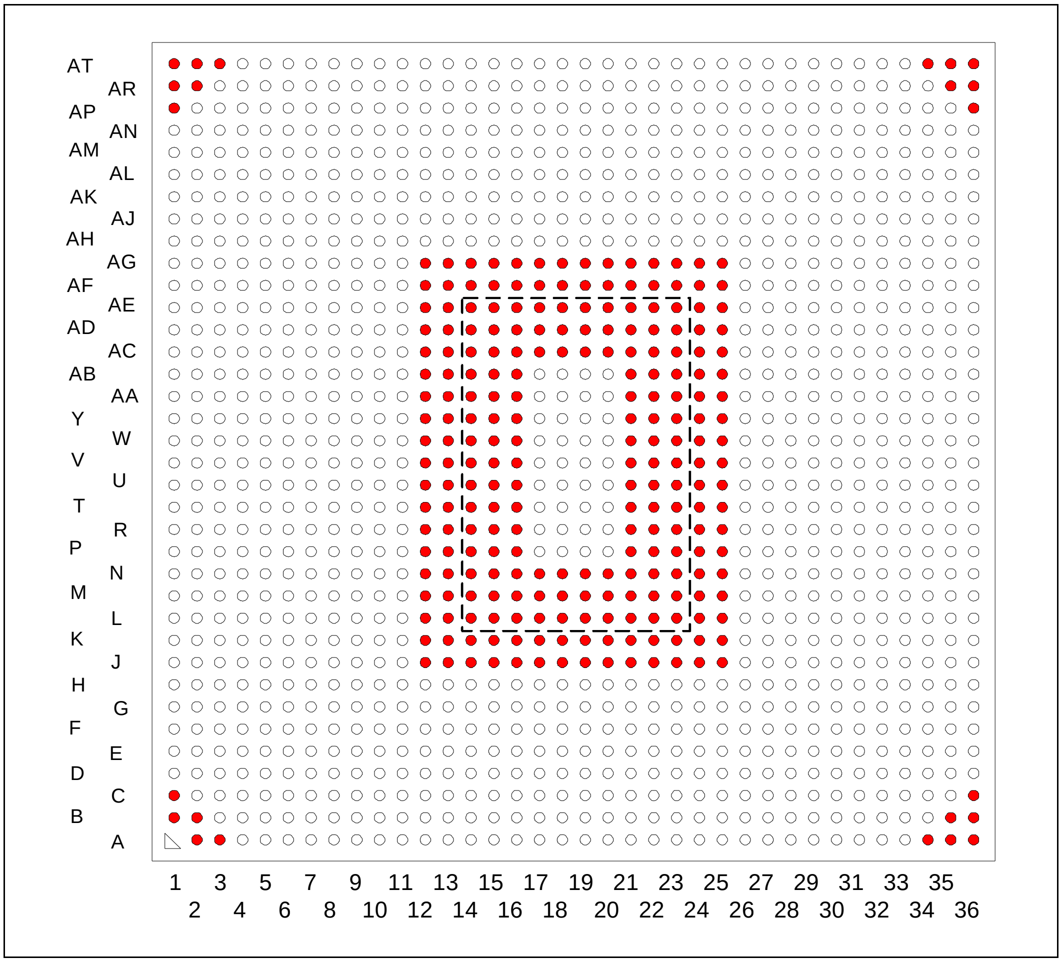


Notes:

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

2.1 Non-Critical to Function Solder Joints

Figure 2-4. Non-Critical to Function Solder Joints



Intel has defined selected solder joints of the IOH as non-critical to function (NCTF) when evaluating package solder joints post environmental testing. The IOH signals at NCTF locations are typically redundant ground or non-critical reserved, so the loss of the solder joint continuity at end of life conditions will not affect the overall product functionality. Figure 2-4 identifies the NCTF solder joints of the IOH package.

2.2 Package Mechanical Requirements

The IOH package has a bare die that is capable of sustaining a maximum static normal load of 15 lbf (67N). These mechanical load limits must not be exceeded during heatsink installation, mechanical stress testing, standard shipping conditions, and/or any other use condition.

Note: The heatsink attach solutions must not induce continuous stress to the IOH package with the exception of a uniform load to maintain the heatsink-to-package thermal interface.

Note: These specifications apply to uniform compressive loading in a direction perpendicular to the die top surface.

Note: 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 IOH component 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 characterizes power consumption based on known platform benchmark applications. The resulting power consumption is referred to as the Thermal Design Power (TDP). TDP is the target power level to which the thermal solutions should be designed. TDP is not the maximum power that the IOH can dissipate.

For TDP specifications, see Table 3-1 for the Intel® X58 Express Chipset IOH. FC-BGA packages have poor heat transfer capability into the board and have minimal thermal capability without thermal solution. Intel recommends that system designers plan for a heatsink with the IOH.

Table 3-1. Intel® X58 Express Chipset IOH Thermal Design Power

Product	TDP	Idle	Notes
IOH 36S	24.1 W	13.0 W	1, 2, 4
IOH 36S	20–24 W	13.0 W	1, 3, 4

Notes:
1. These specifications are based on silicon measurements.
2. TDP assumes the following configuration: 36 PCIe* Gen. 2.0 lanes configured as 2 x16 PEG and 1 x4 PCIe, the DMI link to the ICH and the Intel® QuickPath Interconnect operating at 6.4 GT /s.
3. TDP assumes the following configuration: 36 PCIe* Gen. 2.0 lanes configured as 2 x16 PEG and 1 x4 PCIe, the DMI link to the ICH and the Intel QuickPath Interconnect operating at 4.8 GT /s.
4. The idle power assumes the case temperature is at or below 65 °C.

3.2 Case Temperature

To ensure proper operation and reliability of the IOH, the case temperature must comply with the thermal profile as specified in Table 3-2. System and/or component level thermal solutions are required to maintain these temperature specifications. Refer to Chapter 4 for guidelines on accurately measuring package case temperatures.

Table 3-2. Intel® X58 Express ChipsetThermal Specification

Parameter	Value
Tcase_max	100 °C
Tcase_min	5 °C
Tcontrol	95 °C

Note: The reference thermal solution is described in Chapter 5, “ATX Reference Thermal Solution”.

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4 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 IOH die temperatures. Section 4.1 provides guidelines on how to accurately measure the IOH die temperatures. The flowchart in Figure 4-1 offers useful guidelines for thermal performance and evaluation.

4.1 Die Temperature Measurements

To ensure functionality and reliability, the T_{case} of the IOH must be maintained at or between the maximum/minimum operating range of the temperature specification as noted in Table 3-2. The surface temperature at the geometric center of the die corresponds to T_{case}. Measuring T_{case} 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 heatsink base (if a heatsink is used). For maximum measurement accuracy, only the 0° thermocouple attach approach is recommended.

4.1.1 Zero Degree Angle Attach Methodology

1. Mill a 3.3 mm (0.13 in.) diameter and 1.5 mm (0.06 in.) deep hole centered on the bottom of the heatsink base.
2. Mill a 1.3 mm (0.05 in.) wide and 0.5 mm (0.02 in.) deep slot from the centered hole to one edge of the heatsink. The slot should be parallel to the heatsink fins (see Figure 4-2).
3. Attach thermal interface material (TIM) to the bottom of the heatsink base.
4. Cut out portions of the TIM to make room for the thermocouple wire and bead. The cutouts should match the slot and hole milled into the heatsink base.
5. Attach a 36 gauge or smaller calibrated K-type thermocouple bead or junction to the center of the top surface of the die using a high thermal conductivity cement. During this step, ensure no contact is present between the thermocouple cement and the heatsink base because any contact will affect the thermocouple reading. **It is critical that the thermocouple bead makes contact with the die** (see Figure 4-3).
6. Attach heatsink assembly to the IOH and route thermocouple wires out through the milled slot.

Figure 4-1. Thermal Solution Decision Flow Chart

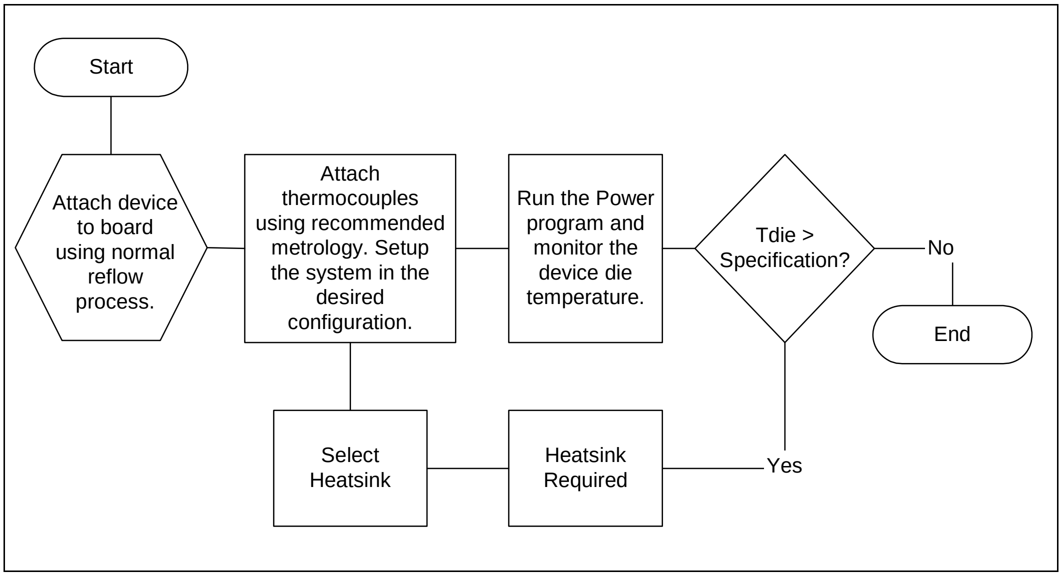
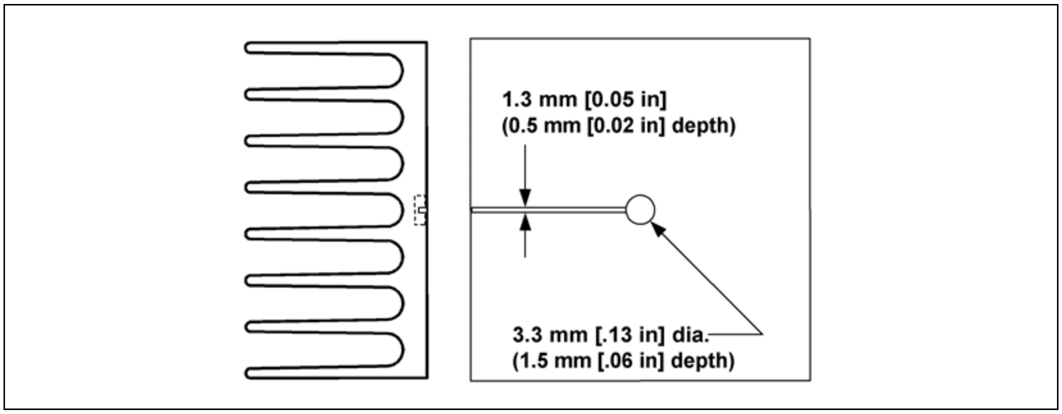
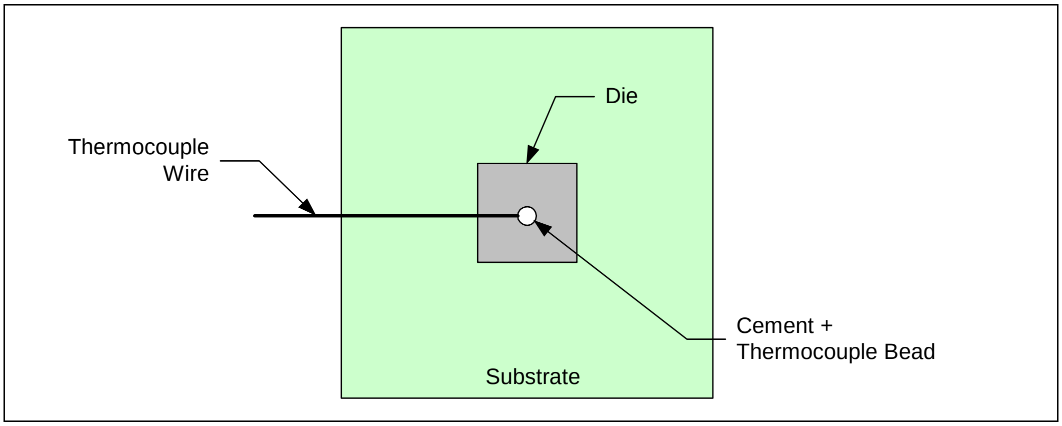


Figure 4-2. Zero Degree Angle Attach Heatsink Modifications



NOTE: Not to scale.

Figure 4-3. Zero Degree Angle Attach Methodology (Top View)

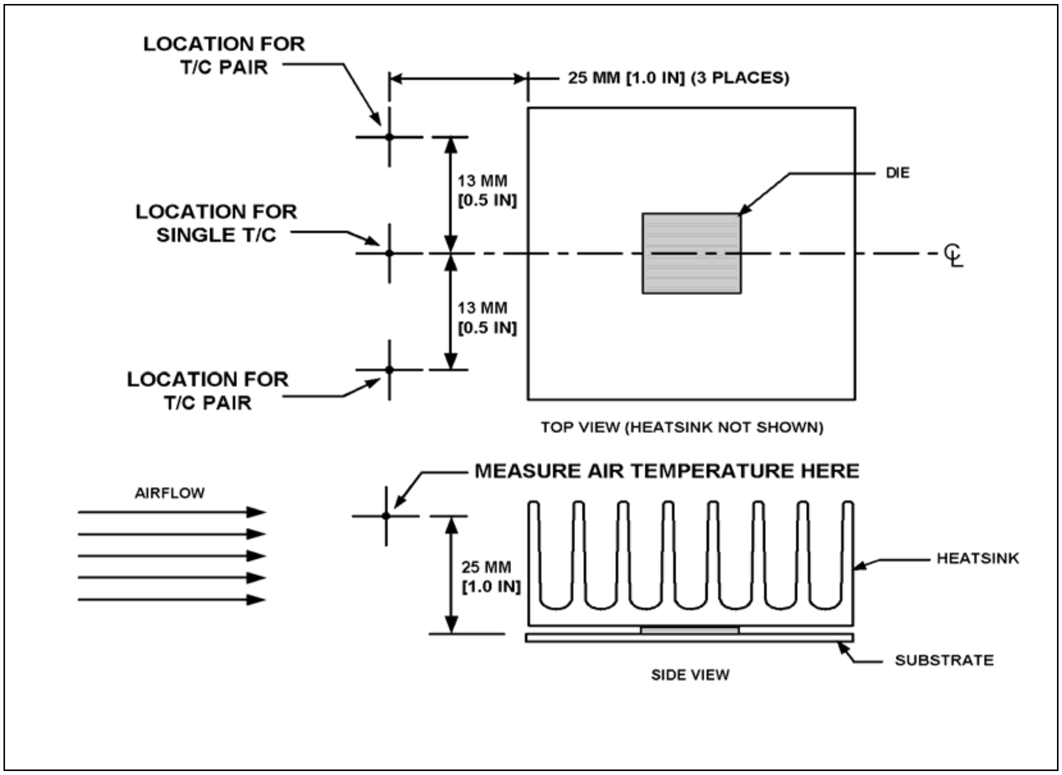


NOTE: Not to scale.

4.2 Airflow Characterization

Figure 4-4 describes the recommended location for air temperature measurements measured relative to the component. For a more accurate measurement of the average approach air temperature, Intel recommends averaging temperatures recorded from two thermocouples spaced about 25 mm [1.0 in] apart. Locations for both a single thermocouple and a pair of thermocouples are presented.

Figure 4-4. Airflow and Temperature Measurement Locations



Airflow velocity can be measured using sensors that combine air velocity and temperature measurements. Typical airflow sensor technology may include hot wire anemometers. Figure 4-4 provides guidance for airflow velocity measurement locations which should be the same as used for temperature measurement. These locations are for a typical JEDEC test setup and may not be compatible with chassis layouts due to the proximity of the processor to the IOH. The user may have to adjust the locations for a specific chassis. Be aware that sensors may need to be aligned perpendicular to the airflow velocity vector or an inaccurate measurement may result. Measurements should be taken with the chassis fully sealed in its operational configuration to achieve a representative airflow profile within the chassis.

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5 ATX Reference Thermal Solution

The design strategy for the Intel® X58 Express Chipset thermal solution is to reuse a z-clip heatsink originally designed for the Intel® 965 Express Chipset. This is a change from the previous revision of this document. The change is based on structural analysis and testing for solder joint reliability that showed minimal risk for the critical to function solder joints.

The Preload Wave Solder Heatsink (PWHS) documented in the previous revision of this document is now listed as an alternate thermal solution for designs that deviate from the core layout for the position of the IOH with respect to the processor, chassis mounting holes or IOH pad sizes.

This section describes the overall requirements for the ATX heatsink reference thermal solution including critical-to-function dimensions, operating environment, and validation criteria. Other chipset components may or may not need attached thermal solutions depending on your specific system local-ambient operating conditions.

5.1 Operating Environment

The IOH reference thermal solution is dependent on the exhaust air flow from the processor thermal solution. This airstream is assumed to be approaching the heatsink at a 30° angle from the processor thermal solution, see Figure 5-1 and Figure 5-2 for more details.

This airflow can be achieved by using a processor heatsink providing omni-directional airflow, such as a radial fin or "X" pattern heatsink. Such a heatsink can deliver airflow to the IOH and other areas like the voltage regulator. In addition, IOH board placement should ensure that the IOH heatsink is within the air exhaust area of the processor heatsink.

The local ambient air temperature, T_A, at the IOH heatsink inlet is dependent on the processor power dissipation, see Table 5-1 for assumed conditions. The thermal designer must carefully select the location to measure airflow to get a representative sampling. These environmental assumptions are based on a 35 °C maximum system external temperature measured at sea level.

Finally, heatsink orientation alone does not ensure that airflow speed will be achieved. The system integrator should use analytical or experimental means to determine whether a system design provides adequate airflow speed for a particular to the heatsink.

Three system level boundary conditions will be used to determine IOH thermal solution requirements identified as Case 1 through 3.

- Low external ambient (25 °C)/ idle power for the components (Case 3). This covers the system idle acoustic condition.
- Low external ambient (25 °C)/ TDP for the components (Case 2). The processor thermal solution fan speed is limited by the thermistor in the fan hub.
- High external ambient (35 °C)/ TDP for the components (Case 1). This covers the maximum processor thermal solution fan speed condition.

Table 5-1. IOH Thermal Solution Boundary Conditions

Case	External Ambient	IOH Power	Processor Power	$T_{A\text{-Local}}$	Target Psi-ca	Airflow
1	35 °C	TDP	TDP	56 °C	1.83 °C/W	756 LFM[3.8 m/S]
2	25 °C	TDP	TDP	55 °C	1.86 °C/W	420 LFM[2.1m/S]
3	25 °C	Idle	Idle	37 °C	3.29 °C/W	163 LFM[0.83m/S]

Notes:

1. Target Psi-ca for Case 3 is based on the idle conditions listed in Table 3-1.

Figure 5-1. ATX Boundary Conditions

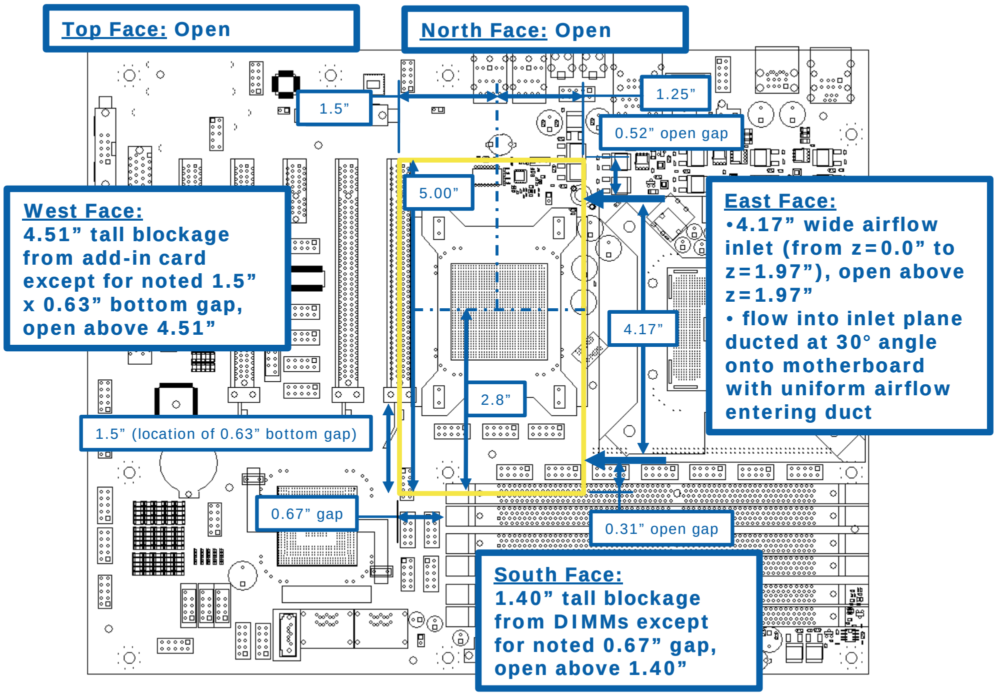
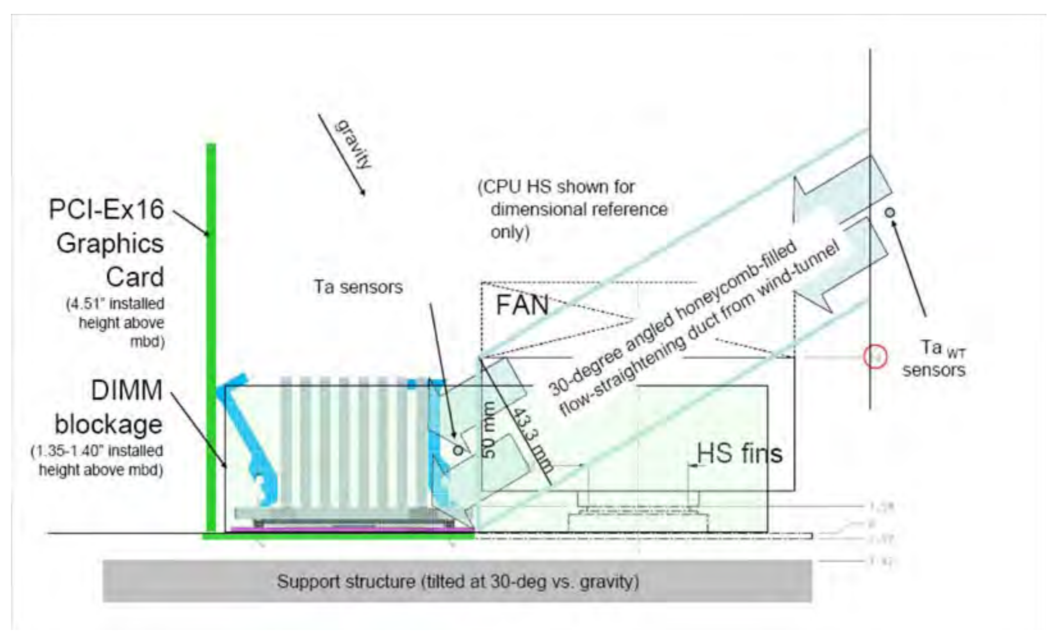


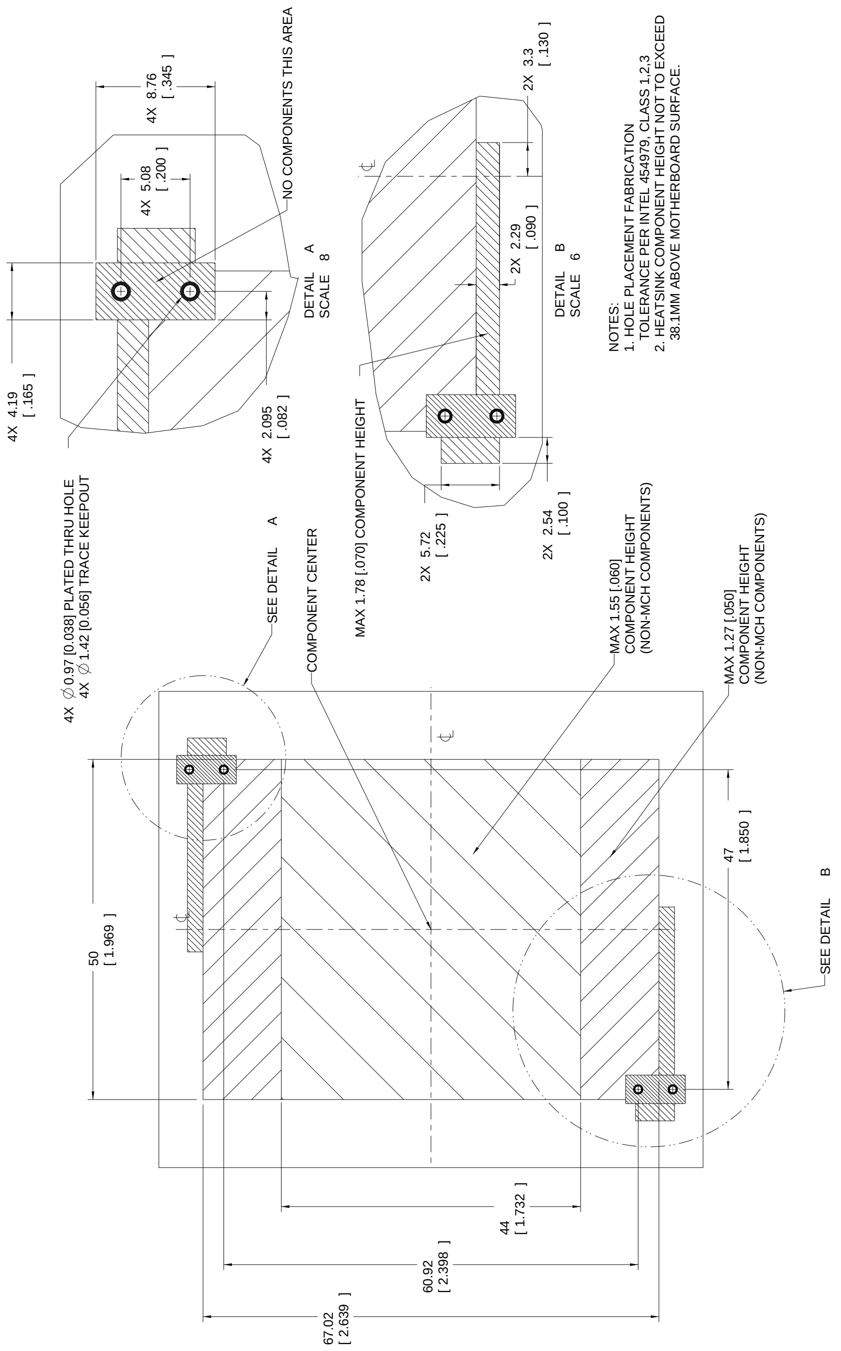
Figure 5-2. Side View of ATX Boundary Conditions



5.2 Board-Level Components Keepout Dimensions

The location of hole patterns and keepout zones for the reference thermal solution are shown in Figure 5-3.

Figure 5-3. Heatsink Board Component Keepout

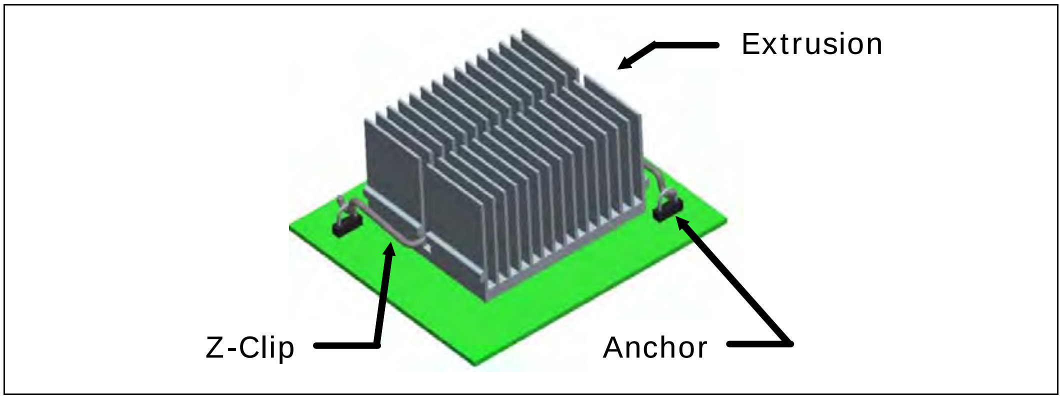


5.3 Reference Heatsink Thermal Solution Assembly

The reference thermal solution for the IOH is a passive aluminum extruded heatsink with a preapplied thermal interface material and a z-clip to attach the extrusion to anchors on the board.

The heatsink is attached to the motherboard by assembling the anchors into the board and sending the board through the wave solder. After wavesolder the heatsink is positioned on the IOH and the z-clips snapped into the anchors.

Figure 5-4. Reference Heatsink Assembly



5.4 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® X58 Express Chipset IOH thermal solution are shown in Figure 5-3. The maximum height of the installed IOH thermal solution is approximately 33.7 mm [1.3 inches].

5.4.1 Extruded Heatsink Profiles

The reference thermal solution uses an extruded heatsink for cooling the IOH. Appendix A lists a supplier for this extruded heatsink. Other heatsinks with similar dimensions and increased thermal performance may be available. Full mechanical drawing of this heatsink is provided in Appendix B.

5.4.2 Heatsink Orientation

Since this solution is based on a unidirectional heatsink, mean airflow direction must be aligned with the direction of the heatsink fins. The use of an omni-directional processor heatsink as described in Section 5.1 will facilitate but not ensured adequate air flow.

5.4.3 Thermal Interface Material

A thermal interface material (TIM) provides conductivity between the IHS and heat sink. The reference thermal solution uses Honeywell PCM45 F*, 0.25 mm (0.010 in.) thick, 20 mm x 20 mm (0.79 in. x 0.79 in.) square.

Note: Unflowed or “dry” Honeywell PCM45 F has a material thickness of 0.010 inch. The flowed or “wet” Honeywell PCM45F has a material thickness of ~0.003 inch after it reaches its phase change temperature.

5.4.3.1 Effect of Pressure on TIM Performance

As mechanical pressure increases on the TIM, the thermal resistance of the TIM decreases. This phenomenon is due to the decrease of the bond line thickness (BLT). BLT is the final settled thickness of the thermal interface material after installation of heatsink. The effect of pressure on the thermal resistance of the Honeywell PCM45 F TIM is shown in Table 5-2.

Intel provides both End of Line and End of Life TIM thermal resistance values of Honeywell PCM45F. End of Line and End of Life TIM thermal resistance values are obtained through measurement on a Test Vehicle similar to Intel® X58 Express Chipset's physical attributes using an extruded aluminum heatsink. The End of Line value represents the TIM performance post heatsink assembly while the End of Life value is the predicted TIM performance when the product and TIM reaches the end of its life. The heatsink clip provides enough pressure for the TIM to achieve End of Line and End of Life thermal resistances shown in Figure 5-2.

Table 5-2. Honeywell PCM45 F* TIM Performance as a Function of Attach Pressure

Pressure on Thermal Solution and Package Interface (PSI)	Thermal Resistance (°C × in^2) / W	
	End of Line	End of Life
50	0.533	0.646

5.4.4 Heatsink Clip

The reference solution Z-clip is a new design to span the previously defined anchor locations. It provide a constant preload on the extrusion for the TIM. See Appendix A for the part number and supplier information. See Appendix B for a mechanical drawings.

5.4.5 Anchor

The anchor from previous z-clip solutions will be reused. By using anchors that are separate from the extrusion the solderability of the anchors is improved. The elimination of the conduction path from pins in the extrusion reduces the chance for cold solder joints. This design incorporates a 45° bent leads to increase the anchor attach reliability over time. See Appendix A for the part number and supplier information. See Appendix B for a mechanical drawings.

5.5 Reliability Guidelines

Each motherboard, heatsink 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 5-3.

Table 5-3. Reliability Guidelines

Test [1]	Requirement	Pass/Fail Criteria [2]
Mechanical Shock	3 drops each for + and - directions in each of 3 perpendicular axes (i.e., total 18 drops) Profile: 50 g, Trapezoidal waveform, 4.3 m/s [170 in/s] minimum velocity change	Visual Check and Electrical Functional Test
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 Check and Electrical Functional Test
THermal Cycling	• 7500 cycles (on/off) of minimum temperature 27 °C / maximum temperature 96 °C • 1400 cycles (on/off) of minimum temperature 35 °C / maximum temperature 96 °C • A 15 second dwell at high / low temperature for both test cycles	Thermal Performance
Humidity	85% relative humidity, 55 °C, 576 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.

5.6 Alternate Heatsink Thermal Solution Assembly

The alternate reference thermal solution for the IOH is a passive extruded heatsink that uses two ramp retainers, a wire preload clip, and four motherboard anchors with pre-applied thermal interface. Figure 5-5 through Figure 5-7 shows the reference thermal solution assembly, associated components, and relevant keepout zones.

The heatsink is attached to the motherboard by assembling the anchors into the board, placing the heatsink, with the wire preload clip over the IOH and anchors at each of the corners, and securing the plastic ramp retainers through the anchor loops before snapping each retainer into the fin gap. Leave the wire preload clip loose in the extrusion during the wave solder process. The assembly is then sent through the wave process. Post wave, the wire preload clip is snapped into place on the hooks located on each of the ramp retainers. The clip provides the mechanical preload to the package. A thermal interface material is pre-applied to the heatsink bottom over an area which contacts the package die See Section 5.7.5 for additional details.

Figure 5-5. Alternate Heatsink Assembly

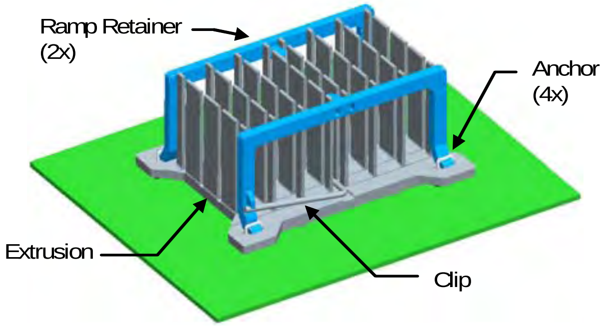


Figure 5-6. Retention Mechanism Component Keepout Zones for Alternate Heatsink

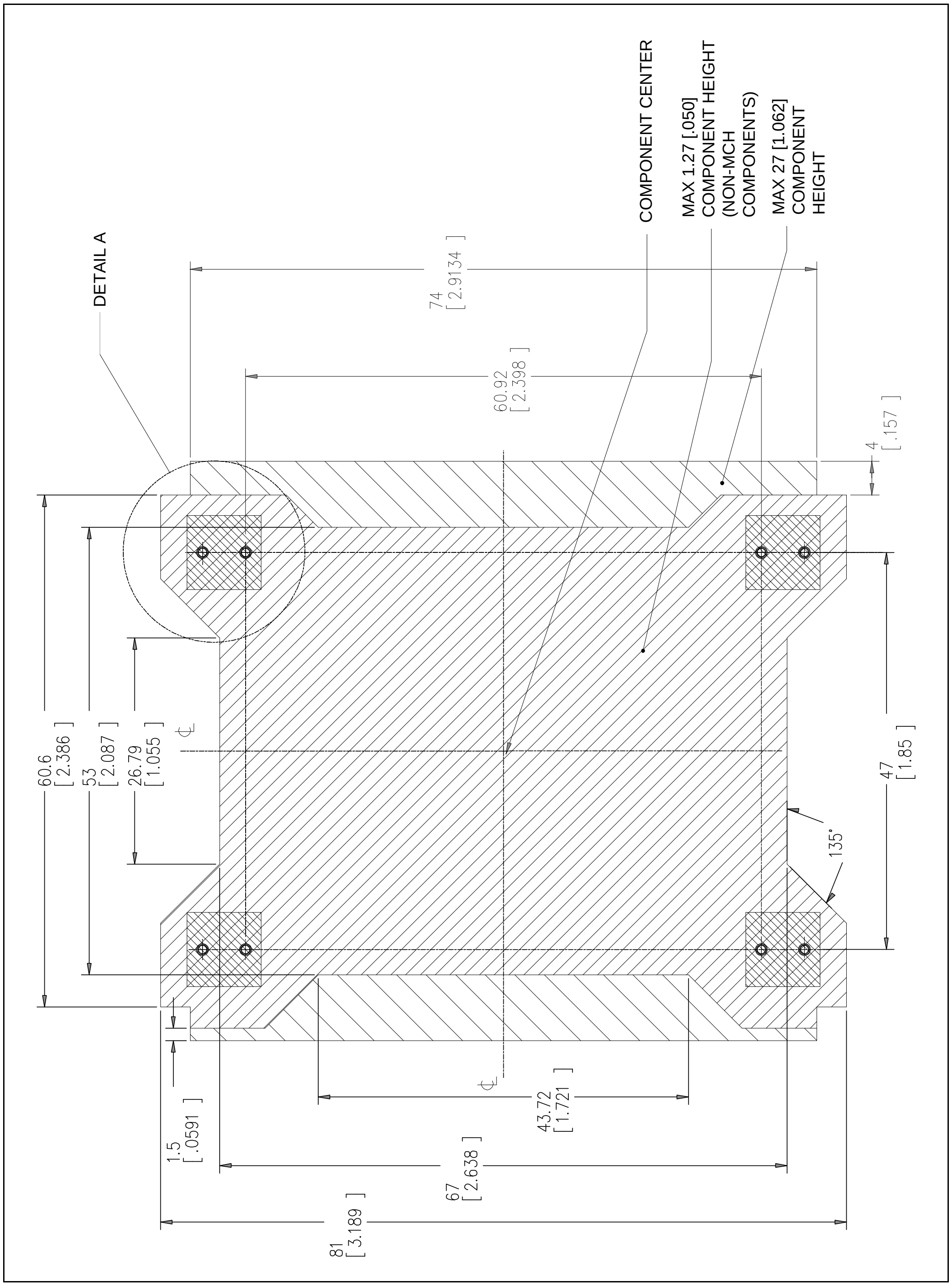
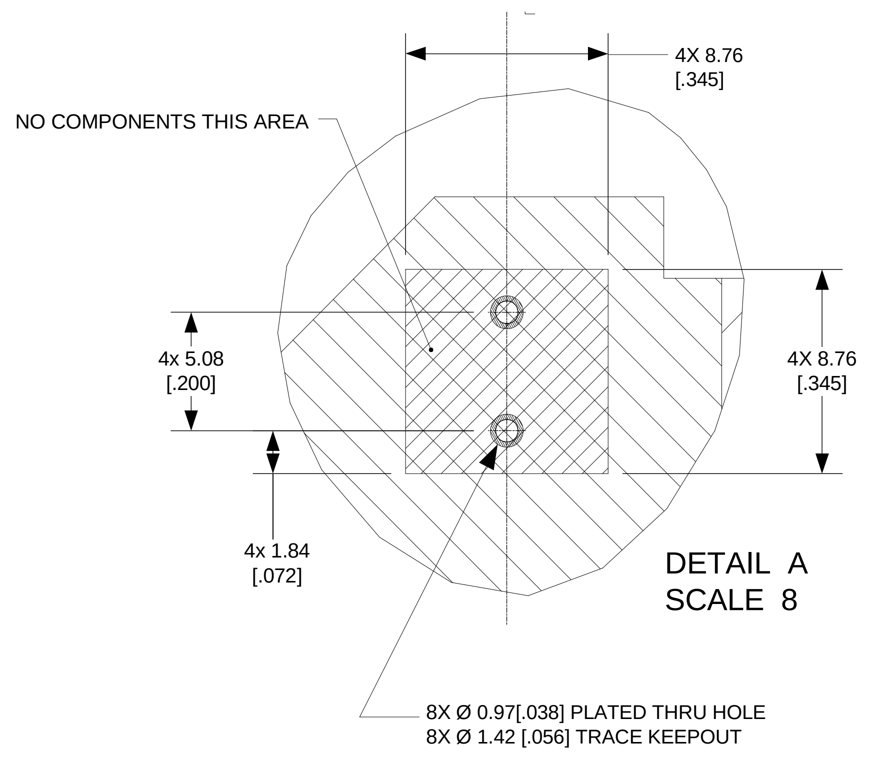


Figure 5-7. Retention Mechanism Component Keepout Zones for Alternate Heatsink



5.7 Alternate Heatsink 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® X58 Express Chipset IOH thermal solution are shown in Figure 5-6 and Figure 5-7. The maximum height of the installed IOH thermal solution is 38.1 mm [1.5 inches].

5.7.1 Extruded Heatsink Profiles

The reference thermal solution uses an extruded heatsink for cooling the IOH. Appendix A lists a supplier for this extruded heatsink. Other heatsinks with similar dimensions and increased thermal performance may be available. Full mechanical drawing of this heatsink is provided in Appendix C.

5.7.2 Heatsink Clip

The reference solution reuses the existing PWHS Z-clip. It provide a constant preload on the extrusion for the TIM. The ends of the Z-clip attach to features in the ramp retainer. See Appendix A for the part number and supplier information. See Appendix C for a mechanical drawings.

5.7.3 Anchor

For Intel® X58 Express Chipset based platforms the anchor from previous PWHS will be reused. By using anchors that are separate from the extrusion, the solderability of the anchors is improved. The elimination of the conduction path from pins in the extrusion reduces the chance for cold solder joints. This design incorporates a 45° bent leads to increase the anchor attach reliability over time. See Appendix A for the part number and supplier information. See Appendix C for a mechanical drawings.

5.7.4 Ramp Retainer

The ramp retainer is a molded plastic component that is reused from previous PWHS designs. It is integral to the ability of the design to shift the shock and vibration loads away from the IOH solder joints. By assembling the heatsink extrusion, anchors and ramp retainer before wave solder the tolerances between the top of the IOH and the extrusion are absorbed as the board cools from the wave solder process.See Appendix A for the part number and supplier information. See Appendix C for a mechanical drawings.

5.7.5 Thermal Interface Material

A thermal interface material (TIM) provides conductivity between the IHS and heat sink. The reference thermal solution uses Honeywell PCM45 F*, 0.25 mm (0.010 in.) thick, 20 mm x 20 mm (0.79 in. x 0.79 in.) square.

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A Thermal Solution Component Suppliers

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.

Table A-1. Reference Heatsink Enabled Components

Item	Intel PN	AVC	CCI	Foxconn	Wieson
Heatsink Assembly (Extrusion, Clip & TIM)	E16429-001			1A013WV00	
Anchor	A13494-008			HB9703E-DW	G2100C888-064H

Table A-2. Alternate Heatsink - Preload Wavesolder Heatsink (PWHS) Components

Item	Intel PN	AVC	CCI	Foxconn	Wieson
Heatsink & TIM	D77030-001	S907C00002			
Ramp Retainer	C85370-001	P109000024	334C863501A	3EE77-002	
Wire Clip	D29082-001	A208000233	334I833301A	3KS02-155	
Anchor	C85376-001			2Z802-015	G2100C888-143

Table A-3. Supplier Contact Information

Supplier	Contact	Phone	Email
AVC (Asia Vital Corporation)	David Chao Raichel Hsu	+886-2-2299-6930 ext. 7619 +886-2-2299-6930 ext. 7630	david_chao@avc.com.tw raichel_hsi@avc.com.tw
CCI(Chaun Choung Technology	Monica Chih Harry Lin	+886-2-2995-2666 (714) 739-5797	monica_chih@ccic.com.tw hlinack@aol.com
Foxconn	Jack Chen Wanchi Chen	(408) 919-6121 (408) 919-6135	jack.chen@foxconn.com wanchi.chen@foxconn.com
Wieson	Chary Lee Henry Liu	+886-2-2647-1896 ext. 6684 +886-2-2647-1896 ext.6330	chary@wieson.com henry@wieson.com

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

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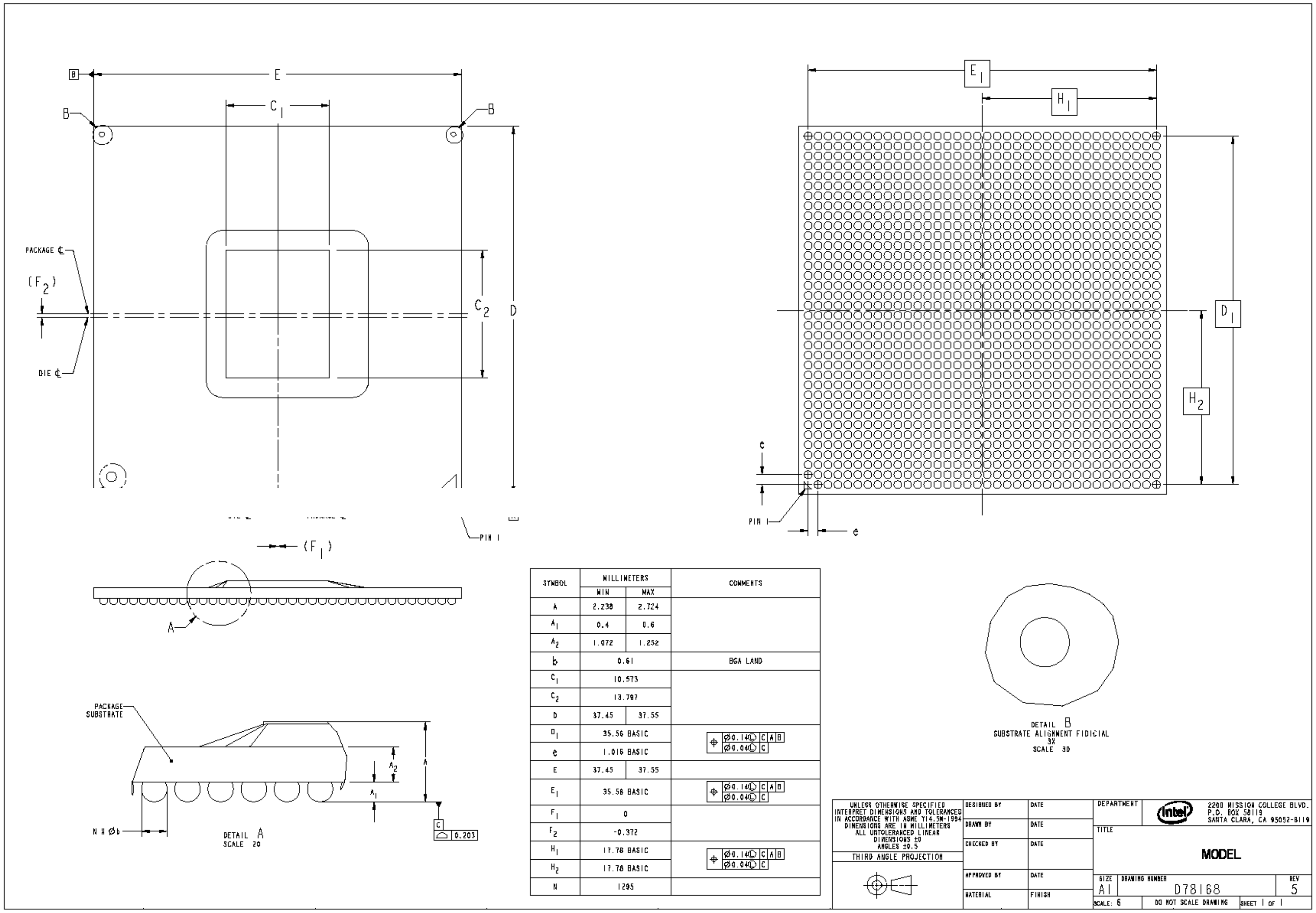
B Mechanical Drawings for Package & Reference Thermal Solution

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

Table B-1. Mechanical Drawing List

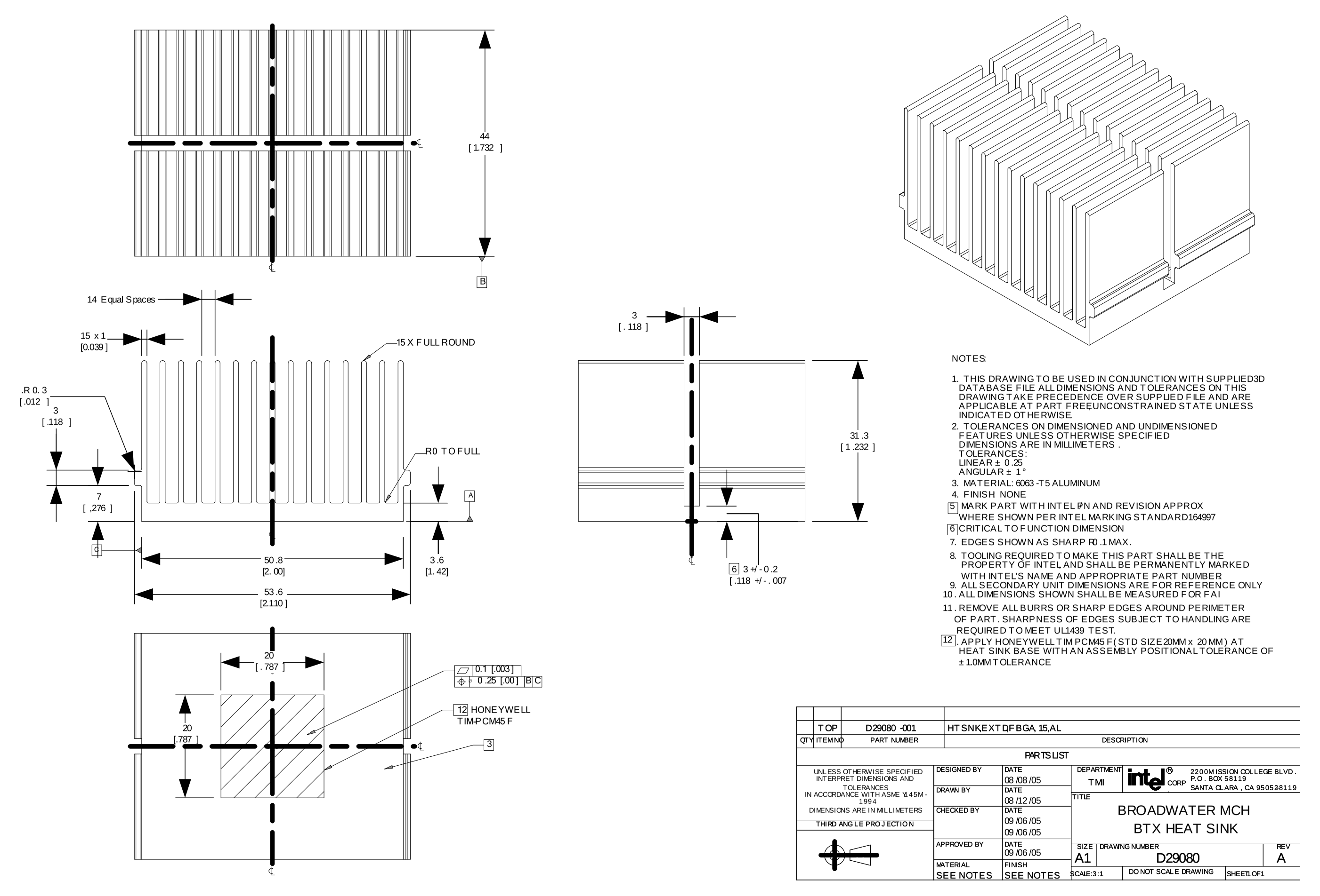
Drawing Description	Figure Number
“IOH Package Drawing”	Figure B-1
“Heatsink Extrusion Drawing”	Figure B-2
“Z-Clip Wire”	Figure B-3

Figure B-1. IOH Package Drawing



SYMBOL	MILLIMETERS		COMMENTS
	MIN	MAX	
A	2.238	2.724	
A_1	0.4	0.6	
A_2	1.072	1.252	
b	0.61		BGA LAND
C_1	10.573		
C_2	13.797		
D	37.45	37.55	
D_1	35.56 BASIC		⌖ Ø0.14Ⓛ C A B Ø0.04Ⓛ C
e	1.016 BASIC		
E	37.45	37.55	
E_1	35.58 BASIC		⌖ Ø0.14Ⓛ C A B Ø0.04Ⓛ C
F_1	0		
F_2	-0.372		
H_1	17.78 BASIC		⌖ Ø0.14Ⓛ C A B Ø0.04Ⓛ C
H_2	17.78 BASIC		
N	1295		

Figure B-2. Heatsink Extrusion Drawing



NOTES:

1. THIS DRAWING TO BE USED IN CONJUNCTION WITH SUPPLIED3D DATABASE FILE. ALL DIMENSIONS AND TOLERANCES ON THIS DRAWING TAKE PRECEDENCE OVER SUPPLIED FILE AND ARE APPLICABLE AT PART FREE, UNCONSTRAINED STATE UNLESS INDICATED OTHERWISE.
2. TOLERANCES ON DIMENSIONED AND UNDIMENSIONED FEATURES UNLESS OTHERWISE SPECIFIED
   DIMENSIONS ARE IN MILLIMETERS .
   TOLERANCES:
   LINEAR ± 0.25
   ANGULAR ± 1°
3. MATERIAL: 6063 -T5 ALUMINUM
4. FINISH: NONE
5. MARK PART WITH INTEL P/N AND REVISION APPROX WHERE SHOWN PER INTEL MARKING STANDARD164997
6. CRITICAL TO FUNCTION DIMENSION
7. EDGES SHOWN AS SHARP R0 .1 MAX.
8. TOOLING REQUIRED TO MAKE THIS PART SHALL BE THE PROPERTY OF INTEL, AND SHALL BE PERMANENTLY MARKED WITH INTEL'S NAME AND APPROPRIATE PART NUMBER.
9. ALL SECONDARY UNIT DIMENSIONS ARE FOR REFERENCE ONLY
10. ALL DIMENSIONS SHOWN SHALL BE MEASURED FOR FAI
11. REMOVE ALL BURRS OR SHARP EDGES AROUND PERIMETER OF PART. SHARPNESS OF EDGES SUBJECT TO HANDLING ARE REQUIRED TO MEET UL1439 TEST.
12. APPLY HONEYWELL TIM PCM45 F (STD SIZE 20MM x 20 MM) AT HEAT SINK BASE WITH AN ASSEMBLY POSITIONAL TOLERANCE OF ± 1.0MM TOLERANCE

QTY	ITEM NO	PART NUMBER	DESCRIPTION
	TOP	D29080 -001	HT SNK,EXT D,F BGA, 15,AL

PARTS LIST

UNLESS OTHERWISE SPECIFIED INTERPRET DIMENSIONS AND TOLERANCES IN ACCORDANCE WITH ASME Y14.5M - 1994
DIMENSIONS ARE IN MILLIMETERS
THIRD ANGLE PROJECTION

DESIGNED BY	DATE 08 /08 /05
DRAWN BY	DATE 08 /12 /05
CHECKED BY	DATE 09 /06 /05 09 /06 /05
APPROVED BY	DATE 09 /06 /05
MATERIAL SEE NOTES	FINISH SEE NOTES

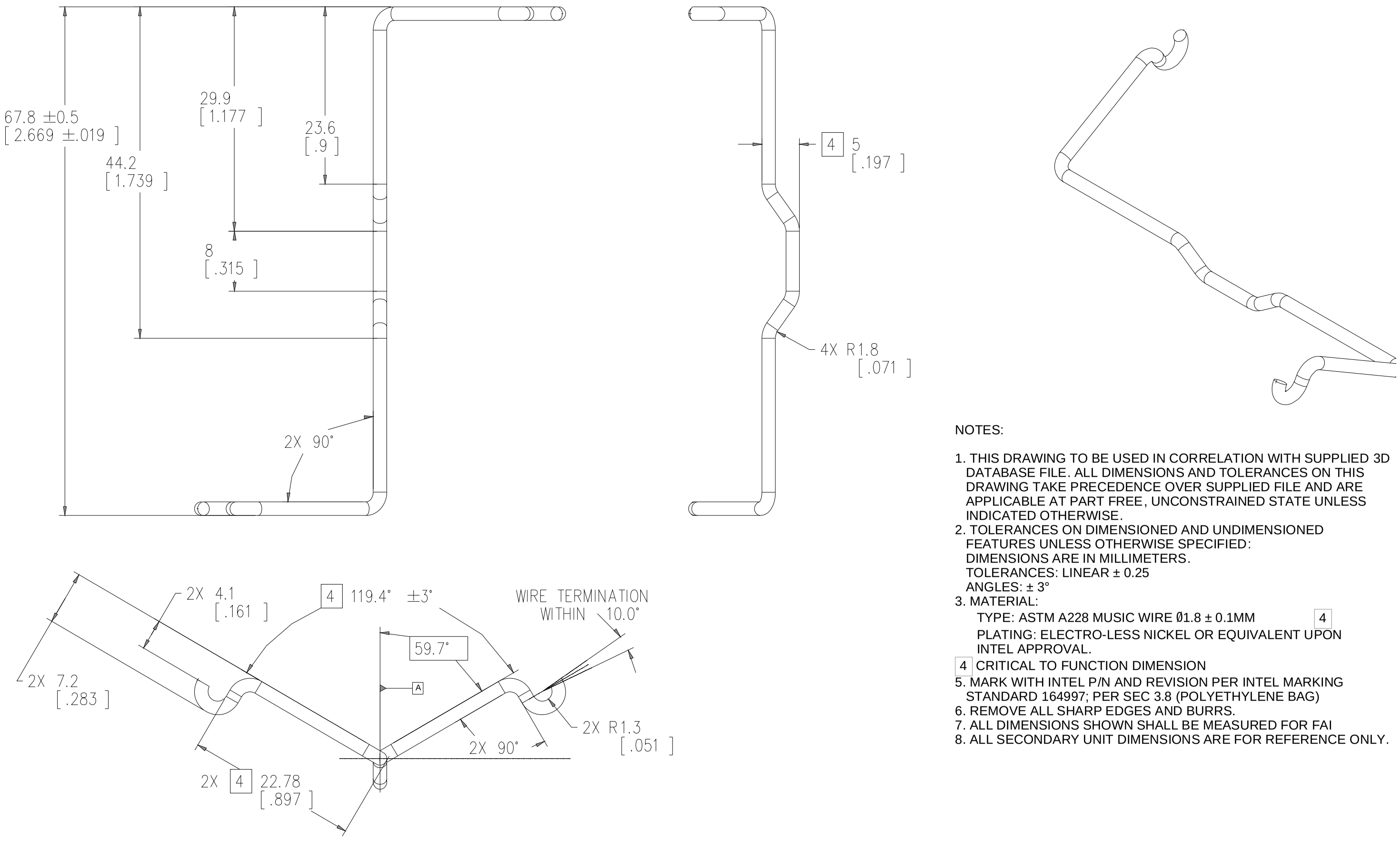
DEPARTMENT TMI
intel® CORP
2200 MISSION COLLEGE BLVD.
P.O. BOX 58119
SANTA CLARA, CA 95052-8119

TITLE
BROADWATER MCH
BTX HEAT SINK

SIZE	DRAWING NUMBER	REV
A1	D29080	A

SCALE: 3:1 | DO NOT SCALE DRAWING | SHEET 1 OF 1

Figure B-3. Z-Clip Wire



NOTES:

1. THIS DRAWING TO BE USED IN CORRELATION WITH SUPPLIED 3D DATABASE FILE. ALL DIMENSIONS AND TOLERANCES ON THIS DRAWING TAKE PRECEDENCE OVER SUPPLIED FILE AND ARE APPLICABLE AT PART FREE, UNCONSTRAINED STATE UNLESS INDICATED OTHERWISE.
2. TOLERANCES ON DIMENSIONED AND UNDIMENSIONED FEATURES UNLESS OTHERWISE SPECIFIED:
   DIMENSIONS ARE IN MILLIMETERS.
   TOLERANCES: LINEAR ± 0.25
   ANGLES: ± 3°
3. MATERIAL:
   TYPE: ASTM A228 MUSIC WIRE Ø1.8 ± 0.1MM 4
   PLATING: ELECTRO-LESS NICKEL OR EQUIVALENT UPON INTEL APPROVAL.
4. CRITICAL TO FUNCTION DIMENSION
5. MARK WITH INTEL P/N AND REVISION PER INTEL MARKING STANDARD 164997; PER SEC 3.8 (POLYETHYLENE BAG)
6. REMOVE ALL SHARP EDGES AND BURRS.
7. ALL DIMENSIONS SHOWN SHALL BE MEASURED FOR FAI
8. ALL SECONDARY UNIT DIMENSIONS ARE FOR REFERENCE ONLY.

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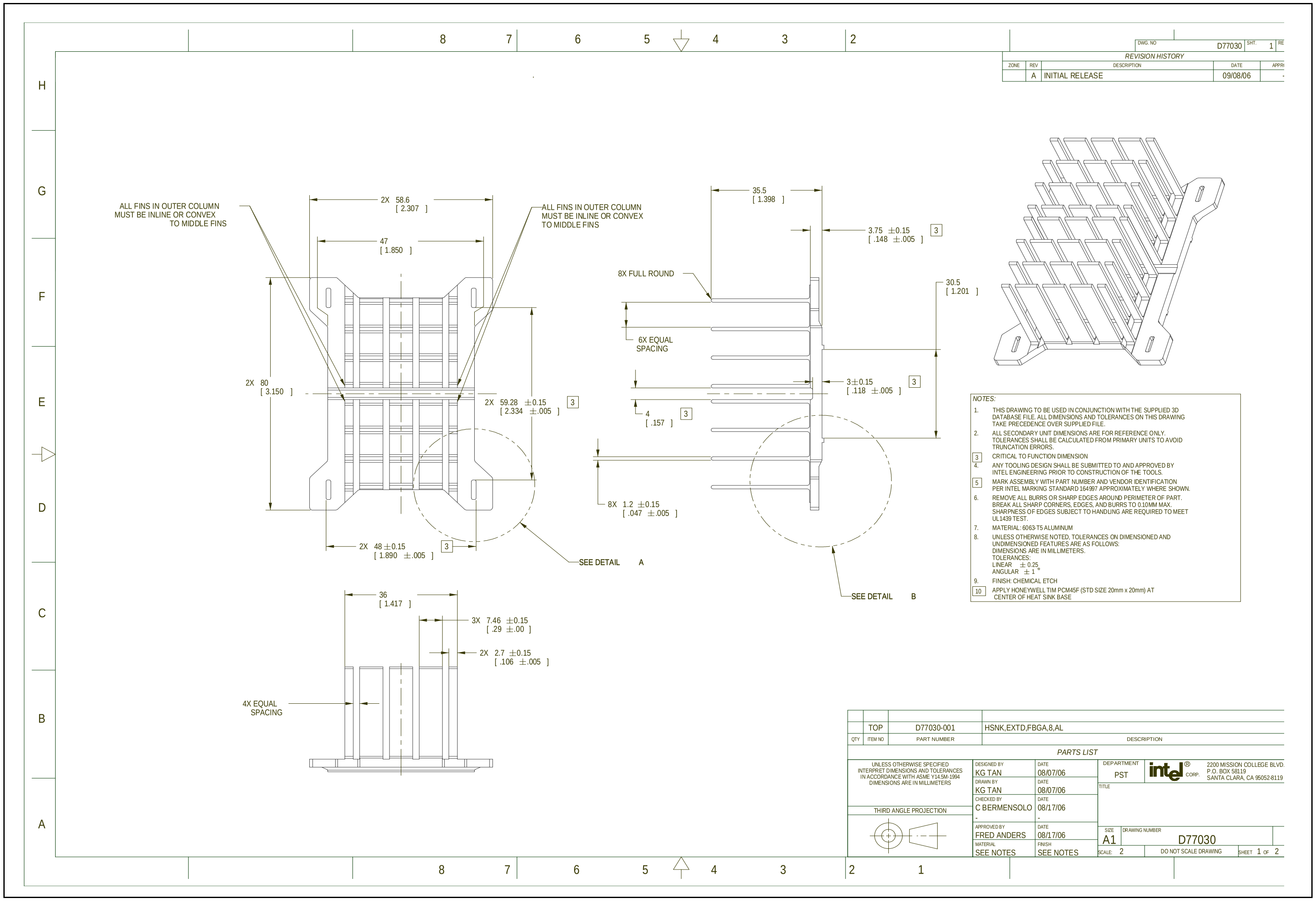
C Mechanical Drawings for Alternate Thermal Solution

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

Table C-1. Mechanical Drawing List

Drawing Description	Figure Number
"Heatsink Extrusion Drawing"	Figure C-1
"Heat Sink Extrusion Detail"	Figure C-2
"Anchor"	Figure C-3
"Ramp Retainer - Page 1"	Figure C-4
"Ramp Retainer - Page 2"	Figure C-5
"Wire Preload Clip"	Figure C-6

Figure C-1. Heatsink Extrusion Drawing



REVISION HISTORY

ZONE	REV	DESCRIPTION	DATE	APPR
	A	INITIAL RELEASE	09/08/06	-

NOTES:

1. THIS DRAWING TO BE USED IN CONJUNCTION WITH THE SUPPLIED 3D DATABASE FILE. ALL DIMENSIONS AND TOLERANCES ON THIS DRAWING TAKE PRECEDENCE OVER SUPPLIED FILE.
2. ALL SECONDARY UNIT DIMENSIONS ARE FOR REFERENCE ONLY. TOLERANCES SHALL BE CALCULATED FROM PRIMARY UNITS TO AVOID TRUNCATION ERRORS.
3. CRITICAL TO FUNCTION DIMENSION
4. ANY TOOLING DESIGN SHALL BE SUBMITTED TO AND APPROVED BY INTEL ENGINEERING PRIOR TO CONSTRUCTION OF THE TOOLS.
5. MARK ASSEMBLY WITH PART NUMBER AND VENDOR IDENTIFICATION PER INTEL MARKING STANDARD 164997 APPROXIMATELY WHERE SHOWN.
6. REMOVE ALL BURRS OR SHARP EDGES AROUND PERIMETER OF PART. BREAK ALL SHARP CORNERS, EDGES, AND BURRS TO 0.10MM MAX. SHARPNESS OF EDGES SUBJECT TO HANDLING ARE REQUIRED TO MEET UL1439 TEST.
7. MATERIAL: 6063-T5 ALUMINUM
8. UNLESS OTHERWISE NOTED, TOLERANCES ON DIMENSIONED AND UNDIMENSIONED FEATURES ARE AS FOLLOWS:
   DIMENSIONS ARE IN MILLIMETERS.
   TOLERANCES:
   LINEAR ± 0.25
   ANGULAR ± 1 °
9. FINISH: CHEMICAL ETCH
10. APPLY HONEYWELL TIM PCM45F (STD SIZE 20mm x 20mm) AT CENTER OF HEAT SINK BASE

QTY	ITEM NO	PART NUMBER	DESCRIPTION
	TOP	D77030-001	HSNK,EXTD,FBGA,8,AL

PARTS LIST

UNLESS OTHERWISE SPECIFIED INTERPRET DIMENSIONS AND TOLERANCES IN ACCORDANCE WITH ASME Y14.5M-1994 DIMENSIONS ARE IN MILLIMETERS

THIRD ANGLE PROJECTION

DESIGNED BY KG TAN	DATE 08/07/06	DEPARTMENT PST	intel® CORP. 2200 MISSION COLLEGE BLVD. P.O. BOX 58119 SANTA CLARA, CA 95052-8119
DRAWN BY KG TAN	DATE 08/07/06	TITLE	
CHECKED BY C BERMENSOLO -	DATE 08/17/06 -		
APPROVED BY FRED ANDERS	DATE 08/17/06	SIZE A1	DRAWING NUMBER D77030
MATERIAL SEE NOTES	FINISH SEE NOTES	SCALE: 2	DO NOT SCALE DRAWING SHEET 1 OF 2

Figure C-2. Heat Sink Extrusion Detail

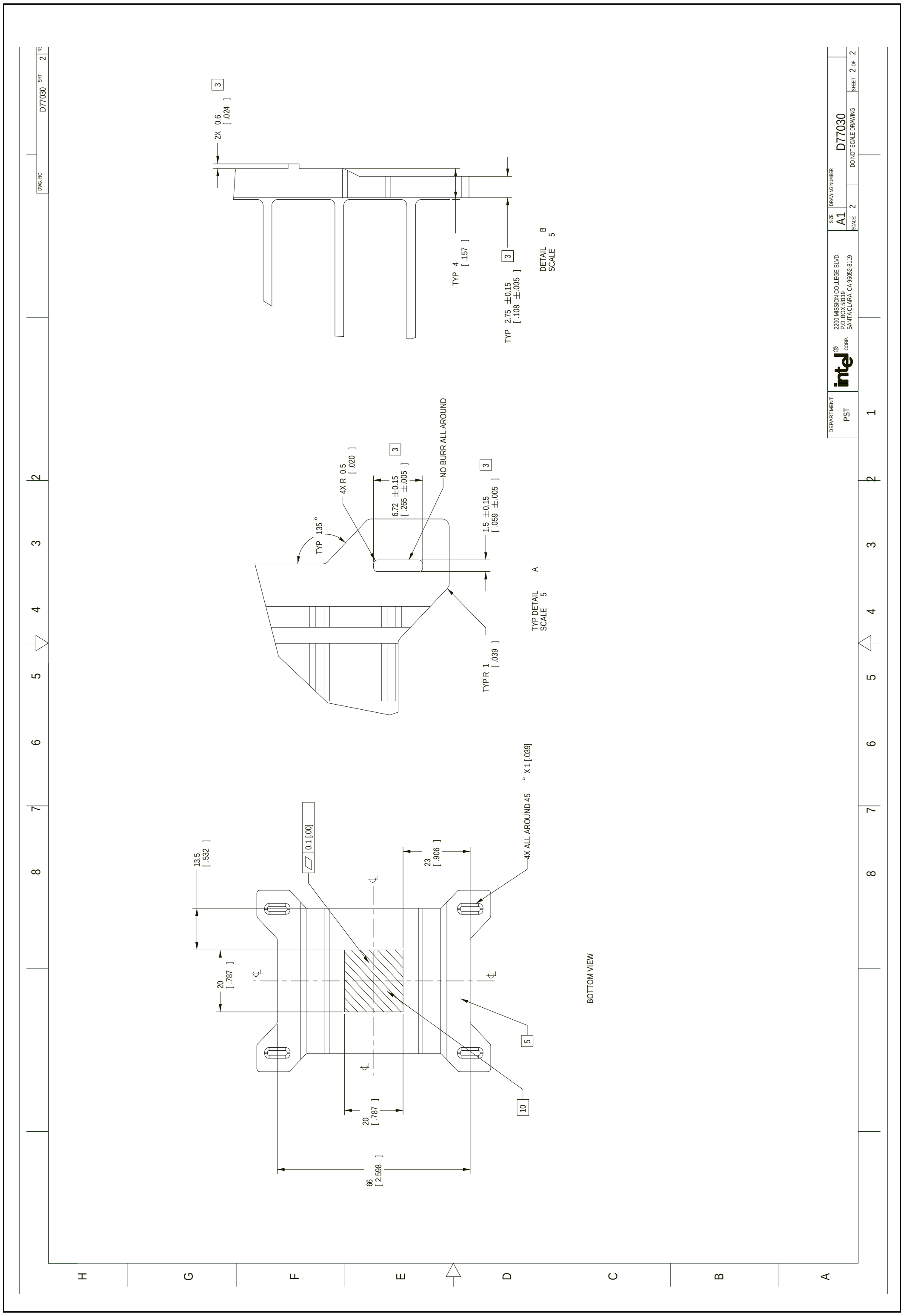
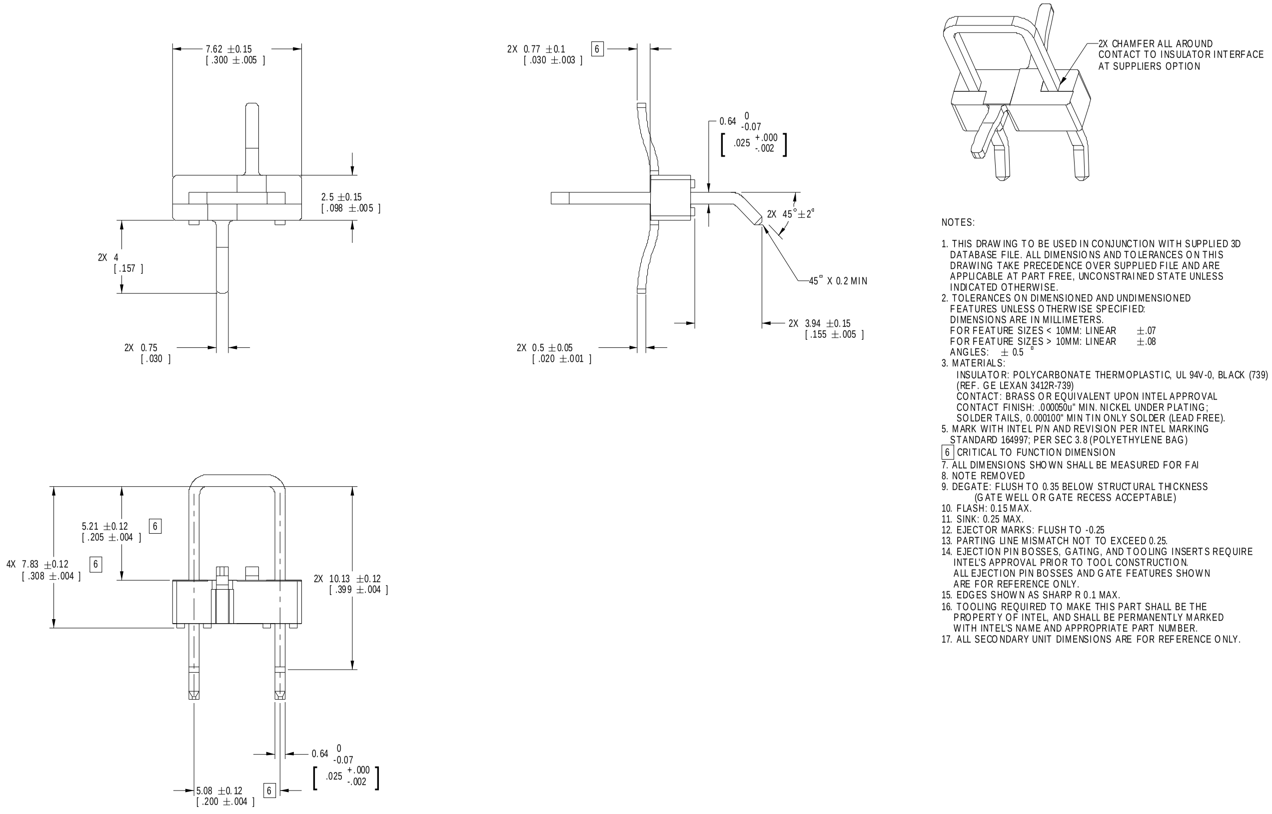


Figure C-3. Anchor



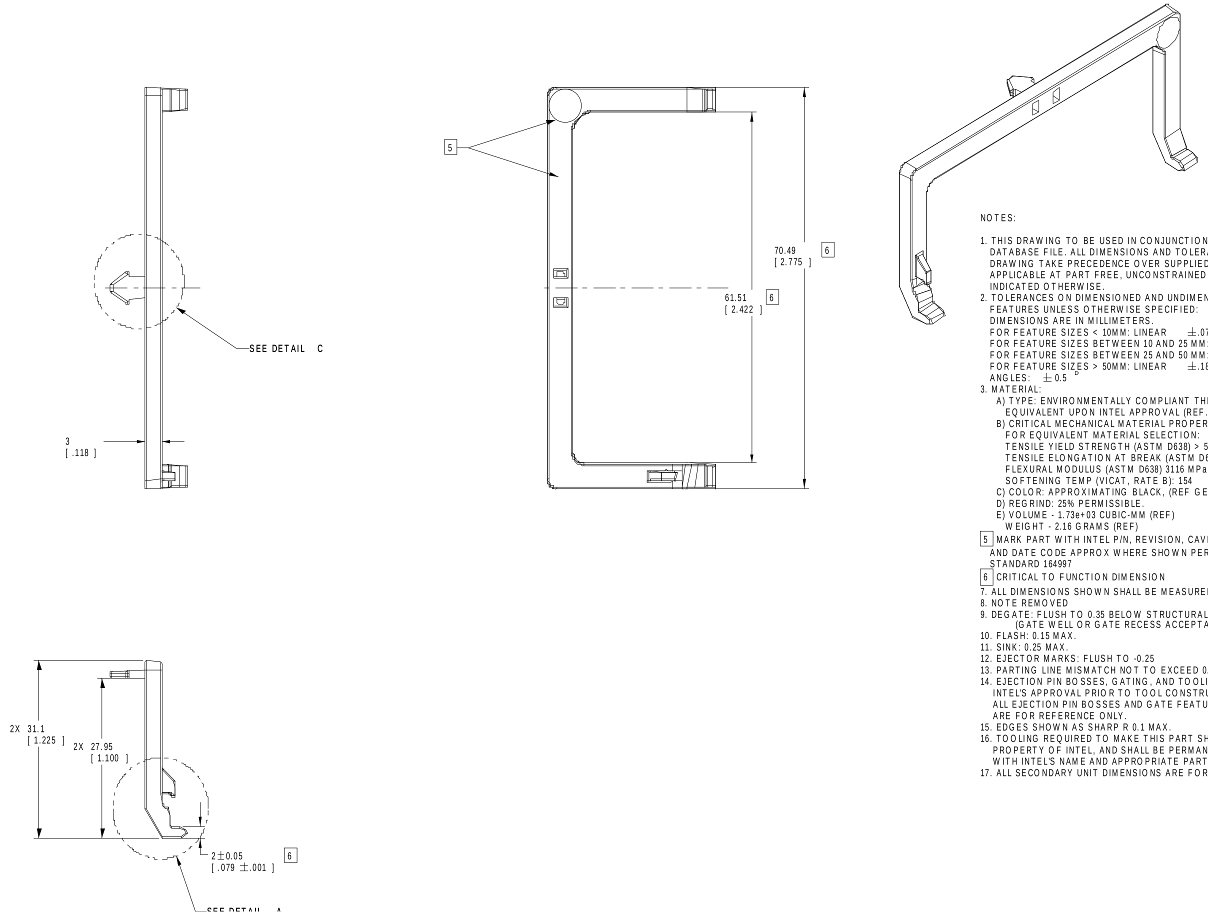
NOTES:

1. THIS DRAWING TO BE USED IN CONJUNCTION WITH SUPPLIED 3D DATABASE FILE. ALL DIMENSIONS AND TOLERANCES ON THIS DRAWING TAKE PRECEDENCE OVER SUPPLIED FILE AND ARE APPLICABLE AT PART FREE, UNCONSTRAINED STATE UNLESS INDICATED OTHERWISE.
2. TOLERANCES ON DIMENSIONED AND UNDIMENSIONED FEATURES UNLESS OTHERWISE SPECIFIED:
   DIMENSIONS ARE IN MILLIMETERS.
   FOR FEATURE SIZES < 10MM: LINEAR ±.07
   FOR FEATURE SIZES > 10MM: LINEAR ±.08
   ANGLES: ± 0.5 °
3. MATERIALS:
   INSULATOR: POLYCARBONATE THERMOPLASTIC, UL 94V-0, BLACK (739) (REF. GE LEXAN 3412R-739)
   CONTACT: BRASS OR EQUIVALENT UPON INTEL APPROVAL
   CONTACT FINISH: .000050u" MIN. NICKEL UNDER PLATING; SOLDER TAILS, 0.000100" MIN TIN ONLY SOLDER (LEAD FREE).
5. MARK WITH INTEL P/N AND REVISION PER INTEL MARKING STANDARD 164997; PER SEC 3.8 (POLYETHYLENE BAG)

6 CRITICAL TO FUNCTION DIMENSION

7. ALL DIMENSIONS SHOWN SHALL BE MEASURED FOR FAI
8. NOTE REMOVED
9. DEGATE: FLUSH TO 0.35 BELOW STRUCTURAL THICKNESS (GATE WELL OR GATE RECESS ACCEPTABLE)
10. FLASH: 0.15 MAX.
11. SINK: 0.25 MAX.
12. EJECTOR MARKS: FLUSH TO -0.25
13. PARTING LINE MISMATCH NOT TO EXCEED 0.25.
14. EJECTION PIN BOSSES, GATING, AND TOOLING INSERTS REQUIRE INTEL'S APPROVAL PRIOR TO TOOL CONSTRUCTION.
    ALL EJECTION PIN BOSSES AND GATE FEATURES SHOWN ARE FOR REFERENCE ONLY.
15. EDGES SHOWN AS SHARP R 0.1 MAX.
16. TOOLING REQUIRED TO MAKE THIS PART SHALL BE THE PROPERTY OF INTEL, AND SHALL BE PERMANENTLY MARKED WITH INTEL'S NAME AND APPROPRIATE PART NUMBER.
17. ALL SECONDARY UNIT DIMENSIONS ARE FOR REFERENCE ONLY.

Figure C-4. Ramp Retainer - Page 1



NOTES:

1. THIS DRAWING TO BE USED IN CONJUNCTION WITH SUPPLIED 3D DATABASE FILE. ALL DIMENSIONS AND TOLERANCES ON THIS DRAWING TAKE PRECEDENCE OVER SUPPLIED FILE AND ARE APPLICABLE AT PART FREE, UNCONSTRAINED STATE UNLESS INDICATED OTHERWISE.
2. TOLERANCES ON DIMENSIONED AND UNDIMENSIONED FEATURES UNLESS OTHERWISE SPECIFIED:
   DIMENSIONS ARE IN MILLIMETERS.
   FOR FEATURE SIZES < 10MM: LINEAR ±.07
   FOR FEATURE SIZES BETWEEN 10 AND 25 MM: LINEAR ± .08
   FOR FEATURE SIZES BETWEEN 25 AND 50 MM: LINEAR ± .10
   FOR FEATURE SIZES > 50MM: LINEAR ±.18
   ANGLES: ± 0.5 °
3. MATERIAL:
   A) TYPE: ENVIRONMENTALLY COMPLIANT THERMOPLASTIC OR EQUIVALENT UPON INTEL APPROVAL (REF. GE LEXAN 500ECR-739)
   B) CRITICAL MECHANICAL MATERIAL PROPERTIES FOR EQUIVALENT MATERIAL SELECTION:
      TENSILE YIELD STRENGTH (ASTM D638) > 57 MPa
      TENSILE ELONGATION AT BREAK (ASTM D638) >= 46%
      FLEXURAL MODULUS (ASTM D638) 3116 MPa ±10%
      SOFTENING TEMP (VICAT, RATE B): 154 °C
   C) COLOR: APPROXIMATING BLACK, (REF GE 739)
   D) REGRIND: 25% PERMISSIBLE.
   E) VOLUME - 1.73e+03 CUBIC-MM (REF)
      WEIGHT - 2.16 GRAMS (REF)

5 MARK PART WITH INTEL P/N, REVISION, CAVITY NUMBER AND DATE CODE APPROX WHERE SHOWN PER INTEL MARKING STANDARD 164997

6 CRITICAL TO FUNCTION DIMENSION

7. ALL DIMENSIONS SHOWN SHALL BE MEASURED FOR FAI
8. NOTE REMOVED
9. DEGATE: FLUSH TO 0.35 BELOW STRUCTURAL THICKNESS (GATE WELL OR GATE RECESS ACCEPTABLE)
10. FLASH: 0.15 MAX.
11. SINK: 0.25 MAX.
12. EJECTOR MARKS: FLUSH TO -0.25
13. PARTING LINE MISMATCH NOT TO EXCEED 0.25.
14. EJECTION PIN BOSSES, GATING, AND TOOLING INSERTS REQUIRE INTEL'S APPROVAL PRIOR TO TOOL CONSTRUCTION. ALL EJECTION PIN BOSSES AND GATE FEATURES SHOWN ARE FOR REFERENCE ONLY.
15. EDGES SHOWN AS SHARP R 0.1 MAX.
16. TOOLING REQUIRED TO MAKE THIS PART SHALL BE THE PROPERTY OF INTEL, AND SHALL BE PERMANENTLY MARKED WITH INTEL'S NAME AND APPROPRIATE PART NUMBER.
17. ALL SECONDARY UNIT DIMENSIONS ARE FOR REFERENCE ONLY.

Figure C-5. Ramp Retainer - Page 2

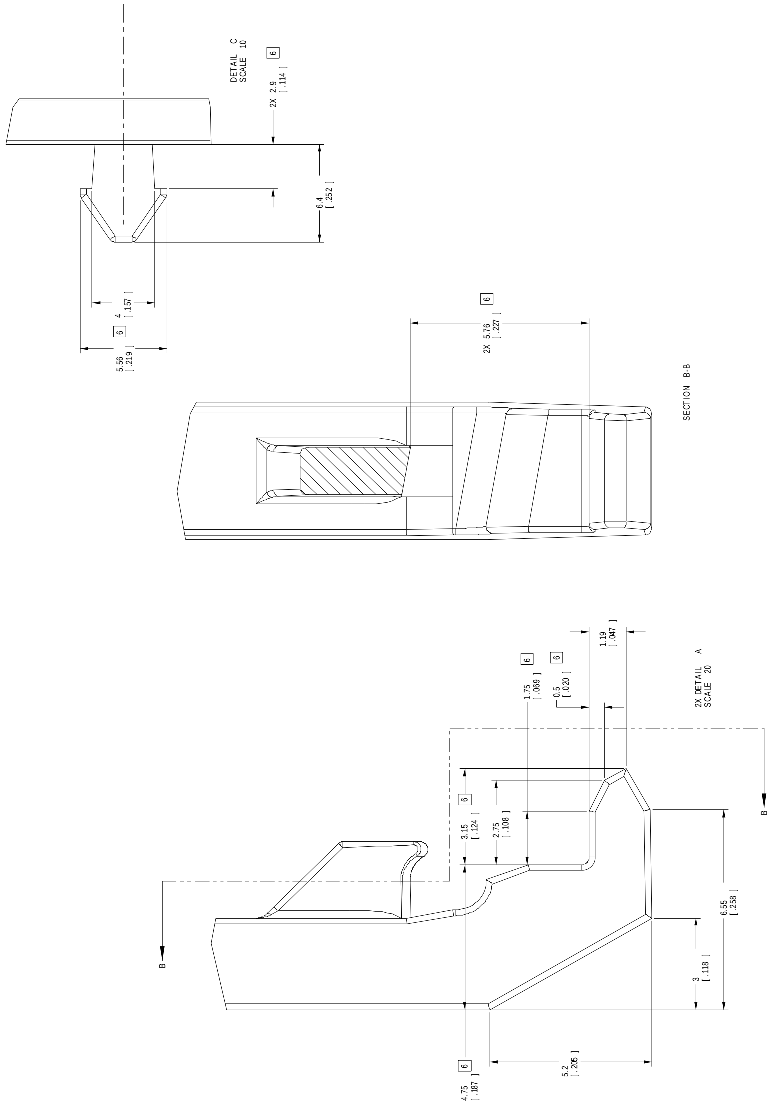
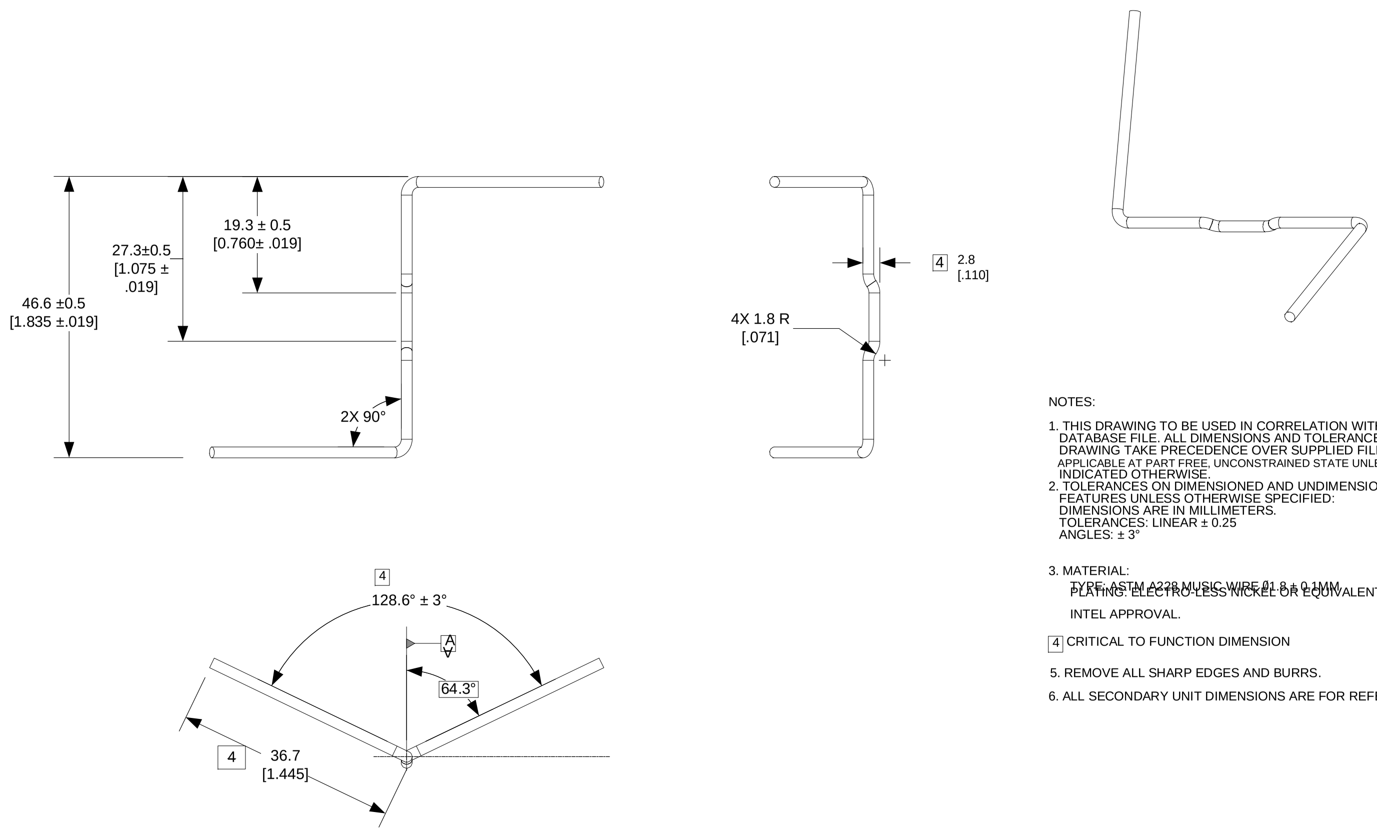


Figure C-6. Wire Preload Clip



NOTES:

1. THIS DRAWING TO BE USED IN CORRELATION WITH SUPPLIED 3 DATABASE FILE. ALL DIMENSIONS AND TOLERANCES ON THIS DRAWING TAKE PRECEDENCE OVER SUPPLIED FILE AND ARE APPLICABLE AT PART FREE, UNCONSTRAINED STATE UNLESS INDICATED OTHERWISE.
2. TOLERANCES ON DIMENSIONED AND UNDIMENSIONED FEATURES UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS.
TOLERANCES: LINEAR ± 0.25
ANGLES: ± 3°

3. MATERIAL:
TYPE: ASTM A228 MUSIC WIRE Ø1.8 ± 0.1MM
PLATING: ELECTRO-LESS NICKEL OR EQUIVALENT UPON INTEL APPROVAL.

4 CRITICAL TO FUNCTION DIMENSION

5. REMOVE ALL SHARP EDGES AND BURRS.

6. ALL SECONDARY UNIT DIMENSIONS ARE FOR REFERENCE ONLY

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