Intel® 965 Express Chipset Family

Thermal and Mechanical Design Guidelines

- For the Intel® 82Q965, 82Q963, 82G965 Graphics and Memory Controller Hub (GMCH) and Intel® 82P965 Memory Controller Hub (MCH)

January 2007
Introduction

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<th>Revision</th>
<th>Description</th>
<th>Date</th>
</tr>
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<tr>
<td>-001</td>
<td>• Initial Release</td>
<td>June 2006</td>
</tr>
<tr>
<td>-002</td>
<td>• Added 82Q965, 82G965, and 82Q963 GMCHs</td>
<td>July 2006</td>
</tr>
<tr>
<td>-003</td>
<td>• Updated idle power values in Table 2.</td>
<td>January 2007</td>
</tr>
<tr>
<td></td>
<td>• Updated enabled suppliers information. In Table 7.</td>
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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 active/passive heatsinks.

The objective of thermal management is to ensure that the temperatures of all components in a system are 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.

This document is for the following components:

- Intel® 82Q965 GMCH
- Intel® 82Q963 GMCH
- Intel® 82G965 GMCH
- Intel® 82P965 MCH

This document presents the conditions and requirements to properly design a cooling solution for systems that implement the MCH. Properly designed solutions provide adequate cooling to maintain the (G)MCH 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 (G)MCH case temperature at or below those recommended in this document, a system designer can ensure the proper functionality, performance, and reliability of this component.

Note: Unless otherwise specified, the term (G)MCH refers to the Intel® 82Q965 GMCH, Intel® 82Q963 GMCH, Intel® 82G965 GMCH, and Intel® 82P965 MCH.

Note: In this document the use of the term chipset refers to the combination of the (G)MCH and the Intel ICH8.

Note: Unless otherwise specified, ICH8 refers to the Intel® I/O Controller Hub 8 (ICH8) desktop family.
## 1.1 Terminology

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FC-BGA</td>
<td>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.</td>
</tr>
<tr>
<td>Intel® ICH8</td>
<td>Intel® I/O Controller Hub 8. The chipset component that contains the primary PCI interface, LPC interface, USB, ATA, and/or other legacy functions.</td>
</tr>
<tr>
<td>MCH</td>
<td>Memory Controller Hub. The chipset component that contains the processor and memory interfaces.</td>
</tr>
<tr>
<td>GMCH</td>
<td>Graphic Memory Controller Hub. The chipset component that contains the processor and memory interface and integrated graphics core.</td>
</tr>
<tr>
<td>( T_A )</td>
<td>The local ambient air temperature at the component of interest. The ambient temperature should be measured just upstream of airflow for a passive heatsink or at the fan inlet for an active heatsink.</td>
</tr>
<tr>
<td>( T_C )</td>
<td>The case temperature of the (G)MCH component. The measurement is made at the geometric center of the die.</td>
</tr>
<tr>
<td>( T_{C-MAX} )</td>
<td>The maximum value of ( T_C ).</td>
</tr>
<tr>
<td>( T_{C-MIN} )</td>
<td>The minimum valued of ( T_C ).</td>
</tr>
<tr>
<td>TDP</td>
<td>Thermal Design Power is specified as the maximum sustainable power to be dissipated by the (G)MCH. This is based on extrapolations in both hardware and software technology. Thermal solutions should be designed to TDP.</td>
</tr>
<tr>
<td>TIM</td>
<td>Thermal Interface Material: thermally conductive material installed between two surfaces to improve heat transfer and reduce interface contact resistance.</td>
</tr>
<tr>
<td>( \Psi_{CA} )</td>
<td>Case-to-ambient thermal solution characterization parameter (Psi). A measure of thermal solution performance using total package power. Defined as ( (T_C - T_A) / \text{Total Package Power} ). Heat source size should always be specified for ( \Psi ) measurements.</td>
</tr>
</tbody>
</table>
1.2 Reference Documents

<table>
<thead>
<tr>
<th>Document</th>
<th>Location / Document Number</th>
</tr>
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<tr>
<td>Intel® 965 Express Chipset Family Datasheet</td>
<td><a href="http://developer.intel.com/design/chipsets/datashts/313053.htm">http://developer.intel.com/design/chipsets/datashts/313053.htm</a></td>
</tr>
<tr>
<td>Intel® Pentium® D Processor 840, 830 and 820 Datasheet</td>
<td><a href="http://developer.intel.com/design/PentiumD//datashts/307506.htm">http://developer.intel.com/design/PentiumD//datashts/307506.htm</a></td>
</tr>
<tr>
<td>Intel® Pentium® 4 Processor 6x1 Sequence Datasheet</td>
<td><a href="http://developer.intel.com/design/pentium4/datashts/310308.htm">http://developer.intel.com/design/pentium4/datashts/310308.htm</a></td>
</tr>
<tr>
<td>Various System Thermal Design Suggestions</td>
<td><a href="http://www.formfactors.org">http://www.formfactors.org</a></td>
</tr>
</tbody>
</table>
# Product Specifications

## 2.1 Package Description

The (G)MCH is available in a 34 mm [1.34 in] x 34 mm [1.34 in] Flip Chip Ball Grid Array (FC-BGA) package with 1226 solder balls. The die size is 9.6 mm [0.378in] x 10.6 mm [0.417in]. A mechanical drawing of the package is shown in Figure 9, Appendix B.

### 2.1.1 Non-Grid Array Package Ball Placement

The (G)MCH package uses a “balls anywhere” concept. Minimum ball pitch is 0.8 mm [0.031 in], but ball ordering does not follow a 0.8-mm grid. Board designers should ensure correct ball placement when designing for the non-grid array pattern. For exact ball locations relative to the package, refer to the Intel® 965 Express Chipset Datasheet.
2.2 Package Loading Specifications

Table 1 provides static load specifications for the package. This mechanical maximum load limit should not be exceeded during heatsink assembly, shipping conditions, or use conditions. Also, any mechanical system or component testing should not exceed the maximum limit. The package substrate should not be used as a mechanical reference or load-bearing surface for the thermal and mechanical solution.

**Table 1. Package Loading Specifications**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Maximum</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static</td>
<td>15 lbf</td>
<td>1,2,3</td>
</tr>
</tbody>
</table>

**NOTES:**
1. These specifications apply to uniform compressive loading in a direction normal to the package.
2. This is the maximum force that can be applied by a heatsink retention clip. The clip must also provide the minimum specified load on the package.
3. These specifications are based on limited testing for design characterization. Loading limits are for the package only.
2.3 Thermal Specifications

To ensure proper operation and reliability of the (G)MCH, the temperature must be at or below the maximum case temperature specified in Table 2 when operating at TDP. System and component level thermal enhancements are required to dissipate the heat generated and maintain the (G)MCH within specifications. Chapter 3 provides the thermal metrology guidelines for case temperature measurements.

The (G)MCH should also operate above the minimum case temperature specification listed in Table 2.

2.4 Thermal Design Power (TDP)

2.4.1 Definition

Thermal design power (TDP) is the estimated power dissipation of the (G)MCH based on normal operating conditions including \( V_{CC} \) and \( T_{C-MAX} \) while executing real worst-case power intensive applications. This value is based on expected worst-case data traffic patterns and usage of the chipset and does not represent a specific software application. TDP attempts to account for expected increases in power due to variation in (G)MCH current consumption due to silicon process variation, processor speed, DRAM capacitive bus loading and temperature. However, since these variations are subject to change, the TDP cannot ensure that all applications will not exceed the TDP value.

The system designer must design a thermal solution for the (G)MCH such that it maintains \( T_{C} \) below \( T_{C-MAX} \) for a sustained power level equal to TDP. Note that the \( T_{C-MAX} \) specification is a requirement for a sustained power level equal to TDP, and that the case temperature must be maintained at temperatures less than \( T_{C-MAX} \) when operating at power levels less than TDP. This temperature compliance is to ensure component reliability over its useful life. The TDP value can be used for thermal design if the thermal protection mechanisms are enabled. The (G)MCH incorporates a hardware-based fail-safe mechanism to keep the product temperature within specifications in the event of unusually strenuous usage above the TDP power.

2.4.2 Methodology

2.4.2.1 Pre-Silicon

To determine TDP for pre-silicon products in development, it is necessary to make estimates based on analytical models. These models rely on knowledge of the past MCH power dissipation behavior along with knowledge of planned architectural and process changes that may affect TDP. Knowledge of applications available today and their ability to stress various aspects of the (G)MCH is also included in the model. The projection for TDP assumes (G)MCH operation at \( T_{C-MAX} \). The TDP estimate also accounts for normal manufacturing process variation.

2.4.2.2 Post-Silicon

Once the product silicon is available, post-silicon validation is performed to assess the validity of pre-silicon projections. Testing is performed on both commercially available and synthetic high power applications and power data is compared to pre-silicon estimates. Post-silicon validation may result in a small adjustment to pre-silicon TDP estimates.
2.4.3 Specifications

The data in Table 2 is based on post-silicon power measurements of initial (G)MCH silicon. The system configuration is: two (2) DIMMs per channel, DDR2, FSB operating at the top speed allowed by the chipset with a processor operating at that system bus speed. FC-BGA packages have poor heat transfer capability into the board and have minimal thermal capability without thermal solutions. Intel requires that system designers plan for an attached heatsink when using the (G)MCH.

Table 2. Thermal Design Power

<table>
<thead>
<tr>
<th>Component</th>
<th>System Bus Speed</th>
<th>Memory Frequency</th>
<th>$T_{C-MIN}$</th>
<th>$T_{C-MAX}$</th>
<th>Idle Power</th>
<th>TDP Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>82G965 GMCH</td>
<td>1066 MHz</td>
<td>800 MHz</td>
<td>0 °C</td>
<td>97°C</td>
<td>10.7 W</td>
<td>28 W</td>
</tr>
<tr>
<td>82Q965 GMCH</td>
<td>1066 MHz</td>
<td>800 MHz</td>
<td>0 °C</td>
<td>97°C</td>
<td>10.7 W</td>
<td>28 W</td>
</tr>
<tr>
<td>82Q963 GMCH</td>
<td>1066 MHz</td>
<td>800 MHz</td>
<td>0 °C</td>
<td>97°C</td>
<td>10.6 W</td>
<td>28 W</td>
</tr>
<tr>
<td>82P965 MCH</td>
<td>1066 MHz</td>
<td>800 MHz</td>
<td>0 °C</td>
<td>102 °C</td>
<td>9.3 W</td>
<td>19 W</td>
</tr>
</tbody>
</table>

NOTES:
1. Thermal specifications assume an attached heatsink is present.
2. Idle Power is based on a typical part in system booted to Windows® OS with no background applications running and the component has a 65 °C case temperature.
3. When an external graphics card is installed in a system with the 82G965, 82Q965 or 82Q963 GMCH, the TDP for these components will drop to approximately 19 W. The GMCH will detect the presence of the graphics card and disable the on-board graphics resulting in the lower TDP for the components.

2.4.4 TCONTROL Limit

Intel® Quiet System Technology (Intel® QST) monitors an embedded thermal sensor. The maximum operating limit when monitoring this thermal sensor is $T_{CONTROL}$. For the (G)MCH, this value as been defined as 95 °C. This value should be programmed into the appropriate Intel® QST register as the maximum sensor temperature for operation of the (G)MCH.
3 Thermal Metrology

The system designer must measure temperatures in order to accurately determine the thermal performance of the system. Intel has established guidelines for proper techniques of measuring (G)MCH component case temperatures.

3.1 Case Temperature Measurements

To ensure functionality and reliability of the (G)MCH the $T_C$ must be maintained at or below the maximum temperature listed in Table 2. The surface temperature measured at the geometric center of the die corresponds to $T_C$. Measuring $T_C$ requires special care to ensure an accurate temperature reading.

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 bead and the surface of the package, heat loss by radiation and/or convection, conduction through thermocouple leads, or contact between the thermocouple cement and the heatsink base (if a heatsink is used). To minimize these measurement errors a thermocouple attach with a zero-degree methodology is recommended.

3.1.1 Thermocouple Attach Methodology

1. Mill a 3.3 mm [0.13 in] diameter hole centered on bottom of the heatsink base. The milled hole should be approximately 1.5 mm [0.06 in] deep.
2. Mill a 1.3 mm [0.05 in] wide slot, 0.5 mm [0.02 in] deep, from the centered hole to one edge of the heatsink. The slot should be in the direction parallel to the heatsink fins (see Figure 3).
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 K-type thermocouple bead to the center of the top surface of the die using cement with high thermal conductivity. During this step, make sure 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 2).
6. Attach heatsink assembly to the (G)MCH, and route thermocouple wires out through the milled slot.
Figure 2. 0° Angle Attach Methodology (top view, not to scale)

Figure 3. 0° Angle Attach Heatsink Modifications (generic heatsink side and bottom view)

**NOTE:** Diagram not to scale
3.2 Airflow Characterization

Figure 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. 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 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 (G)MCH. 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.
3.3 Thermal Mechanical Test Vehicle

A Thermal Mechanical Test Vehicle (TMTV) is available for early thermal testing prior to the availability of actual silicon. The TMTV contains a heater die and can be powered up to a desired power level to simulate the heating of a (G)MCH package. The TMTV also contains daisy chain functionality and can be used for mechanical testing. The TMTV needs to be surface mounted to a custom board designed to provide connectivity to the die heater and/or daisy chain depending on the needs of the user. The package ball connections are provided so the user may design and build a board to interface with the TMTV. Note that although the TMTV is designed to closely match the (G)MCH package mechanical form and fit, it is recommended that final validation be performed with actual production silicon. The TMTV mechanical features, including die size, ball count, etc., may not reflect those of the final production package.

Contact your Intel Field Sales Representative on the availability of the (G)MCH TMTV for your development needs.
4 Reference Thermal Solution

The design strategy for the reference component thermal solution for the (G)MCH in ATX platforms reuses the ramp retainer, extrusion design and anchors from the (G)MCH thermal solution. The thermal interface material and a wire preload clip are being redesigned to meet the (G)MCH thermal requirements.

The BTX reference design for the (G)MCH include a new extrusion, clip with higher preload and a new thermal interface material. A slightly larger motherboard keep out zone than used by the (G)MCH thermal solution has been defined, see Figure 11

This chapter provides detailed information on operating environment assumptions, heatsink manufacturing, and mechanical reliability requirements for the (G)MCH.

4.1 Operating Environment

The operating environment of the (G)MCH will differ depending on system configuration and motherboard layout. This section defines operating environment boundary conditions that are typical for ATX and BTX form factors. The system designer should perform analysis on platform operating environment to assess impact to thermal solution selection.

4.1.1 ATX Form Factor Operating Environment

In ATX platforms, an airflow speed of 0.76 m/s [150 lfm] is assumed to be present 25 mm [1 in] in front of the heatsink air inlet side of the attached reference thermal solution. The local ambient air temperature, $T_{A}$, at the (G)MCH heatsink in an ATX platform is assumed to be 47°C. The system integrator should note that board layout may be such that there will not be 25mm [1in] between the processor heatsink and the (G)MCH. The potential for increased airflow speeds may be realized by ensuring that airflow from the processor heatsink fan exhausts in the direction of the (G)MCH heatsink. This can be achieved by using a heatsink providing multi-directional airflow, such as a radial fin or “X” pattern heatsink. Such heatsink can deliver airflow to both the (G)MCH and other areas like the voltage regulator, as shown in Figure 5. In addition, (G)MCH board placement should ensure that the (G)MCH heatsink is within the air exhaust area of the processor heatsink.

Note that heatsink orientation alone does not ensure that 0.76 m/s [150 lfm] 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 (G)MCH heatsink.

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 system external temperature measured at sea level.
Other methods exist for providing airflow to the (G)MCH heatsink, including the use of system fans and/or ducting, or the use of an attached fan (active heatsink).

### 4.1.2 Balanced Technology Extended (BTX) Form Factor Operating Environment

This section provides operating environment conditions based on what has been exhibited on the Intel micro-BTX reference design. On a BTX platform, the (G)MCH obtains in-line airflow directly from the processor thermal module. Since the processor thermal module provides lower inlet temperature airflow to the processor, reduced inlet ambient temperatures are also often seen at the (G)MCH as compared to ATX. An example of how airflow is delivered to the (G)MCH on a BTX platform is shown in Figure 6.

The local ambient air temperature, $T_A$, at the (G)MCH heatsink in the Intel micro-BTX reference design is predicted to be $\sim 45{\degree}C$. 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 system external temperature measured at sea level.

**Note that the local ambient air temperature is a projection based on the power for a 2005 platform, with processor TDP up to 130 W, and are subject to change in the next revision of this document.**
4.2 Reference Design Mechanical Envelope

The motherboard component keep-out restrictions for the (G)MCH for an ATX platform are included in Appendix B, Figure 10. The motherboard component keep-out restrictions for the (G)MCH on a BTX platform are included in Appendix B, Figure 11.

4.3 Thermal Solution Assembly

The reference thermal solution for the (G)MCH for an ATX chassis is shown in Figure 7 and is an aluminum extruded heatsink that uses two ramp retainers, a wire preload clip, and four motherboard anchors. Refer to Appendix B for the mechanical drawings. The heatsink is attached to the motherboard by assembling the anchors into the board, placing the heatsink over the (G)MCH 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. The assembly is then sent through the wave process. Post wave, the wire preload clip is assembled using the hooks on each of the ramp retainers. The clip provides the mechanical preload to the package. A thermal interface material (Honeywell* PCM45F) is pre-applied to the heatsink bottom over an area which contacts the package die.

Note: The ATX design is similar in appearance to the Intel® 945G Express chipset thermal solution, but two critical items have been changed.

- A higher performance TIM
- A clip with a higher preload to meet the TIM preload requirements.

The combination of the two new items provide the performance increase to meet the (G)MCH thermal requirements.

The reference thermal solution for the (G)MCH in a BTX chassis is shown in Figure 8. The heatsink is aluminum extruded and utilizes a Z-clip for attach. The clip is secured to the system motherboard via two solder down anchors around the (G)MCH. The clip helps to provide a mechanical preload to the package via the heatsink. A thermal
interface material (Honeywell® PCM45F) is pre-applied to the heatsink bottom over an area in contact with the package die.

Figure 7. ATX (G)MCH Heatsink - Installed on Board

Figure 8. Balanced Technology Extended (BTX) (G)MCH Heatsink - Installed on Board
4.4 Environmental Reliability Requirements

The environmental reliability requirements for the reference thermal solution are shown in Table 3 and Table 4. These should be considered as general guidelines. Validation test plans should be defined by the user based on anticipated use conditions and resulting reliability requirements.

The ATX testing will be performed with the sample board mounted on a test fixture and includes a processor heatsink with a mass of 550g. The test profiles are unpackaged board level limits.

Table 3. ATX Reference Thermal Solution Environmental Reliability Requirements (Board Level)

<table>
<thead>
<tr>
<th>Test Type</th>
<th>Requirement</th>
<th>Pass/Fail Criteria</th>
</tr>
</thead>
</table>
| Mechanical Shock      | • 3 drops 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/Electrical Check \ Thermal Performance |
| 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 Performance |
| Unbiased Humidity     | • 85 % relative humidity / 85 °C, 576 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.
<table>
<thead>
<tr>
<th>Test</th>
<th>Requirement</th>
<th>Pass/Fail Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical Shock</td>
<td>• 2 drops for + and - directions in each of 3 perpendicular axes (i.e., total 12 drops).&lt;br&gt;  • Profile: 25g, Trapezoidal waveform, 5.7 m/s [225 in/sec] minimum velocity change.</td>
<td>Visual/Electrical Check/Thermal Performance</td>
</tr>
<tr>
<td>Random Vibration</td>
<td>• Duration: 10 min/axis, 3 axes&lt;br&gt;  • Frequency Range: .001 g2/Hz @ 5Hz, ramping to .01 g2/Hz @ 20 Hz, .01 g2/Hz @ 20 Hz to 500 Hz&lt;br&gt;  • Power Spectral Density (PSD) Profile: 2.20 g RMS</td>
<td>Visual/Electrical Check/Thermal Performance</td>
</tr>
<tr>
<td>Power Cycling</td>
<td>• 7500 cycles (on/off) of minimum temperature min 27 / max 96.&lt;br&gt;• 1400 cycles (on/standby) min 35 / max 96.&lt;br&gt;• A 15 second dwell at high / low temperature for both cycles.</td>
<td>Thermal Performance - TIM degradation</td>
</tr>
<tr>
<td>Unbiased Humidity</td>
<td>• 85 % relative humidity / 85 °C, 576 hours</td>
<td>Visual Check</td>
</tr>
</tbody>
</table>

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.
3. Mechanical Shock minimum velocity change is based on a system weight of 20 to 29 lbs [9.08 kg to 13.166 kg].
4. For the chassis level testing the system will include: 1 HD, 1 ODD, 1 PSU, 2 DIMMs and the I/O shield.
5. BTX reference solution testing for shock and vibration is to mount the sample board mounted in a BTX chassis with a thermal module assembly having a maximum mass of 900 g. The test profiles are unpackaged system level limits.
Currently enabled suppliers for the (G)MCH reference thermal solution are listed in Table 5 through Table 7.

### Table 5. ATX Intel® Reference Heatsink Enabled Suppliers for Intel® 965 Express Chipset Family

<table>
<thead>
<tr>
<th>ATX items</th>
<th>Intel Part Number</th>
<th>AVC</th>
<th>CCI</th>
<th>Foxconn</th>
<th>Wieson</th>
</tr>
</thead>
<tbody>
<tr>
<td>heatsink &amp; TIM</td>
<td>D31682-001</td>
<td>S902Y1000</td>
<td>335I833301</td>
<td>2Z802-032</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>plastic clip</td>
<td>C85370-001</td>
<td>P10900002</td>
<td>334C863501</td>
<td>3EE77-002</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>wire clip</td>
<td>D29082-001</td>
<td>A20800023</td>
<td>334I833301</td>
<td>3KS02-155</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>anchor</td>
<td>C85376-001</td>
<td></td>
<td></td>
<td>2Z802-015</td>
<td>G2100C888-143</td>
</tr>
</tbody>
</table>

**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 6. Balanced Technology Extended (BTX) Intel Reference Heatsink Enabled Suppliers for Intel® 965 Express Chipset Family

<table>
<thead>
<tr>
<th>BTX items</th>
<th>Intel PN</th>
<th>AVC</th>
<th>CCI</th>
<th>Foxconn</th>
<th>Wieson</th>
</tr>
</thead>
<tbody>
<tr>
<td>heatsink assembly (HS, wire clip &amp; TIM)</td>
<td>D34258-001</td>
<td>S905Y0000</td>
<td>00183320-1A</td>
<td>2ZQ99-066</td>
<td></td>
</tr>
<tr>
<td>anchor, LF</td>
<td>A13494-008</td>
<td></td>
<td></td>
<td>HB9703E-DW</td>
<td>G2100C888-064H</td>
</tr>
</tbody>
</table>
Table 7. Supplier Contacts

<table>
<thead>
<tr>
<th>Supplier</th>
<th>Contacts</th>
<th>Phone</th>
<th>email</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVC (Asia Vital Components)</td>
<td>David Chao</td>
<td>+886-2-2299-6930 ext. 7619</td>
<td><a href="mailto:david_chao@avc.com.tw">david_chao@avc.com.tw</a></td>
</tr>
<tr>
<td></td>
<td>Raichel Hsu</td>
<td>+886-2-2299-6930 ext. 7630</td>
<td><a href="mailto:raichel_hsi@avc.com.tw">raichel_hsi@avc.com.tw</a></td>
</tr>
<tr>
<td>CCI (Chaun Choung Technology)</td>
<td>Monica Chih</td>
<td>+886-2-2995-2666</td>
<td><a href="mailto:monica_chih@ccic.com.tw">monica_chih@ccic.com.tw</a></td>
</tr>
<tr>
<td></td>
<td>Harry Lin</td>
<td>(714) 739-5797</td>
<td><a href="mailto:hlinack@aol.com">hlinack@aol.com</a></td>
</tr>
<tr>
<td>Foxconn</td>
<td>Jack Chen</td>
<td>(714) 626-1233</td>
<td><a href="mailto:jack.chen@foxconn.com">jack.chen@foxconn.com</a></td>
</tr>
<tr>
<td></td>
<td>Wanchi Chen</td>
<td>(714) 626-1376</td>
<td><a href="mailto:wanchi.chen@foxconn.com">wanchi.chen@foxconn.com</a></td>
</tr>
<tr>
<td>Wieson Technologies</td>
<td>Beatrice Chang</td>
<td>+886-2-2647-1896 ext. 6395</td>
<td><a href="mailto:beatrice@wieson.com">beatrice@wieson.com</a></td>
</tr>
<tr>
<td></td>
<td>Edwina Chu</td>
<td>+886-2-2647-1896 ext. 6390</td>
<td><a href="mailto:edwina@wieson.com">edwina@wieson.com</a></td>
</tr>
</tbody>
</table>
The following table lists the mechanical drawings available in this document.

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<th>Drawing Name</th>
<th>Page Number</th>
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</thead>
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<tr>
<td>(G)MCH Component Keep-Out Restrictions for Balanced Technology Extended (BTX) Platforms</td>
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<tr>
<td>(G)MCH Reference Heatsink for ATX Platforms – Sheet 1</td>
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<tr>
<td>(G)MCH Heatsink for ATX Platforms – Anchor</td>
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<tr>
<td>(G)MCH Reference Heatsink for ATX Platforms – Ramp Retainer Sheet 1</td>
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</tr>
<tr>
<td>(G)MCH Reference Heatsink for ATX Platforms – Ramp Retainer Sheet 2</td>
<td>35</td>
</tr>
<tr>
<td>(G)MCH Reference Heatsink for ATX Platforms – Wire Preload Clip</td>
<td>36</td>
</tr>
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<td>(G)MCH Reference Heatsink for BTX Platforms</td>
<td>37</td>
</tr>
<tr>
<td>(G)MCH Reference Heatsink for Balanced Technology Extended (BTX) Platforms – Clip</td>
<td>38</td>
</tr>
</tbody>
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**NOTE:** Unless otherwise specified, all figures in this appendix are dimensioned in millimeters. Dimensions shown in brackets are in inches.
Figure 9. (G)MCH Package Drawing
Figure 10. (G)MCH Component Keep-Out Restrictions for ATX Platforms
Figure 11. (G)MCH Component Keep-Out Restrictions for Balanced Technology Extended (BTX) Platforms
Figure 13. (G)MCH Reference Heatsink for ATX Platforms – Sheet 2
Figure 14. (G)MCH Heatsink for ATX Platforms – Anchor

NOTES:
1. THIS DRAWING TO BE USED IN CONJUNCTION WITH SUPPLIED 3D DATABASE FILE. ALL DIMENSIONS AND TOLERANCES TO NOT OPEN NO TAKE PREFERENCE OVER SUPPLIED FILE AND ARE APPLIED AT PART FREE, UNCONSTRAINED STATE UNLESS OTHERWISE SPECIFIED. DIMENSIONS AND TOLERANCES SPECIFIED ARE PRECISION LIMITS. TOLERANCES GIVEN ARE +/-.001 UNLESS OTHERWISE SPECIFIED.
2. MACHINES, MATERIALS, AND TOOLS TO BE USED ARE THE DISCRETION OF THE MANUFACTURER.
3. MATERIALS:
   - INSULATOR: POLYCARBONATE THERMOPLASTIC ULTRA-Black (ALT MR. GELICEXAN 3412R-739)
   - CONTACT: BRASS OR EQUIVALENT UPON INTEL APPROVAL
4. CONTACT FINISH: .000050u" MIN. NICKEL UNDERPLATING; SOLDER TAILS, .000100" MIN. 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
7. ALL DIMENSIONS SHOWN SHALL BE MEASURED PER 36197, 36119, 36198, 36119.4, 36119.5, 36119.6, A TOLERANCE OF 0.1 MAX.
8. ALL SECONDARY UNIT DIMENSIONS ARE FOR REFERENCE ONLY.
NOTES:
1. THIS DRAWING TO BE USED IN CONJUNCTION WITH SUPPLIED 3D DATABASE FILE. ALL DIMENSIONS AND TOLERANCES ON THIS DRAWING TAKE PRIORITY OVER ANY SUPPLIED FILE AND ARE APPLICABLE AT PART FREE, UNCONSTRAINED STATE UNLESS INDICATED OTHERWISE.
2. TOLERANCES ON DIMENSIONED AND UNDIMENSIONED FEATURES UNLESS OTHERWISE SPECIFIED:
   - DIMENSIONS IN MILLIMETERS
   - FEATURESLESS THAN 10MM: LINEAR ±.07
   - FEATURES BETWEEN 10 AND 25 MM: LINEAR ±.08
   - FEATURES BETWEEN 25 AND 50 MM: LINEAR ±.10
   - FEATURES > 50MM: LINEAR ±.18
   - ANGLES ±0.5
3. MATERIAL:
   A) TYPE: ENVIRONMENTALLY COMPLIANT THERMOPLASTIC OR EQUIVALENT UPON INTEL APPROVAL
   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
      - SOFTENING TEMP (VICTAT, RATE B): 154°C
   C) COLOR: APPROXIMATING BLACK (REF GE 739)
   D) REGRIND: 25% PERMISSIBLE.
   E) VOLUME: 1.73e+03 CUBIC-MM
      HEIGHT: 2.16 Grams
5. MARK PART WITH INTEL P/N, REVISION, CAVITY NUMBER AND DATE CODE APPROXIMATELY SHOWN FOR INTEL MARKING STANDARDS 164997
6. CRITICAL TO FUNCTION DIMENSION
7. ALL DIMENSIONS SHOWN SHALL BE MEASURED FOR ALL NOTE REMOVED
8. CREATE TOLLED TO A 3.2MM STRUCTURAL THICKNESS
9. FLASH: 0.35 MAX.
10. SINK: 0.25 MAX.
11. EJECTOR MARKS: FLUSH TO -0.25
12. EJECTOR MARK P. PUSH TO -0.25
13. PARTING LINE 45°MATCH NOT TO EXCEED 0.15
14. PARTING LINE TO MATCH NOT TO EXCEED 0.15
15. ALL SECONDARY UNIT DIMENSIONS ARE FOR REFERENCE ONLY.
16. ALL EDGES SHOW AS SHARP 0.1 MAX.
17. TOOLING REQUIRED TO MAKE THIS PART SHALL BE THE PROPERTY OF INTEL, AND SHALL BE PERMANENTLY MARKED WITH INTEL NAME AND APPROPRIATE PART NUMBER.
18. ALL SECONDARY UNIT DIMENSIONS ARE FOR REFERENCE ONLY.
Figure 16. (G)MCH Reference Heatsink for ATX Platforms – Ramp Retainer Sheet 2
Figure 18. (G)MCH Reference Heatsink for BTX Platforms
Figure 19. (G)MCH Reference Heatsink for Balanced Technology Extended (BTX) Platforms – Clip