



Intel[®] Pentium[®] Dual-Core Desktop Processor E2000[△] Series

Datasheet

March 2008



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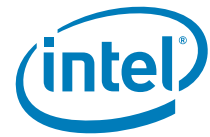
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Intel[®] Pentium[®] Dual-Core Desktop Processor E2000^Δ Series

- Available at 2.4 GHz, 2.2 GHz, 2.0 GHz, 1.80 GHz, and 1.60 GHz
- Enhanced Intel SpeedStep[®] Technology
- Supports Intel[®] 64 architecture
- Supports Execute Disable Bit capability
- Binary compatible with applications running on previous members of the Intel microprocessor line
- FSB frequency at 800 MHz
- Advance Dynamic Execution
- Very deep out-of-order execution
- Enhanced branch prediction
- Optimized for 32-bit applications running on advanced 32-bit operating systems
- Two 32-KB Level 1 data caches
- 1 MB Advanced Smart Cache
- Advanced Digital Media Boost
- Enhanced floating point and multimedia unit for enhanced video, audio, encryption, and 3D performance
- Power Management capabilities
- System Management mode
- Multiple low-power states
- 8-way cache associativity provides improved cache hit rate on load/store operations
- 775-land Package

The Intel Pentium[®] Dual-Core desktop processor E2000 series deliver Intel's advanced, powerful processors for desktop PCs. The processor is designed to deliver performance across applications and usages where end-users can truly appreciate and experience the performance. These applications include Internet audio and streaming video, image processing, video content creation, speech, 3D, CAD, games, multimedia, and multitasking user environments.

Intel[®] 64 architecture enables the processor to execute operating systems and applications written to take advantage of the Intel 64 architecture. The processor supporting Enhanced Intel SpeedStep[®] technology allows tradeoffs to be made between performance and power consumption.

The Intel Pentium[®] Dual-Core desktop processor E2000 series also includes the Execute Disable Bit capability. This feature, combined with a supported operating system, allows memory to be marked as executable or non-executable.





Revision History

| Revision Number | Description | Date |
|-----------------|--|----------------|
| -001 | <ul style="list-style-type: none">Initial release | June 2007 |
| -002 | <ul style="list-style-type: none">Added specifications for Intel® Pentium® Dual-Core Desktop processor E2180 | August 2007 |
| -003 | <ul style="list-style-type: none">Added specifications for Intel® Pentium® Dual-Core Desktop processor E2160 and E2140 for a second thermal profile (See Table 26) | September 2007 |
| -004 | <ul style="list-style-type: none">Added specifications for Intel® Pentium® Dual-Core Desktop processor E2200 | December 2007 |
| -005 | <ul style="list-style-type: none">Added specifications for Intel® Pentium® Dual-Core Desktop processor E2220 | March 2008 |

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1 Introduction

The Intel® Pentium® Dual-Core Desktop processor E2000 series combines the performance of the current generation of desktop products with the power efficiencies of a low-power microarchitecture to enable smaller, quieter systems. These dual-core processors are based on 65 nm process technology. They are 64-bit processors that maintain compatibility with IA-32 software.

The Intel® Pentium® Dual-Core Desktop processor E2000 series uses Flip-Chip Land Grid Array (FC-LGA6) package technology, and plugs into a 775-land surface mount, Land Grid Array (LGA) socket, referred to as the LGA775 socket.

Note: In this document, unless otherwise specified, the Intel® Pentium® Dual-Core Desktop processor E2000 series refers to Intel® Pentium® Dual-Core Desktop processor E2220, E2200, E2180, E2160, and E2140.

Note: In this document, unless otherwise specified, the Intel® Pentium® Dual-Core Desktop processor E2000 series is referred to as “processor.”

The processor supports advanced technologies including Execute Disable Bit, Intel® 64 architecture, and Enhanced Intel SpeedStep® technology.

The processor's front side bus (FSB) uses a split-transaction, deferred reply protocol like the Intel® Pentium® 4 processor. The FSB uses Source-Synchronous Transfer (SST) of address and data to improve performance by transferring data four times per bus clock (4X data transfer rate, as in AGP 4X). Along with the 4X data bus, the address bus can deliver addresses two times per bus clock and is referred to as a “double-clocked” or 2X address bus. Working together, the 4X data bus and 2X address bus provide a data bus bandwidth of up to 8.5 GB/s.

Intel will enable support components for the processor including heatsink, heatsink retention mechanism, and socket. Manufacturability is a high priority; hence, mechanical assembly may be completed from the top of the baseboard and should not require any special tooling.

The processor includes an address bus power-down capability which removes power from the address and data signals when the FSB is not in use. This feature is always enabled on the processor.

1.1 Terminology

A '#' symbol after a signal name refers to an active low signal, indicating a signal is in the active state when driven to a low level. For example, when RESET# is low, a reset has been requested. Conversely, when NMI is high, a nonmaskable interrupt has occurred. In the case of signals where the name does not imply an active state but describes part of a binary sequence (such as *address* or *data*), the '#' symbol implies that the signal is inverted. For example, D[3:0] = 'HLHL' refers to a hex 'A', and D[3:0]# = 'LHLH' also refers to a hex 'A' (H= High logic level, L= Low logic level).

Front Side Bus” refers to the interface between the processor and system core logic (a.k.a. the chipset components). The FSB is a multiprocessing interface to processors, memory, and I/O.



1.1.1 Processor Terminology

Commonly used terms are explained here for clarification:

- **Intel® Pentium® Dual-Core Desktop processor E2000 series** — Dual core processor in the FC-LGA6 package with a 1 MB L2 cache.
- **Processor** — For this document, the term processor is the generic form of the Intel® Pentium® Dual-Core Desktop processor E2000 series. The processor is a single package that contains one or more execution units.
- **Keep-out zone** — The area on or near the processor that system design can not use.
- **Processor core** — Processor core die with integrated L2 cache.
- **LGA775 socket** — The processors mate with the system board through a surface mount, 775-land, LGA socket.
- **Integrated heat spreader (IHS)** — A component of the processor package used to enhance the thermal performance of the package. Component thermal solutions interface with the processor at the IHS surface.
- **Retention mechanism (RM)** — Since the LGA775 socket does not include any mechanical features for heatsink attach, a retention mechanism is required. Component thermal solutions should attach to the processor via a retention mechanism that is independent of the socket.
- **FSB (Front Side Bus)** — The electrical interface that connects the processor to the chipset. Also referred to as the processor system bus or the system bus. All memory and I/O transactions as well as interrupt messages pass between the processor and chipset over the FSB.
- **Storage conditions** — Refers to a non-operational state. The processor may be installed in a platform, in a tray, or loose. Processors may be sealed in packaging or exposed to free air. Under these conditions, processor lands should not be connected to any supply voltages, have any I/Os biased, or receive any clocks. Upon exposure to “free air” (i.e., unsealed packaging or a device removed from packaging material) the processor must be handled in accordance with moisture sensitivity labeling (MSL) as indicated on the packaging material.
- **Functional operation** — Refers to normal operating conditions in which all processor specifications, including DC, AC, system bus, signal quality, mechanical and thermal are satisfied.
- **Execute Disable Bit** — The Execute Disable bit allows memory to be marked as executable or non-executable, when combined with a supporting operating system. If code attempts to run in non-executable memory the processor raises an error to the operating system. This feature can prevent some classes of viruses or worms that exploit buffer over run vulnerabilities and can thus help improve the overall security of the system. See the Intel® Architecture Software Developer's Manual for more detailed information.
- **Intel® 64 Architecture** — An enhancement to Intel's IA-32 architecture, allowing the processor to execute operating systems and applications written to take advantage of the Intel 64 architecture. Further details on Intel 64 architecture and programming model can be found in the Intel Extended Memory 64 Technology Software Developer Guide at <http://developer.intel.com/technology/64bitextensions/>.
- **Enhanced Intel SpeedStep® Technology** — Enhanced Intel SpeedStep technology allows trade-offs to be made between performance and power consumptions, based on processor utilization. This may lower average power consumption (in conjunction with OS support).



1.2 References

Material and concepts available in the following documents may be beneficial when reading this document.

Table 1. References

| Document | Location |
|---|---|
| <i>Intel® Pentium® Dual-Core Desktop Processor E2000 Series Specification Update</i> | http://www.intel.com/design/processor/specupdt/316982.htm |
| <i>Intel® Core™2 Duo Processor and Intel® Pentium® Dual Core Thermal and Mechanical Design Guidelines</i> | http://www.intel.com/design/processor/designex/317804.htm |
| <i>Intel® Pentium® D Processor, Intel® Pentium® Processor Extreme Edition, Intel® Pentium® 4 Processor, and Intel® Core™2 Duo Extreme Processor Thermal and Mechanical Design Guidelines.</i> | http://www.intel.com/design/pentiumXE/designex/306830.htm |
| <i>Voltage Regulator-Down (VRD) 11.0 Processor Power Delivery Design Guidelines For Desktop LGA775 Socket</i> | http://www.intel.com/design/processor/applnots/313214.htm |
| <i>LGA775 Socket Mechanical Design Guide</i> | http://intel.com/design/Pentium4/guides/302666.htm |
| <i>Intel® 64 and IA-32 Architecture Software Developer's Manuals</i> <i>Intel® 64 and IA-32 Architecture Software Developer's Manual Volume 1: Basic Architecture</i> <i>Intel® 64 and IA-32 Architecture Software Developer's Manual Volume 2A: Instruction Set Reference Manual A–M</i> <i>Intel® 64 and IA-32 Architecture Software Developer's Manual Volume 2B: Instruction Set Reference Manual, N–Z</i> <i>Intel® 64 and IA-32 Architecture Software Developer's Manual Volume 3A: System Programming Guide</i> <i>Intel® 64 and IA-32 Architecture Software Developer's Manual Volume 3B: System Programming Guide</i> | http://www.intel.com/products/processor/manuals/ |

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2 Electrical Specifications

This chapter describes the electrical characteristics of the processor interfaces and signals. DC electrical characteristics are provided.

2.1 Power and Ground Lands

The processor has VCC (power), VTT and VSS (ground) inputs for on-chip power distribution. All power lands must be connected to V_{CC}, while all VSS lands must be connected to a system ground plane. The processor VCC lands must be supplied the voltage determined by the **V**oltage **I**dentification (VID) lands.

The signals denoted as V_{TT} provide termination for the front side bus and power to the I/O buffers. A separate supply must be implemented for these lands, that meets the V_{TT} specifications outlined in [Table 5](#).

2.2 Decoupling Guidelines

Due to its large number of transistors and high internal clock speeds, the processor is capable of generating large current swings. This may cause voltages on power planes to sag below their minimum specified values if bulk decoupling is not adequate. Larger bulk storage (C_{BULK}), such as electrolytic or aluminum-polymer capacitors, supply current during longer lasting changes in current demand by the component, such as coming out of an idle condition. Similarly, they act as a storage well for current when entering an idle condition from a running condition. The motherboard must be designed to ensure that the voltage provided to the processor remains within the specifications listed in [Table 5](#). Failure to do so can result in timing violations or reduced lifetime of the component.

2.2.1 V_{CC} Decoupling

V_{CC} regulator solutions need to provide sufficient decoupling capacitance to satisfy the processor voltage specifications. This includes bulk capacitance with low effective series resistance (ESR) to keep the voltage rail within specifications during large swings in load current. In addition, ceramic decoupling capacitors are required to filter high frequency content generated by the front side bus and processor activity. Consult the *Voltage Regulator-Down (VRD) 11.0 Processor Power Delivery Design Guidelines For Desktop LGA775 Socket* for further information.

2.2.2 V_{TT} Decoupling

Decoupling must be provided on the motherboard. Decoupling solutions must be sized to meet the expected load. To ensure compliance with the specifications, various factors associated with the power delivery solution must be considered including regulator type, power plane and trace sizing, and component placement. A conservative decoupling solution would consist of a combination of low ESR bulk capacitors and high frequency ceramic capacitors.



2.2.3 FSB Decoupling

The processor integrates signal termination on the die. In addition, some of the high frequency capacitance required for the FSB is included on the processor package. However, additional high frequency capacitance must be added to the motherboard to properly decouple the return currents from the front side bus. Bulk decoupling must also be provided by the motherboard for proper [A]GTL+ bus operation.

2.3 Voltage Identification

The Voltage Identification (VID) specification for the processor is defined by the *Voltage Regulator-Down (VRD) 11.0 Processor Power Delivery Design Guidelines For Desktop LGA775 Socket*. The voltage set by the VID signals is the reference VR output voltage to be delivered to the processor VCC pins (see [Section 2.6.3](#) for V_{CC} overshoot specifications). Refer to [Table 13](#) for the DC specifications for these signals. Voltages for each processor frequency is provided in [Table 5](#).

Individual processor VID values may be calibrated during manufacturing such that two devices at the same core speed may have different default VID settings. This is reflected by the VID Range values provided in [Table 5](#). Refer to the *Intel® Pentium® Dual-Core Desktop Processor E2000 Series Specification Update* for further details on specific valid core frequency and VID values of the processor. Note this differs from the VID employed by the processor during a power management event (Thermal Monitor 2, Enhanced Intel SpeedStep® Technology, or Enhanced HALT State).

The processor uses six voltage identification signals, VID[6:1], to support automatic selection of power supply voltages. [Table 2](#) specifies the voltage level corresponding to the state of VID[6:1]. A '1' in this table refers to a high voltage level and a '0' refers to a low voltage level. If the processor socket is empty (VID[6:1] = 111111), or the voltage regulation circuit cannot supply the voltage that is requested, it must disable itself. The *Voltage Regulator-Down (VRD) 11.0 Processor Power Delivery Design Guidelines For Desktop LGA775 Socket* defines VID [7:0], VID7 and VID0 are not used on the processor; VID0 and VID7 are strapped to V_{SS} on the processor package. VID0 and VID7 must be connected to the VR controller for compatibility with future processors.

The processor provides the ability to operate while transitioning to an adjacent VID and its associated processor core voltage (V_{CC}). This will represent a DC shift in the load line. It should be noted that a low-to-high or high-to-low voltage state change may result in as many VID transitions as necessary to reach the target core voltage. Transitions above the specified VID are not permitted. [Table 5](#) includes VID step sizes and DC shift ranges. Minimum and maximum voltages must be maintained as shown in [Table 6](#) and [Figure 1](#) as measured across the VCC_SENSE and VSS_SENSE lands.

The VRM or VRD used must be capable of regulating its output to the value defined by the new VID. DC specifications for dynamic VID transitions are included in [Table 5](#) and [Table 6](#). Refer to the *Voltage Regulator-Down (VRD) 11.0 Processor Power Delivery Design Guidelines For Desktop LGA775 Socket* for further details.



Table 2. Voltage Identification Definition

| VID6 | VID5 | VID4 | VID3 | VID2 | VID1 | V _{CC_MAX} |
|------|------|------|------|------|------|---------------------|
| 1 | 1 | 1 | 1 | 0 | 1 | 0.8500 |
| 1 | 1 | 1 | 1 | 0 | 0 | 0.8625 |
| 1 | 1 | 1 | 0 | 1 | 1 | 0.8750 |
| 1 | 1 | 1 | 0 | 1 | 0 | 0.8875 |
| 1 | 1 | 1 | 0 | 0 | 1 | 0.9000 |
| 1 | 1 | 1 | 0 | 0 | 0 | 0.9125 |
| 1 | 1 | 0 | 1 | 1 | 1 | 0.9250 |
| 1 | 1 | 0 | 1 | 1 | 0 | 0.9375 |
| 1 | 1 | 0 | 1 | 0 | 1 | 0.9500 |
| 1 | 1 | 0 | 1 | 0 | 0 | 0.9625 |
| 1 | 1 | 0 | 0 | 1 | 1 | 0.9750 |
| 1 | 1 | 0 | 0 | 1 | 0 | 0.9875 |
| 1 | 1 | 0 | 0 | 0 | 1 | 1.0000 |
| 1 | 1 | 0 | 0 | 0 | 0 | 1.0125 |
| 1 | 0 | 1 | 1 | 1 | 1 | 1.0250 |
| 1 | 0 | 1 | 1 | 1 | 0 | 1.0375 |
| 1 | 0 | 1 | 1 | 0 | 1 | 1.0500 |
| 1 | 0 | 1 | 1 | 0 | 0 | 1.0625 |
| 1 | 0 | 1 | 0 | 1 | 1 | 1.0750 |
| 1 | 0 | 1 | 0 | 1 | 0 | 1.0875 |
| 1 | 0 | 1 | 0 | 0 | 1 | 1.1000 |
| 1 | 0 | 1 | 0 | 0 | 0 | 1.1125 |
| 1 | 0 | 0 | 1 | 1 | 1 | 1.1250 |
| 1 | 0 | 0 | 1 | 1 | 0 | 1.1375 |
| 1 | 0 | 0 | 1 | 0 | 1 | 1.1500 |
| 1 | 0 | 0 | 1 | 0 | 0 | 1.1625 |
| 1 | 0 | 0 | 0 | 1 | 1 | 1.1750 |
| 1 | 0 | 0 | 0 | 1 | 0 | 1.1875 |
| 1 | 0 | 0 | 0 | 0 | 1 | 1.2000 |
| 1 | 0 | 0 | 0 | 0 | 0 | 1.2125 |
| 0 | 1 | 1 | 1 | 1 | 1 | 1.2250 |

| VID6 | VID5 | VID4 | VID3 | VID2 | VID1 | V _{CC_MAX} |
|------|------|------|------|------|------|---------------------|
| 0 | 1 | 1 | 1 | 1 | 0 | 1.2375 |
| 0 | 1 | 1 | 1 | 0 | 1 | 1.2500 |
| 0 | 1 | 1 | 1 | 0 | 0 | 1.2625 |
| 0 | 1 | 1 | 0 | 1 | 1 | 1.2750 |
| 0 | 1 | 1 | 0 | 1 | 0 | 1.2875 |
| 0 | 1 | 1 | 0 | 0 | 1 | 1.3000 |
| 0 | 1 | 1 | 0 | 0 | 0 | 1.3125 |
| 0 | 1 | 0 | 1 | 1 | 1 | 1.3250 |
| 0 | 1 | 0 | 1 | 1 | 0 | 1.3375 |
| 0 | 1 | 0 | 1 | 0 | 1 | 1.3500 |
| 0 | 1 | 0 | 1 | 0 | 0 | 1.3625 |
| 0 | 1 | 0 | 0 | 1 | 1 | 1.3750 |
| 0 | 1 | 0 | 0 | 1 | 0 | 1.3875 |
| 0 | 1 | 0 | 0 | 0 | 1 | 1.4000 |
| 0 | 1 | 0 | 0 | 0 | 0 | 1.4125 |
| 0 | 0 | 1 | 1 | 1 | 1 | 1.4250 |
| 0 | 0 | 1 | 1 | 1 | 0 | 1.4375 |
| 0 | 0 | 1 | 1 | 0 | 1 | 1.4500 |
| 0 | 0 | 1 | 1 | 0 | 0 | 1.4625 |
| 0 | 0 | 1 | 0 | 1 | 1 | 1.4750 |
| 0 | 0 | 1 | 0 | 1 | 0 | 1.4875 |
| 0 | 0 | 1 | 0 | 0 | 1 | 1.5000 |
| 0 | 0 | 1 | 0 | 0 | 0 | 1.5125 |
| 0 | 0 | 0 | 1 | 1 | 1 | 1.5250 |
| 0 | 0 | 0 | 1 | 1 | 0 | 1.5375 |
| 0 | 0 | 0 | 1 | 0 | 1 | 1.5500 |
| 0 | 0 | 0 | 1 | 0 | 0 | 1.5625 |
| 0 | 0 | 0 | 0 | 1 | 1 | 1.5750 |
| 0 | 0 | 0 | 0 | 1 | 0 | 1.5875 |
| 0 | 0 | 0 | 0 | 0 | 1 | 1.6000 |
| 0 | 0 | 0 | 0 | 0 | 0 | OFF |



2.4 Market Segment Identification (MSID)

The MSID[1:0] signals may be used as outputs to determine the Market Segment of the processor. Table 3 provides details regarding the state of MSID[1:0]. A circuit can be used to prevent 130 W TDP processors from booting on boards optimized for 65 W TDP.

Table 3. Market Segment Selection Truth Table for MSID[1:0]^{1, 2, 3, 4}

| MSID1 | MSID0 | Description |
|-------|-------|--|
| 0 | 0 | Intel® Pentium® Dual-Core Desktop processor E2000 series |
| 0 | 1 | Reserved |
| 1 | 0 | Reserved |
| 1 | 1 | Reserved |

NOTES:

1. The MSID[1:0] signals are provided to indicate the Market Segment for the processor and may be used for future processor compatibility or for keying. Circuitry on the motherboard may use these signals to identify the processor installed.
2. These signals are not connected to the processor die.
3. A logic 0 is achieved by pulling the signal to ground on the package.
4. A logic 1 is achieved by leaving the signal as a no connect on the package.

2.5 Reserved, Unused, and TESTHI Signals

All RESERVED lands must remain unconnected. Connection of these lands to V_{CC} , V_{SS} , V_{TT} , or to any other signal (including each other) can result in component malfunction or incompatibility with future processors. See Chapter 4 for a land listing of the processor and the location of all RESERVED lands.

In a system level design, on-die termination has been included by the processor to allow signals to be terminated within the processor silicon. Most unused GTL+ inputs should be left as no connects as GTL+ termination is provided on the processor silicon. However, see Table 8 for details on GTL+ signals that do not include on-die termination.

Unused active high inputs, should be connected through a resistor to ground (V_{SS}). Unused outputs can be left unconnected, however this may interfere with some TAP functions, complicate debug probing, and prevent boundary scan testing. A resistor must be used when tying bidirectional signals to power or ground. When tying any signal to power or ground, a resistor will also allow for system testability. Resistor values should be within $\pm 20\%$ of the impedance of the motherboard trace for front side bus signals. For unused GTL+ input or I/O signals, use pull-up resistors of the same value as the on-die termination resistors (R_{TT}). For details, see Table 14.

TAP and CMOS signals do not include on-die termination. Inputs and used outputs must be terminated on the motherboard. Unused outputs may be terminated on the motherboard or left unconnected. Note that leaving unused outputs unterminated may interfere with some TAP functions, complicate debug probing, and prevent boundary scan testing.

All TESTHI[13:0] lands should be individually connected to V_{TT} via a pull-up resistor that matches the nominal trace impedance.



The TESTHI signals may use individual pull-up resistors or be grouped together as detailed below. A matched resistor must be used for each group:

- TESTHI[1:0]
- TESTHI[7:2]
- TESTHI8/FC42 – cannot be grouped with other TESTHI signals
- TESTHI9/FC43 – cannot be grouped with other TESTHI signals
- TESTHI10 – cannot be grouped with other TESTHI signals
- TESTHI11 – cannot be grouped with other TESTHI signals
- TESTHI12/FC44 – cannot be grouped with other TESTHI signals
- TESTHI13 – cannot be grouped with other TESTHI signals

However, use of boundary scan test will not be functional if these lands are connected together. For optimum noise margin, all pull-up resistor values used for TESTHI[13:0] lands should have a resistance value within $\pm 20\%$ of the impedance of the board transmission line traces. For example, if the nominal trace impedance is $50\ \Omega$, then a value between $40\ \Omega$ and $60\ \Omega$ should be used.

2.6 Voltage and Current Specification

2.6.1 Absolute Maximum and Minimum Ratings

Table 4 specifies absolute maximum and minimum ratings only and lie outside the functional limits of the processor. Within functional operation limits, functionality and long-term reliability can be expected.

At conditions outside functional operation condition limits, but within absolute maximum and minimum ratings, neither functionality nor long-term reliability can be expected. If a device is returned to conditions within functional operation limits after having been subjected to conditions outside these limits, but within the absolute maximum and minimum ratings, the device may be functional, but with its lifetime degraded depending on exposure to conditions exceeding the functional operation condition limits.

At conditions exceeding absolute maximum and minimum ratings, neither functionality nor long-term reliability can be expected. Moreover, if a device is subjected to these conditions for any length of time then, when returned to conditions within the functional operating condition limits, it will either not function, or its reliability will be severely degraded.

Although the processor contains protective circuitry to resist damage from static electric discharge, precautions should always be taken to avoid high static voltages or electric fields.



Table 4. Absolute Maximum and Minimum Ratings

| Symbol | Parameter | Min | Max | Unit | Notes ^{1, 2} |
|---------------|--|---------------|---------------|------|-----------------------|
| V_{CC} | Core voltage with respect to V_{SS} | -0.3 | 1.55 | V | - |
| V_{TT} | FSB termination voltage with respect to V_{SS} | -0.3 | 1.55 | V | - |
| T_C | Processor case temperature | See Chapter 5 | See Chapter 5 | °C | - |
| $T_{STORAGE}$ | Processor storage temperature | -40 | 85 | °C | 3, 4, 5 |

NOTES:

1. For functional operation, all processor electrical, signal quality, mechanical and thermal specifications must be satisfied.
2. Excessive overshoot or undershoot on any signal will likely result in permanent damage to the processor.
3. Storage temperature is applicable to storage conditions only. In this scenario, the processor must not receive a clock, and no lands can be connected to a voltage bias. Storage within these limits will not affect the long-term reliability of the device. For functional operation, refer to the processor case temperature specifications.
4. This rating applies to the processor and does not include any tray or packaging.
5. Failure to adhere to this specification can affect the long term reliability of the processor.



2.6.2 DC Voltage and Current Specification

Table 5. Voltage and Current Specifications

| Symbol | Parameter | Min | Typ | Max | Unit | Notes ^{1, 2} |
|---|---|---|---|------------|----------------------------|-----------------------|
| VID Range | VID | 0.8500 | — | 1.5 | V | 3 |
| V_{CC} | Processor Number E2220 E2200 E2180 E2160 E2140 | V_{CC} for 775_VR_CONFIG_06 2.4 GHz 2.2 GHz 2.0 GHz 1.8 GHz 1.6 GHz | Refer to Table 6 and Table 1 | | V | 4, 5, 6 |
| V_{CC_BOOT} | Default V_{CC} voltage for initial power up | — | 1.10 | — | V | |
| V_{CCPLL} | PLL V_{CC} | - 5% | 1.50 | + 5% | | |
| I_{CC} | Processor Number E2220 E2200 E2180 E2160 E2140 | V_{CC} for 775_VR_CONFIG_06 2.4 GHz 2.2 GHz 2.0 GHz 1.8 GHz 1.6 GHz | — | — | 75 75 75 75 75 | A 7 |
| V_{TT} | FSB termination voltage (DC + AC specifications) | 1.14 | 1.20 | 1.26 | V | 8 |
| VTT_OUT_LEFT and VTT_OUT_RIGHT I_{CC} | DC Current that may be drawn from VTT_OUT_LEFT and VTT_OUT_RIGHT per pin | — | — | 580 | mA | 9 |
| I_{TT} | I_{CC} for V_{TT} supply before V_{CC} stable I_{CC} for V_{TT} supply after V_{CC} stable | — | — | 4.5 4.6 | A | 10 |
| I_{CC_VCCPLL} | I_{CC} for PLL land | — | — | 130 | mA | |
| I_{CC_GTLREF} | I_{CC} for GTLREF | — | — | 200 | μA | |

NOTES:

- Unless otherwise noted, all specifications in this table are based on estimates and simulations or empirical data. These specifications will be updated with characterized data from silicon measurements at a later date.
- Adherence to the voltage specifications for the processor are required to ensure reliable processor operation.
- Each processor is programmed with a maximum valid voltage identification value (VID), which is set at manufacturing and can not be altered. Individual maximum VID values are calibrated during manufacturing such that two processors at the same frequency may have different settings within the VID range. Note this differs from the VID employed by the processor during a power management event (Thermal Monitor 2, Enhanced Intel SpeedStep[®] technology, or Extended HALT State).
- These voltages are targets only. A variable voltage source should exist on systems in the event that a different voltage is required. See [Section 2.3](#) and [Table 2](#) for more information.
- The voltage specification requirements are measured across VCC_SENSE and VSS_SENSE lands at the socket with a 100 MHz bandwidth oscilloscope, 1.5 pF maximum probe capacitance, and 1 MΩ minimum impedance. The maximum length of ground wire on the probe should be less than 5 mm. Ensure external noise from the system is not coupled into the oscilloscope probe.
- Refer to [Table 6](#) and [Figure 1](#) for the minimum, typical, and maximum V_{CC} allowed for a given current. The processor should not be subjected to any V_{CC} and I_{CC} combination wherein V_{CC} exceeds V_{CC_MAX} for a given current.
- I_{CC_MAX} specification is based on the V_{CC_MAX} loadline. Refer to [Figure 1](#) for details.
- V_{TT} must be provided via a separate voltage source and not be connected to V_{CC} . This specification is measured at the land.
- Baseboard bandwidth is limited to 20 MHz.
- This is maximum total current drawn from V_{TT} plane by only the processor. This specification does not include the current coming from R_{TT} (through the signal line). Refer to the *Voltage Regulator-Down (VRD) 11.0 Processor Power Delivery Design Guidelines For Desktop LGA775 Socket* to determine the total I_{TT} drawn by the system. This parameter is based on design characterization and is not tested.

Table 6. V_{CC} Static and Transient Tolerance for Processors

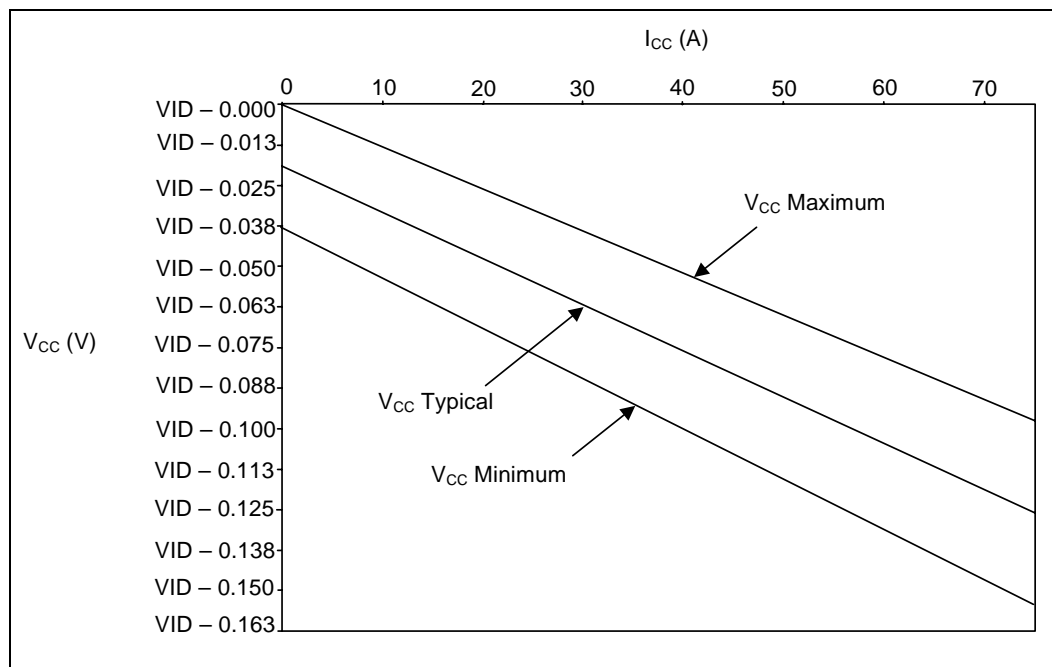
| I_{CC} (A) | Voltage Deviation from VID Setting (V) ^{1, 2, 3, 4} | | |
|--------------|--|-------------------------------------|------------------------------------|
| | Maximum Voltage 1.30 m Ω | Typical Voltage 1.425 m Ω | Minimum Voltage 1.55 m Ω |
| 0 | 0.000 | -0.019 | -0.038 |
| 5 | -0.007 | -0.026 | -0.046 |
| 10 | -0.013 | -0.033 | -0.054 |
| 15 | -0.020 | -0.040 | -0.061 |
| 20 | -0.026 | -0.048 | -0.069 |
| 25 | -0.033 | -0.055 | -0.077 |
| 30 | -0.039 | -0.062 | -0.085 |
| 35 | -0.046 | -0.069 | -0.092 |
| 40 | -0.052 | -0.076 | -0.100 |
| 45 | -0.059 | -0.083 | -0.108 |
| 50 | -0.065 | -0.090 | -0.116 |
| 55 | -0.072 | -0.097 | -0.123 |
| 60 | -0.078 | -0.105 | -0.131 |
| 65 | -0.085 | -0.112 | -0.139 |
| 70 | -0.091 | -0.119 | -0.147 |
| 75 | -0.098 | -0.126 | -0.154 |

NOTES:

1. The loadline specification includes both static and transient limits except for overshoot allowed as shown in [Section 2.6.3](#).
2. This table is intended to aid in reading discrete points on [Figure 1](#).
3. The loadlines specify voltage limits at the die measured at the VCC_SENSE and VSS_SENSE lands. Voltage regulation feedback for voltage regulator circuits must be taken from processor VCC and VSS lands. Refer to the *Voltage Regulator-Down (VRD) 11.0 Processor Power Delivery Design Guidelines For Desktop LGA775 Socket* for socket loadline guidelines and VR implementation details.
4. Adherence to this loadline specification is required to ensure reliable processor operation.



Figure 1. V_{CC} Static and Transient Tolerance for Processors



NOTES:

1. The loadline specification includes both static and transient limits except for overshoot allowed as shown in Section 2.6.3.
2. This loadline specification shows the deviation from the VID set point.
3. The loadlines specify voltage limits at the die measured at the VCC_SENSE and VSS_SENSE lands. Voltage regulation feedback for voltage regulator circuits must be taken from processor VCC and VSS lands. Refer to the *Voltage Regulator-Down (VRD) 11.0 Processor Power Delivery Design Guidelines For Desktop LGA775 Socket* for socket loadline guidelines and VR implementation details.

2.6.3 V_{CC} Overshoot

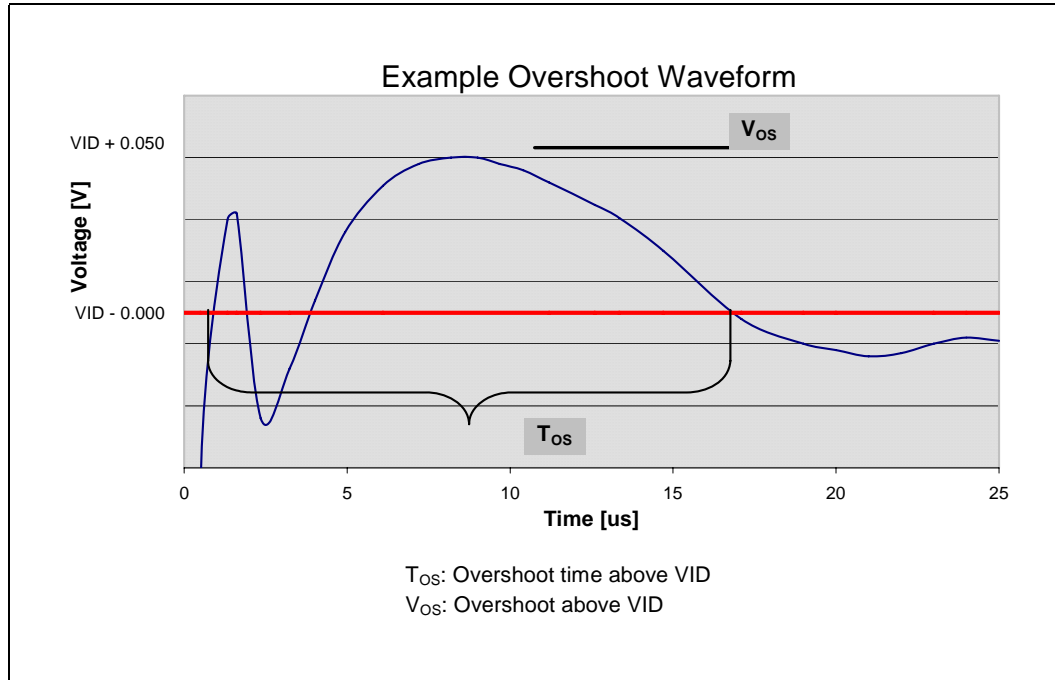
The processor can tolerate short transient overshoot events where V_{CC} exceeds the VID voltage when transitioning from a high to low current load condition. This overshoot cannot exceed VID + V_{OS_MAX} (V_{OS_MAX} is the maximum allowable overshoot voltage). The time duration of the overshoot event must not exceed T_{OS_MAX} (T_{OS_MAX} is the maximum allowable time duration above VID). These specifications apply to the processor die voltage as measured across the VCC_SENSE and VSS_SENSE lands.

Table 7. V_{CC} Overshoot Specifications

| Symbol | Parameter | Min | Max | Unit | Figure | Notes |
|---------------------|--|-----|-----|------|--------|-------|
| V _{OS_MAX} | Magnitude of V _{CC} overshoot above VID | — | 50 | mV | 2 | 1 |
| T _{OS_MAX} | Time duration of V _{CC} overshoot above VID | — | 25 | μs | 2 | 1 |

NOTES:

1. Adherence to these specifications is required to ensure reliable processor operation.

Figure 2. V_{CC} Overshoot Example Waveform

NOTES:

1. V_{OS} is measured overshoot voltage.
2. T_{OS} is measured time duration above VID.

2.6.4 Die Voltage Validation

Overshoot events on processor must meet the specifications in [Table 7](#) when measured across the V_{CC_SENSE} and V_{SS_SENSE} lands. Overshoot events that are < 10 ns in duration may be ignored. These measurements of processor die level overshoot must be taken with a bandwidth limited oscilloscope set to a greater than or equal to 100 MHz bandwidth limit.

2.7 Signaling Specifications

Most processor Front Side Bus signals use Gunning Transceiver Logic (GTL+) signaling technology. This technology provides improved noise margins and reduced ringing through low voltage swings and controlled edge rates. Platforms implement a termination voltage level for GTL+ signals defined as V_{TT} . Because platforms implement separate power planes for each processor (and chipset), separate V_{CC} and V_{TT} supplies are necessary. This configuration allows for improved noise tolerance as processor frequency increases. Speed enhancements to data and address busses have caused signal integrity considerations and platform design methods to become even more critical than with previous processor families. The GTL+ inputs require a reference voltage (GTLREF) which is used by the receivers to determine if a signal is a logical 0 or a logical 1. GTLREF must be generated on the motherboard (see [Table 14](#) for GTLREF specifications). Termination resistors (R_{TT}) for GTL+ signals are provided on the processor silicon and are terminated to V_{TT} . Intel chipsets will also provide on-die termination, thus eliminating the need to terminate the bus on the motherboard for most GTL+ signals.



2.7.1 FSB Signal Groups

The front side bus signals have been combined into groups by buffer type. GTL+ input signals have differential input buffers, which use GTLREF[1:0] as a reference level. In this document, the term “GTL+ Input” refers to the GTL+ input group as well as the GTL+ I/O group when receiving. Similarly, “GTL+ Output” refers to the GTL+ output group as well as the GTL+ I/O group when driving.

With the implementation of a source synchronous data bus comes the need to specify two sets of timing parameters. One set is for common clock signals which are dependent upon the rising edge of BCLK0 (ADS#, HIT#, HITM#, etc.) and the second set is for the source synchronous signals which are relative to their respective strobe lines (data and address) as well as the rising edge of BCLK0. Asynchronous signals are still present (A20M#, IGNNE#, etc.) and can become active at any time during the clock cycle. Table 8 identifies which signals are common clock, source synchronous, and asynchronous.

Table 8. FSB Signal Groups

| Signal Group | Type | Signals ¹ | | | | | | | | | | | | | | |
|----------------------------------|------------------------------|---|---------|-------------------|----------------------------------|---------|------------------------|---------|-----------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| GTL+ Common Clock Input | Synchronous to BCLK[1:0] | BPR1#, DEFER#, RESET#, RS[2:0]#, TRDY# | | | | | | | | | | | | | | |
| GTL+ Common Clock I/O | Synchronous to BCLK[1:0] | ADS#, BNR#, BPM[5:0]#, BR0#, DBSY#, DRDY#, HIT#, HITM#, LOCK# | | | | | | | | | | | | | | |
| GTL+ Source Synchronous I/O | Synchronous to assoc. strobe | <table border="0"> <thead> <tr> <th>Signals</th> <th>Associated Strobe</th> </tr> </thead> <tbody> <tr> <td>REQ[4:0]#, A[16:3]#³</td> <td>ADSTB0#</td> </tr> <tr> <td>A[35:17]#³</td> <td>ADSTB1#</td> </tr> <tr> <td>D[15:0]#, DBI0#</td> <td>DSTBP0#, DSTBN0#</td> </tr> <tr> <td>D[31:16]#, DBI1#</td> <td>DSTBP1#, DSTBN1#</td> </tr> <tr> <td>D[47:32]#, DBI2#</td> <td>DSTBP2#, DSTBN2#</td> </tr> <tr> <td>D[63:48]#, DBI3#</td> <td>DSTBP3#, DSTBN3#</td> </tr> </tbody> </table> | Signals | Associated Strobe | REQ[4:0]#, A[16:3]# ³ | ADSTB0# | A[35:17]# ³ | ADSTB1# | D[15:0]#, DBI0# | DSTBP0#, DSTBN0# | D[31:16]#, DBI1# | DSTBP1#, DSTBN1# | D[47:32]#, DBI2# | DSTBP2#, DSTBN2# | D[63:48]#, DBI3# | DSTBP3#, DSTBN3# |
| Signals | Associated Strobe | | | | | | | | | | | | | | | |
| REQ[4:0]#, A[16:3]# ³ | ADSTB0# | | | | | | | | | | | | | | | |
| A[35:17]# ³ | ADSTB1# | | | | | | | | | | | | | | | |
| D[15:0]#, DBI0# | DSTBP0#, DSTBN0# | | | | | | | | | | | | | | | |
| D[31:16]#, DBI1# | DSTBP1#, DSTBN1# | | | | | | | | | | | | | | | |
| D[47:32]#, DBI2# | DSTBP2#, DSTBN2# | | | | | | | | | | | | | | | |
| D[63:48]#, DBI3# | DSTBP3#, DSTBN3# | | | | | | | | | | | | | | | |
| GTL+ Strobes | Synchronous to BCLK[1:0] | ADSTB[1:0]#, DSTBP[3:0]#, DSTBN[3:0]# | | | | | | | | | | | | | | |
| CMOS | | A20M#, IGNNE#, INIT#, LINT0/INTR, LINT1/NMI, SMI#, STPCLK#, PWRGOOD, TCK, TDI, TMS, TRST#, BSEL[2:0], VID[6:1] | | | | | | | | | | | | | | |
| Open Drain Output | | FERR#/PBE#, IERR#, THERMTRIP#, TDO | | | | | | | | | | | | | | |
| Open Drain Input/Output | | PROCHOT# ⁴ | | | | | | | | | | | | | | |
| FSB Clock | Clock | BCLK[1:0], ITP_CLK[1:0] ² | | | | | | | | | | | | | | |
| Power/Other | | VCC, VTT, VCCA, VCCIOPLL, VCCPLL, VSS, VSSA, GTLREF[1:0], COMP[8,3:0], RESERVED, TESTHI[13:0], VCC_SENSE, VCC_MB_REGULATION, VSS_SENSE, VSS_MB_REGULATION, DBR# ² , VTT_OUT_LEFT, VTT_OUT_RIGHT, VTT_SEL, FCx, PECl, MSID[1:0] | | | | | | | | | | | | | | |

NOTES:

1. Refer to Section 4.2 for signal descriptions.
2. In processor systems where no debug port is implemented on the system board, these signals are used to support a debug port interposer. In systems with the debug port implemented on the system board, these signals are no connects.



3. The value of these signals during the active-to-inactive edge of RESET# defines the processor configuration options. See [Section 6.1](#) for details.
4. PROCHOT# signal type is open drain output and CMOS input.

Table 9. Signal Characteristics

| Signals with R_{TT} | Signals with No R_{TT} |
|---|---|
| A[35:3]#, ADS#, ADSTB[1:0]#, BNR#, BPRI#, D[63:0]#, DBI[3:0]#, DBSY#, DEFER#, DRDY#, DSTBN[3:0]#, DSTBP[3:0]#, HIT#, HITM#, LOCK#, PROCHOT#, REQ[4:0]#, RS[2:0]#, TRDY# | A20M#, BCLK[1:0], BSEL[2:0], COMP[8,3:0], IGNNE#, INIT#, ITP_CLK[1:0], LINT0/INTR, LINT1/NMI, PWRGOOD, RESET#, SMI#, STPCLK#, TESTHI[13:0], VID[6:1], GTLREF[1:0], TCK, TDI, TMS, TRST#, VTT_SEL, MSID[1:0] |
| Open Drain Signals¹ | |
| THERMTRIP#, FERR#/PBE#, IERR#, BPM[5:0]#, BRO#, TDO, FCx | |

NOTES:

1. Signals that do not have R_{TT} , nor are actively driven to their high-voltage level.

Table 10. Signal Reference Voltages

| GTLREF | $V_{TT}/2$ |
|--|--|
| BPM[5:0]#, RESET#, BNR#, HIT#, HITM#, BRO#, A[35:0]#, ADS#, ADSTB[1:0]#, BPRI#, D[63:0]#, DBI[3:0]#, DBSY#, DEFER#, DRDY#, DSTBN[3:0]#, DSTBP[3:0]#, LOCK#, REQ[4:0]#, RS[2:0]#, TRDY# | A20M#, LINT0/INTR, LINT1/NMI, IGNNE#, INIT#, PROCHOT#, PWRGOOD ¹ , SMI#, STPCLK#, TCK ¹ , TDI ¹ , TMS ¹ , TRST# ¹ |

NOTES:

1. These signals also have hysteresis added to the reference voltage. See [Table 12](#) for more information.

2.7.2 CMOS and Open Drain Signals

Legacy input signals such as A20M#, IGNNE#, INIT#, SMI#, and STPCLK# use CMOS input buffers. All of the CMOS and Open Drain signals are required to be asserted/de-asserted for at least four BCLKs in order for the processor to recognize the proper signal state. See [Section 2.7.3](#) for the DC specifications. See [Section 6.2](#) for additional timing requirements for entering and leaving the low power states.



2.7.3 Processor DC Specifications

The processor DC specifications in this section are defined at the processor core (pads) unless otherwise stated. All specifications apply to all frequencies and cache sizes unless otherwise stated.

Table 11. GTL+ Signal Group DC Specifications

| Symbol | Parameter | Min | Max | Unit | Notes ¹ |
|-----------------|------------------------|------------------------|---|------|--------------------|
| V _{IL} | Input Low Voltage | -0.10 | GTLREF – 0.10 | V | 2, 3 |
| V _{IH} | Input High Voltage | GTLREF + 0.10 | V _{TT} + 0.10 | V | 4, 5, 3 |
| V _{OH} | Output High Voltage | V _{TT} – 0.10 | V _{TT} | V | 5, 3 |
| I _{OL} | Output Low Current | N/A | $\frac{V_{TT_MAX}}{[(R_{TT_MIN}) + (2 * R_{ON_MIN})]}$ | A | - |
| I _{LI} | Input Leakage Current | N/A | ± 100 | µA | 6 |
| I _{LO} | Output Leakage Current | N/A | ± 100 | µA | 7 |
| R _{ON} | Buffer On Resistance | 10 | 13 | Ω | |

NOTES:

1. Unless otherwise noted, all specifications in this table apply to all processor frequencies.
2. V_{IL} is defined as the voltage range at a receiving agent that will be interpreted as a logical low value.
3. The V_{TT} referred to in these specifications is the instantaneous V_{TT}.
4. V_{IH} is defined as the voltage range at a receiving agent that will be interpreted as a logical high value.
5. V_{IH} and V_{OH} may experience excursions above V_{TT}. However, input signal drivers must comply with the signal quality specifications.
6. Leakage to V_{SS} with land held at V_{TT}.
7. Leakage to V_{TT} with land held at 300 mV

Table 12. Open Drain and TAP Output Signal Group DC Specifications

| Symbol | Parameter | Min | Max | Unit | Notes ¹ |
|-----------------|------------------------|------------------------|------------------------|------|--------------------|
| V _{OL} | Output Low Voltage | 0 | 0.20 | V | - |
| V _{OH} | Output High Voltage | V _{TT} – 0.05 | V _{TT} + 0.05 | V | 2 |
| I _{OL} | Output Low Current | 16 | 50 | mA | 3 |
| I _{LO} | Output Leakage Current | N/A | ± 200 | µA | 4 |

NOTES:

1. Unless otherwise noted, all specifications in this table apply to all processor frequencies.
2. V_{OH} is determined by the value of the external pull-up resistor to V_{TT}.
3. Measured at V_{TT} * 0.2.
4. For Vin between 0 and V_{OH}



Table 13. CMOS Signal Group DC Specifications

| Symbol | Parameter | Min | Max | Unit | Notes ¹ |
|----------|------------------------|-----------------|-----------------|---------|--------------------|
| V_{IL} | Input Low Voltage | -0.10 | $V_{TT} * 0.30$ | V | 2, 3 |
| V_{IH} | Input High Voltage | $V_{TT} * 0.70$ | $V_{TT} + 0.10$ | V | 4, 5, 3 |
| V_{OL} | Output Low Voltage | -0.10 | $V_{TT} * 0.10$ | V | 3 |
| V_{OH} | Output High Voltage | $0.90 * V_{TT}$ | $V_{TT} + 0.10$ | V | 6, 5, 3 |
| I_{OL} | Output Low Current | 1.70 | 4.70 | mA | 3, 7 |
| I_{OH} | Output High Current | 1.70 | 4.70 | mA | 3, 7 |
| I_{LI} | Input Leakage Current | N/A | ± 100 | μ A | 8 |
| I_{LO} | Output Leakage Current | N/A | ± 100 | μ A | 9 |

NOTES:

1. Unless otherwise noted, all specifications in this table apply to all processor frequencies.
2. V_{IL} is defined as the voltage range at a receiving agent that will be interpreted as a logical low value.
3. The V_{TT} referred to in these specifications refers to instantaneous V_{TT} .
4. V_{IH} is defined as the voltage range at a receiving agent that will be interpreted as a logical high value.
5. V_{IH} and V_{OH} may experience excursions above V_{TT} . However, input signal drivers must comply with the signal quality specifications.
6. All outputs are open drain.
7. I_{OL} is measured at $0.10 * V_{TT}$. I_{OH} is measured at $0.90 * V_{TT}$.
8. Leakage to V_{SS} with land held at V_{TT} .
9. Leakage to V_{TT} with land held at 300 mV.

2.7.3.1 GTL+ Front Side Bus Specifications

In most cases, termination resistors are not required as these are integrated into the processor silicon. See Table 9 for details on which GTL+ signals do not include on-die termination.

Valid high and low levels are determined by the input buffers by comparing with a reference voltage called GTLREF. Table 14 lists the GTLREF specifications. The GTL+ reference voltage (GTLREF) should be generated on the system board using high precision voltage divider circuits.



Table 14. GTL+ Bus Voltage Definitions

| Symbol | Parameter | Min | Typ | Max | Units | Notes ¹ |
|-----------------|---|------------|-------|------------|-------|--------------------|
| GTLREF_PU | GTLREF pull up resistor on Intel 975X and 96x Express Chipset family boards | 124 * 0.99 | 124 | 124 * 1.01 | Ω | 2 |
| GTLREF_PD | GTLREF pull down resistor on Intel 975X and 96x Express Chipset family boards | 210 * 0.99 | 210 | 210 * 1.01 | Ω | 2 |
| GTLREF_PU | GTLREF pull up resistor on Intel Series 3 Express Chipset family boards | 100 * 0.99 | 100 | 100 * 1.01 | Ω | 2 |
| GTLREF_PD | GTLREF pull down resistor on Intel Series 3 Express Chipset family boards | 200 * 0.99 | 200 | 200 * 1.01 | Ω | 2 |
| R _{TT} | Termination Resistance | 45 | 50 | 55 | Ω | 3 |
| COMP[3:0] | COMP Resistance | 49.40 | 49.90 | 50.40 | Ω | 4 |
| COMP8 | COMP Resistance | 24.65 | 24.90 | 25.15 | Ω | 4 |

NOTES:

1. Unless otherwise noted, all specifications in this table apply to all processor frequencies.
2. GTLREF is to be generated from V_{TT} by a voltage divider of 1% resistors (one divider for each GTLREF land).
3. R_{TT} is the on-die termination resistance measured at V_{TT}/3 of the GTL+ output driver.
4. COMP resistance must be provided on the system board with 1% resistors. COMP[3:0] and COMP8 resistors are to V_{SS}.



2.8 Clock Specifications

2.8.1 Front Side Bus Clock (BCLK[1:0]) and Processor Clocking

BCLK[1:0] directly controls the FSB interface speed as well as the core frequency of the processor. As in previous generation processors, the processor's core frequency is a multiple of the BCLK[1:0] frequency. The processor bus ratio multiplier will be set at its default ratio during manufacturing. Refer to [Table 15](#) for the processor supported ratios.

The processor uses a differential clocking implementation. For more information on the processor clocking, contact your Intel field representative. Platforms using a CK505 Clock Synthesizer/Driver should comply with the specifications in [Section 2.8.4](#). Platforms using a CK410 Clock Synthesizer/Driver should comply with the specifications in [Section 2.8.5](#).

Table 15. Core Frequency to FSB Multiplier Configuration

| Multiplication of System Core Frequency to FSB Frequency | Core Frequency (200 MHz BCLK/800 MHz FSB) | Notes ^{1, 2} |
|--|---|-----------------------|
| 1/6 | 1.20 GHz | - |
| 1/7 | 1.40 GHz | - |
| 1/8 | 1.60 GHz | - |
| 1/9 | 1.80 GHz | - |
| 1/10 | 2 GHz | - |
| 1/11 | 2.2 GHz | - |
| 1/12 | 2.4 GHz | - |

NOTES:

1. Individual processors operate only at or below the rated frequency.
2. Listed frequencies are not necessarily committed production frequencies.

2.8.2 FSB Frequency Select Signals (BSEL[2:0])

The BSEL[2:0] signals are used to select the frequency of the processor input clock (BCLK[1:0]). [Table 16](#) defines the possible combinations of the signals and the frequency associated with each combination. The required frequency is determined by the processor, chipset, and clock synthesizer. All agents must operate at the same frequency.

The Intel Pentium Dual-Core Desktop processor E2000 series operates at a 800 MHz FSB frequency (selected by a 200 MHz BCLK[1:0] frequency).



Table 16. BSEL[2:0] Frequency Table for BCLK[1:0]

| BSEL2 | BSEL1 | BSEL0 | FSB Frequency |
|-------|-------|-------|---------------|
| L | L | L | RESERVED |
| L | L | H | RESERVED |
| L | H | H | RESERVED |
| L | H | L | 200 MHz |
| H | H | L | RESERVED |
| H | H | H | RESERVED |
| H | L | H | RESERVED |
| H | L | L | RESERVED |

2.8.3 Phase Lock Loop (PLL) and Filter

An on-die PLL filter solution will be implemented on the processor. The VCCPLL input is used for the PLL. Refer to Table 5 for DC specifications.

2.8.4 BCLK[1:0] Specifications (CK505 based Platforms)

Table 17. Front Side Bus Differential BCLK Specifications

| Symbol | Parameter | Min | Typ | Max | Unit | Figure | Notes ¹ |
|--------------------|---------------------------|--------|-----|-------|---------|--------|--------------------|
| V_L | Input Low Voltage | -0.30 | N/A | N/A | V | 3 | 2 |
| V_H | Input High Voltage | N/A | N/A | 1.15 | V | 3 | 2 |
| $V_{CROSS(ABS)}$ | Absolute Crossing Point | 0.300 | N/A | 0.550 | V | 3, 4 | 3, 4, 5 |
| ΔV_{CROSS} | Range of Crossing Points | N/A | N/A | 0.140 | V | 3, 4 | 4 |
| V_{OS} | Overshoot | N/A | N/A | 1.4 | V | 3 | 6 |
| V_{US} | Undershoot | -0.300 | N/A | N/A | V | 3 | 6 |
| V_{SWING} | Differential Output Swing | 0.300 | N/A | N/A | V | 5 | 7 |
| I_{LI} | Input Leakage Current | -5 | N/A | 5 | μ A | | |
| Cpad | Pad Capacitance | .95 | 1.2 | 1.45 | pF | | 8 |

NOTES:

1. Unless otherwise noted, all specifications in this table apply to all processor frequencies.
2. "Steady state" voltage, not including overshoot or undershoot.
3. Crossing voltage is defined as the instantaneous voltage value when the rising edge of BCLK0 equals the falling edge of BCLK1.
4. V_{Havg} is the statistical average of the V_H measured by the oscilloscope.
5. The crossing point must meet the absolute and relative crossing point specifications simultaneously.
6. Overshoot is defined as the absolute value of the maximum voltage. Undershoot is defined as the absolute value of the minimum voltage.
7. Measurement taken from differential waveform.
8. Cpad includes die capacitance only. No package parasitics are included.

Figure 3. Differential Clock Waveform

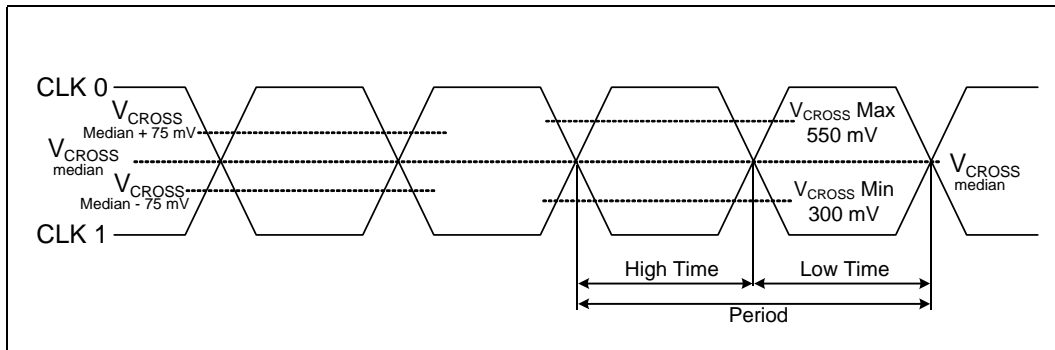


Figure 4. Differential Clock Crosspoint Specification

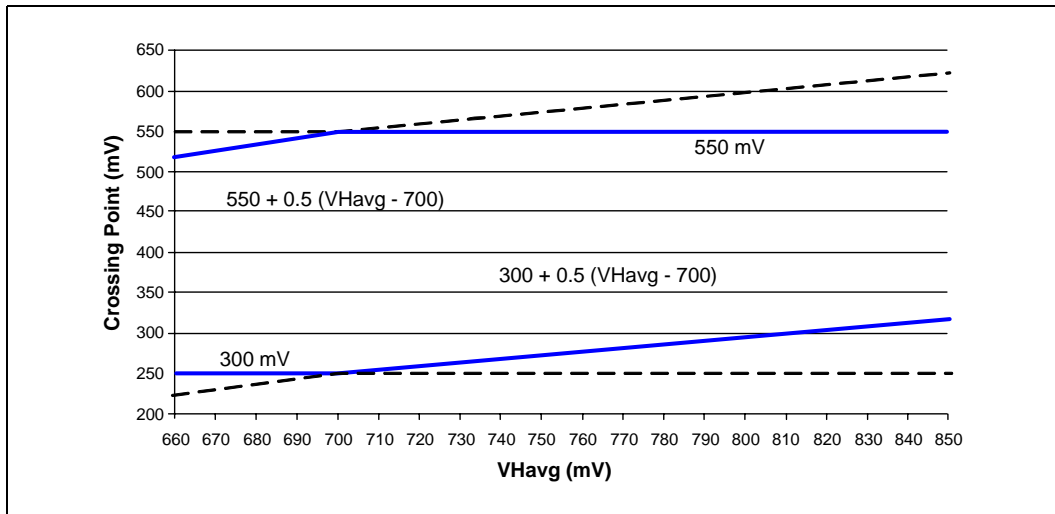
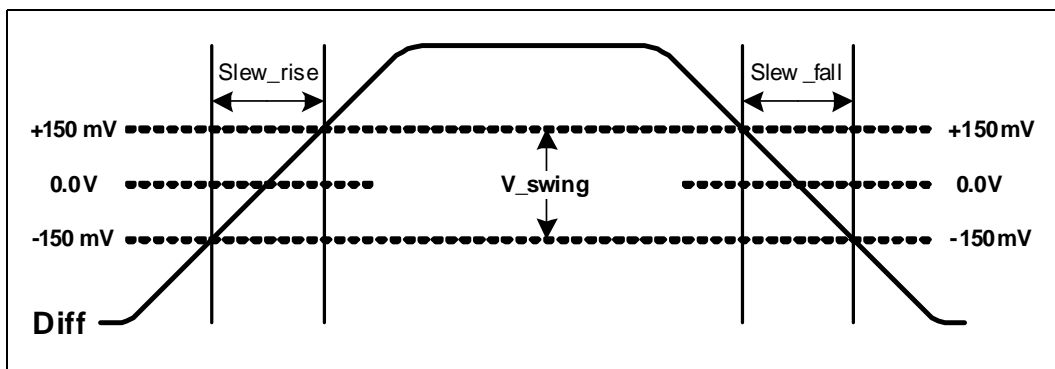


Figure 5. Differential Measurements





2.8.5 BCLK[1:0] Specifications (CK410 based Platforms)

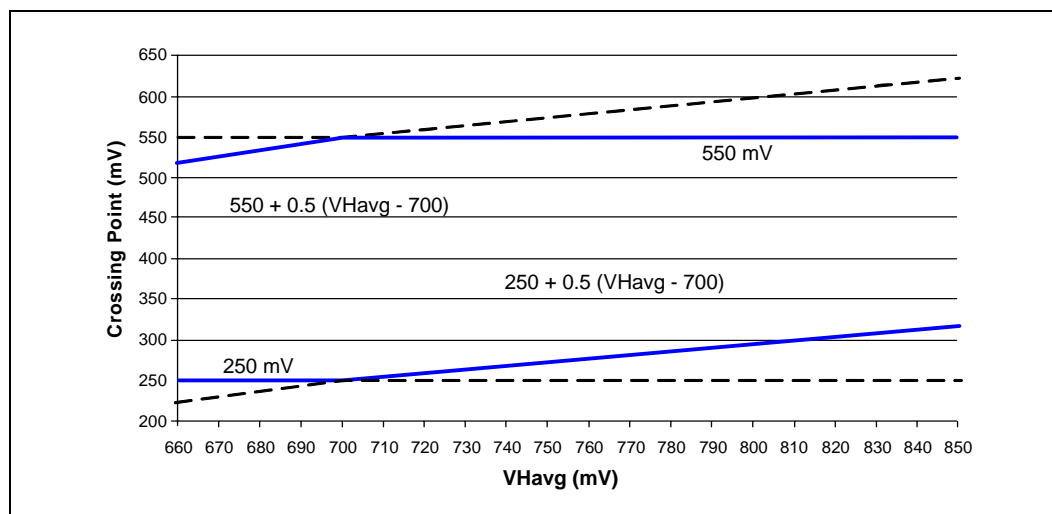
Table 18. Front Side Bus Differential BCLK Specifications

| Symbol | Parameter | Min | Typ | Max | Unit | Figure | Notes ¹ |
|-------------------------|--------------------------|---|-----------|---|------|--------|--------------------|
| V _L | Input Low Voltage | -0.150 | 0.00 0 | N/A | V | 3 | - |
| V _H | Input High Voltage | 0.660 | 0.70 0 | 0.850 | V | 3 | - |
| V _{CROSS(abs)} | Absolute Crossing Point | 0.250 | N/A | 0.550 | V | 3, 4 | 2, 3 |
| V _{CROSS(rel)} | Relative Crossing Point | 0.250 + 0.5(V _{Havg} - 0.700) | N/A | 0.550 + 0.5(V _{Havg} - 0.700) | V | 3, 4 | 4, 3, 5 |
| ΔV _{CROSS} | Range of Crossing Points | N/A | N/A | 0.140 | V | 3, 4 | - |
| V _{OS} | Overshoot | N/A | N/A | V _H + 0.3 | V | 3 | 6 |
| V _{US} | Undershoot | -0.300 | N/A | N/A | V | 3 | 7 |
| V _{RBM} | Ringback Margin | 0.200 | N/A | N/A | V | 3 | 8 |
| V _{TM} | Threshold Region | V _{CROSS} - 0.100 | N/A | V _{CROSS} + 0.100 | V | 3 | 9 |

NOTES:

1. Unless otherwise noted, all specifications in this table apply to all processor frequencies.
2. Crossing voltage is defined as the instantaneous voltage value when the rising edge of BCLK0 equals the falling edge of BCLK1.
3. The crossing point must meet the absolute and relative crossing point specifications simultaneously.
4. V_{Havg} is the statistical average of the V_H measured by the oscilloscope.
5. V_{Havg} can be measured directly using "Vtop" on Agilent* oscilloscopes and "High" on Tektronix* oscilloscopes.
6. overshoot is defined as the absolute value of the maximum voltage.
7. Undershoot is defined as the absolute value of the minimum voltage.
8. Ringback Margin is defined as the absolute voltage difference between the maximum Rising Edge Ringback and the maximum Falling Edge Ringback.
9. Threshold Region is defined as a region entered around the crossing point voltage in which the differential receiver switches. It includes input threshold hysteresis.

Figure 6. Differential Clock Crosspoint Specification





2.9 PECE DC Specifications

PECE is an Intel proprietary one-wire interface that provides a communication channel between Intel processors (may also include chipset components in the future) and external thermal monitoring devices. The processor contains Digital Thermal Sensors (DTS) distributed throughout die. These sensors are implemented as analog-to-digital converters calibrated at the factory for reasonable accuracy to provide a digital representation of relative processor temperature. PECE provides an interface to relay the highest DTS temperature within a die to external management devices for thermal/fan speed control. More detailed information is available in the *Platform Environment Control Interface (PECE) Specification*.

Table 19. PECE DC Electrical Limits

| Symbol | Definition and Conditions | Min | Max | Units | Notes ¹ |
|------------------|--|------------------|------------------|-----------|--------------------|
| V_{in} | Input Voltage Range | -0.15 | V_{TT} | V | |
| $V_{hysteresis}$ | Hysteresis | $0.1 * V_{TT}$ | — | V | 2 |
| V_n | Negative-edge threshold voltage | $0.275 * V_{TT}$ | $0.500 * V_{TT}$ | V | |
| V_p | Positive-edge threshold voltage | $0.550 * V_{TT}$ | $0.762 * V_{TT}$ | V | |
| I_{source} | High level output source ($V_{OH} = 0.75 * V_{TT}$) | -6.0 | N/A | mA | |
| I_{sink} | Low level output sink ($V_{OL} = 0.25 * V_{TT}$) | 0.5 | 1.0 | mA | |
| I_{leak+} | High impedance state leakage to V_{TT} | N/A | 50 | μ A | 3 |
| I_{leak-} | High impedance leakage to GND | N/A | 10 | μ A | 3 |
| C_{bus} | Bus capacitance per node | N/A | 10 | pF | 4 |
| V_{noise} | Signal noise immunity above 300 MHz | $0.1 * V_{TT}$ | — | V_{p-p} | |

NOTES:

1. V_{TT} supplies the PECE interface. PECE behavior does not affect V_{TT} min/max specifications. Refer to [Table 4](#) for V_{TT} specifications.
2. The input buffers use a Schmitt-triggered input design for improved noise immunity.
3. The leakage specification applies to powered devices on the PECE bus.
4. One node is counted for each client and one node for the system host. Extended trace lengths might appear as additional nodes.



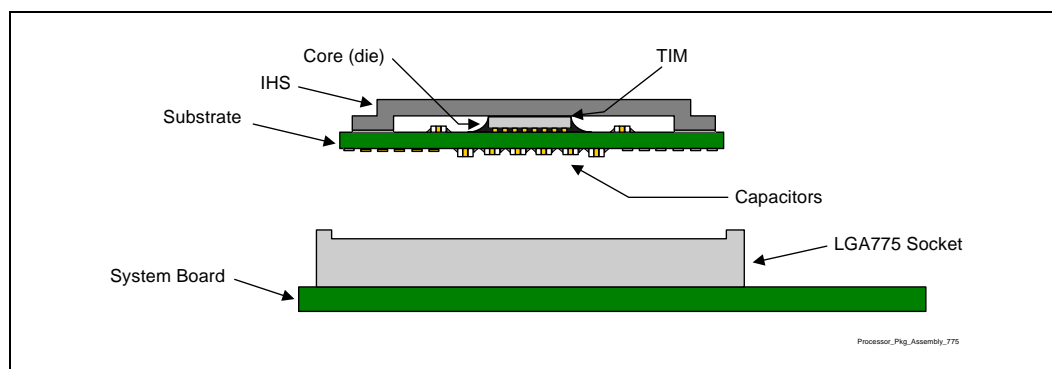
3 Package Mechanical Specifications

The processor is packaged in a Flip-Chip Land Grid Array (FC-LGA6) package that interfaces with the motherboard via an LGA775 socket. The package consists of a processor core mounted on a substrate land-carrier. An integrated heat spreader (IHS) is attached to the package substrate and core and serves as the mating surface for processor component thermal solutions, such as a heatsink. [Figure 7](#) shows a sketch of the processor package components and how they are assembled together. Refer to the *LGA775 Socket Mechanical Design Guide* for complete details on the LGA775 socket.

The package components shown in [Figure 7](#) include the following:

- Integrated Heat Spreader (IHS)
- Thermal Interface Material (TIM)
- Processor core (die)
- Package substrate
- Capacitors

Figure 7. Processor Package Assembly Sketch



NOTE:

1. Socket and system board are included for reference and are not part of processor package.

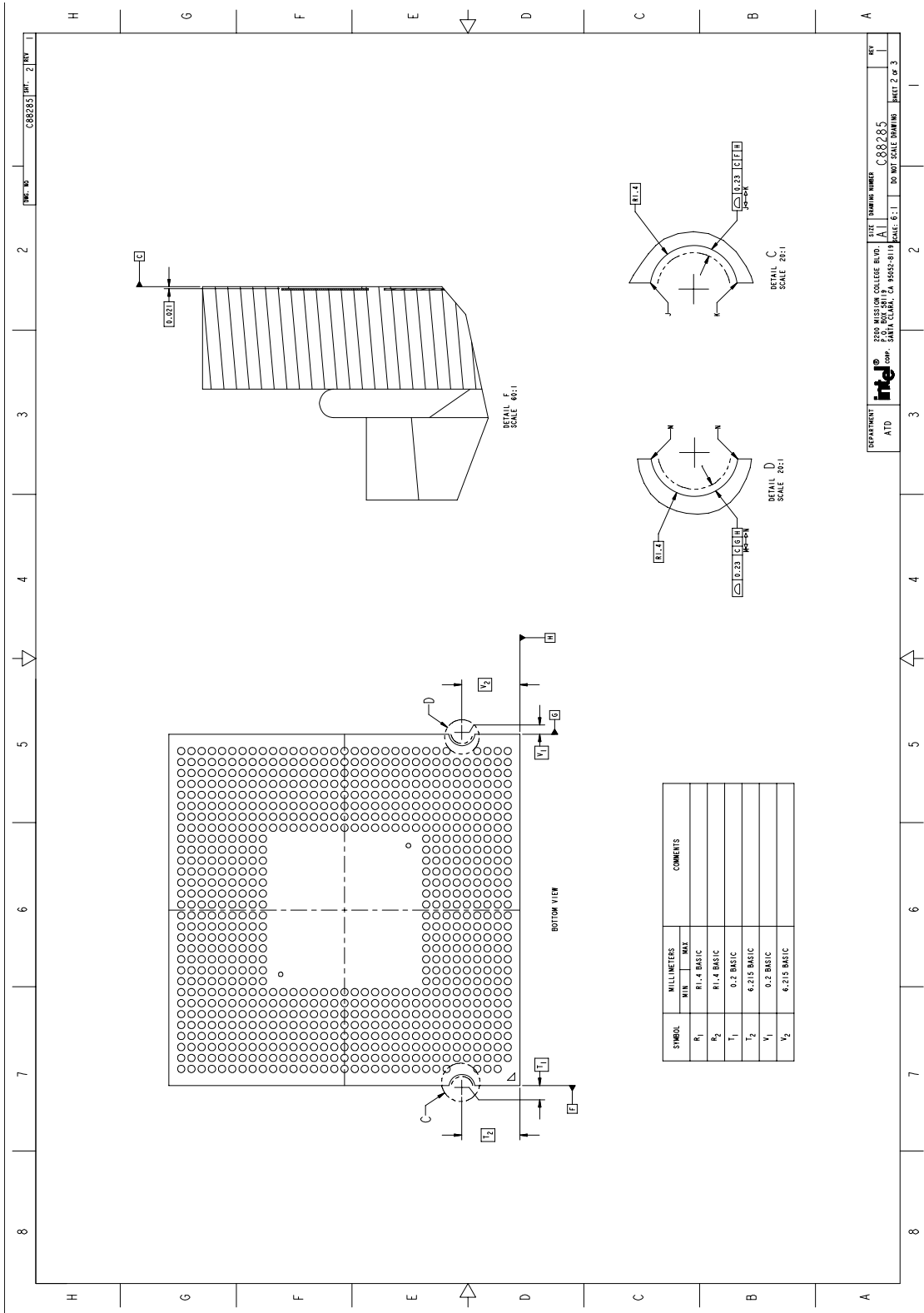
3.1 Package Mechanical Drawing

The package mechanical drawings are shown in [Figure 8](#) and [Figure 9](#). The drawings include dimensions necessary to design a thermal solution for the processor. These dimensions include:

- Package reference with tolerances (total height, length, width, etc.)
- IHS parallelism and tilt
- Land dimensions
- Top-side and back-side component keep-out dimensions
- Reference datums
- All drawing dimensions are in mm [in].
- Guidelines on potential IHS flatness variation with socket load plate actuation and installation of the cooling solution is available in the processor Thermal and Mechanical Design Guidelines (see [Section 1.2](#)).



Figure 9. Processor Package Drawing Sheet 2 of 3



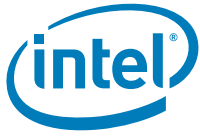
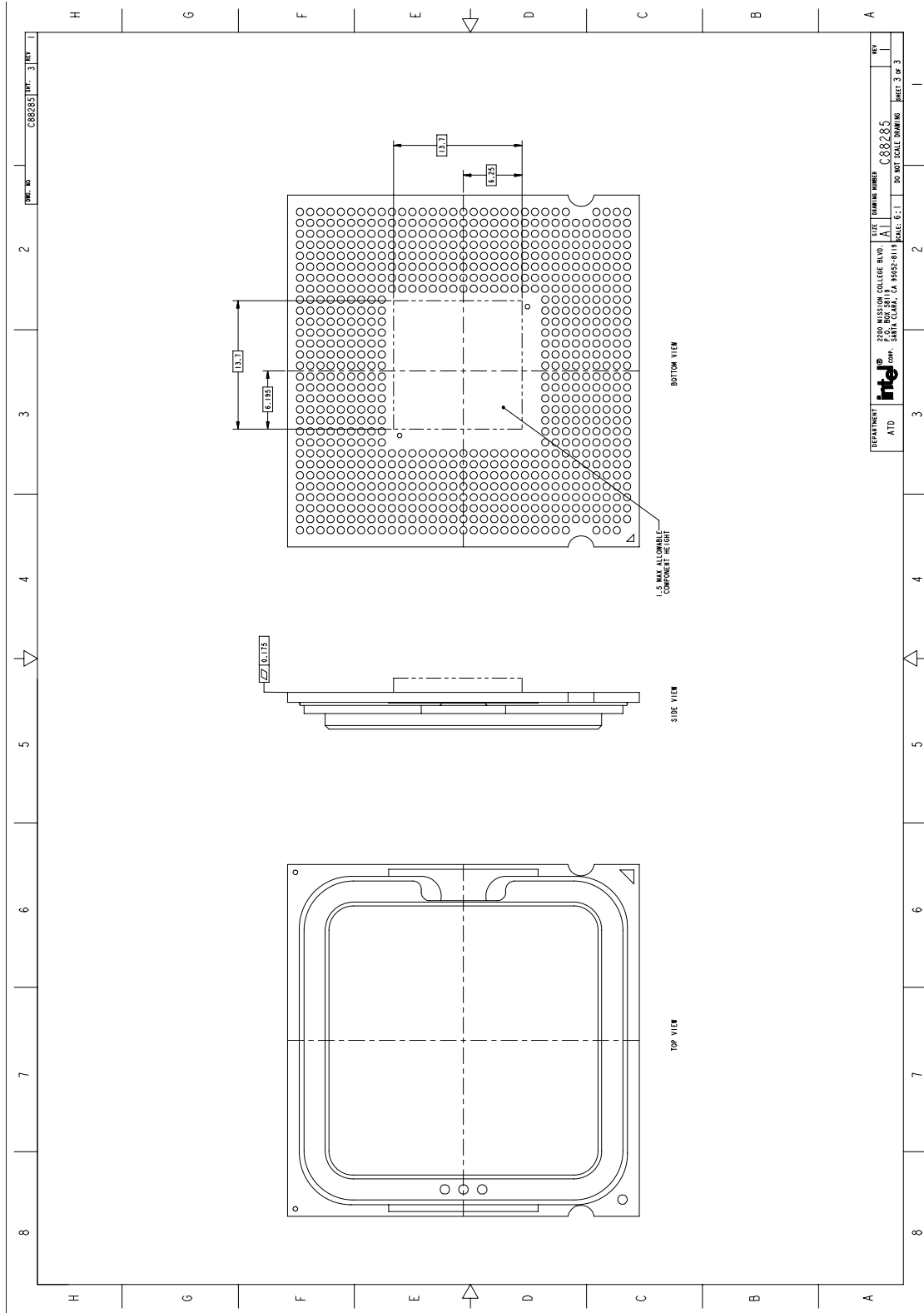


Figure 10. Processor Package Drawing Sheet 3 of 3





3.2 Processor Component Keep-Out Zones

The processor may contain components on the substrate that define component keep-out zone requirements. A thermal and mechanical solution design must not intrude into the required keep-out zones. Decoupling capacitors are typically mounted to either the topside or land-side of the package substrate. See Figure 8 and Figure 9 for keep-out zones. The location and quantity of package capacitors may change due to manufacturing efficiencies but will remain within the component keep-in.

3.3 Package Loading Specifications

Table 20 provides dynamic and static load specifications for the processor package. These mechanical maximum load limits should not be exceeded during heatsink assembly, shipping conditions, or standard use condition. Also, any mechanical system or component testing should not exceed the maximum limits. The processor package substrate should not be used as a mechanical reference or load-bearing surface for thermal and mechanical solution. The minimum loading specification must be maintained by any thermal and mechanical solutions.

Table 20. Processor Loading Specifications

| Parameter | Minimum | Maximum | Notes |
|-----------|---------------|-----------------|---------|
| Static | 80 N [17 lbf] | 311 N [70 lbf] | 1, 2, 3 |
| Dynamic | — | 756 N [170 lbf] | 1, 3, 4 |

NOTES:

1. These specifications apply to uniform compressive loading in a direction normal to the processor IHS.
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 processor package.
3. These specifications are based on limited testing for design characterization. Loading limits are for the package only and do not include the limits of the processor socket.
4. Dynamic loading is defined as an 11 ms duration average load superimposed on the static load requirement.

3.4 Package Handling Guidelines

Table 21 includes a list of guidelines on package handling in terms of recommended maximum loading on the processor IHS relative to a fixed substrate. These package handling loads may be experienced during heatsink removal.

Table 21. Package Handling Guidelines

| Parameter | Maximum Recommended | Notes |
|-----------|----------------------|-------|
| Shear | 311 N [70 lbf] | 1, 2 |
| Tensile | 111 N [25 lbf] | 2, 3 |
| Torque | 3.95 N-m [35 lbf-in] | 2, 4 |

NOTES:

1. A shear load is defined as a load applied to the IHS in a direction parallel to the IHS top surface.
2. These guidelines are based on limited testing for design characterization.
3. A tensile load is defined as a pulling load applied to the IHS in a direction normal to the IHS surface.
4. A torque load is defined as a twisting load applied to the IHS in an axis of rotation normal to the IHS top surface.

3.5 Package Insertion Specifications

The processor can be inserted into and removed from a LGA775 socket 15 times. The socket should meet the LGA775 requirements detailed in the *LGA775 Socket Mechanical Design Guide*.

3.6 Processor Mass Specification

The typical mass of the processor is 21.5 g [0.76 oz]. This mass [weight] includes all the components that are included in the package.

3.7 Processor Materials

Table 22 lists some of the package components and associated materials.

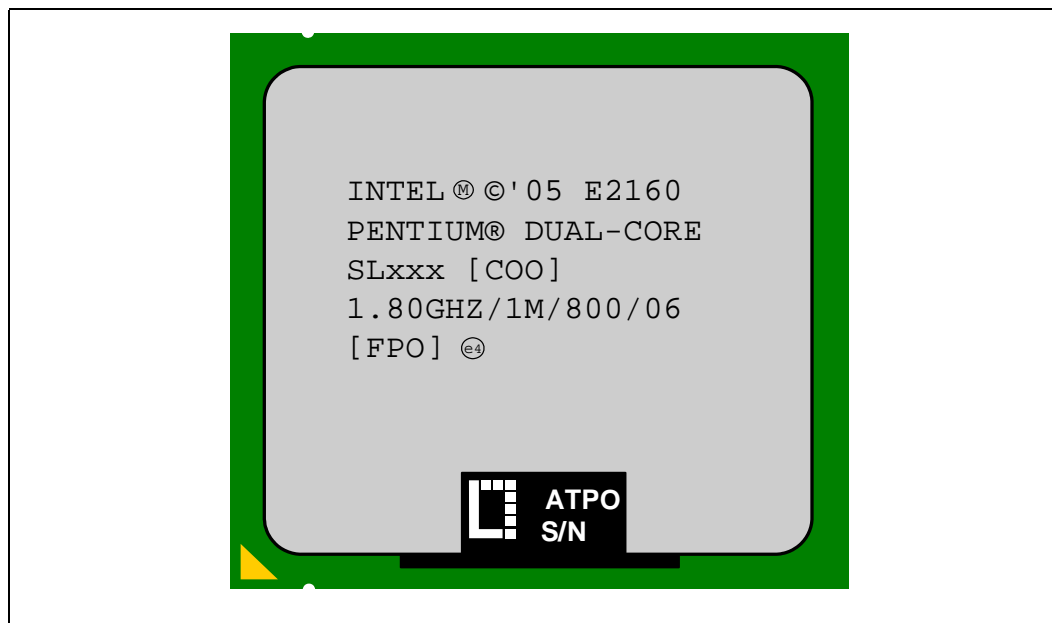
Table 22. Processor Materials

| Component | Material |
|--------------------------------|------------------------|
| Integrated Heat Spreader (IHS) | Nickel Plated Copper |
| Substrate | Fiber Reinforced Resin |
| Substrate Lands | Gold Plated Copper |

3.8 Processor Markings

Figure 11 shows the topside markings on the processors. This diagram aids in the identification of the processor.

Figure 11. Processor Top-Side Markings Example

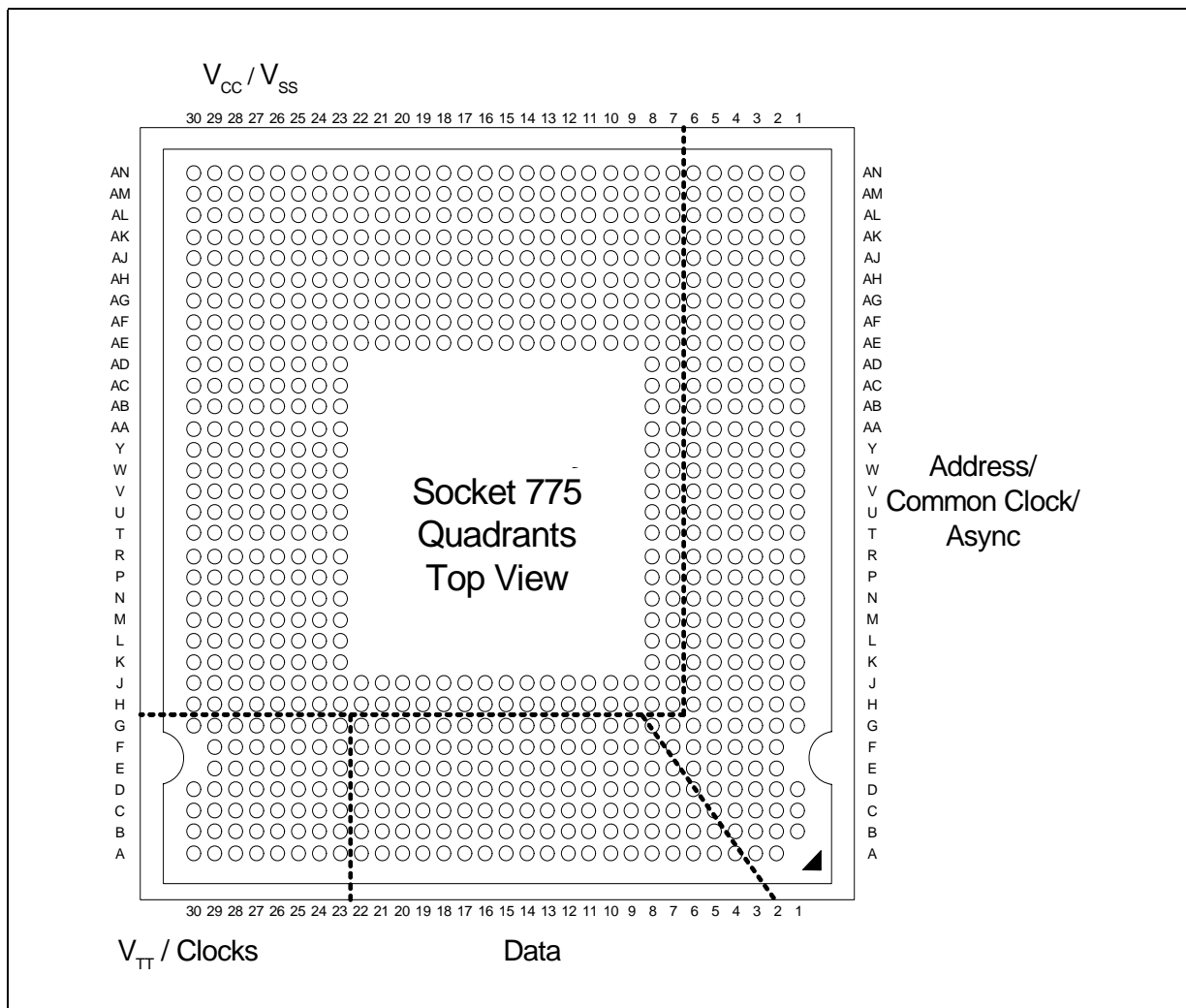




3.9 Processor Land Coordinates

Figure 12 shows the top view of the processor land coordinates. The coordinates are referred to throughout the document to identify processor lands.

Figure 12. Processor Land Coordinates and Quadrants, Top View



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4 *Land Listing and Signal Descriptions*

This chapter provides the processor land assignment and signal descriptions.

4.1 **Processor Land Assignments**

This section contains the land listings for the processor. The land-out footprint is shown in [Figure 13](#) and [Figure 14](#). These figures represent the land-out arranged by land number and they show the physical location of each signal on the package land array (top view). [Table 23](#) provides a list of processor lands ordered alphabetically by land (signal) name. [Table 24](#) provides a list of processor lands ordered by land number.



Figure 13. Land-out Diagram (Top View – Left Side)

| | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15 |
|----|-------|-------|-------|---------|---------|---------|---------|-----------|------|------|---------|---------|------|---------|---------|------|
| AN | VCC | VCC | VSS | VSS | VCC | VCC | VSS | VSS | VCC | VCC | VSS | VCC | VCC | VSS | VSS | VCC |
| AM | VCC | VCC | VSS | VSS | VCC | VCC | VSS | VSS | VCC | VCC | VSS | VCC | VCC | VSS | VSS | VCC |
| AL | VCC | VCC | VSS | VSS | VCC | VCC | VSS | VSS | VCC | VCC | VSS | VCC | VCC | VSS | VSS | VCC |
| AK | VSS | VSS | VSS | VSS | VCC | VCC | VSS | VSS | VCC | VCC | VSS | VCC | VCC | VSS | VSS | VCC |
| AJ | VSS | VSS | VSS | VSS | VCC | VCC | VSS | VSS | VCC | VCC | VSS | VCC | VCC | VSS | VSS | VCC |
| AH | VCC | VCC | VCC | VCC | VCC | VCC | VSS | VSS | VCC | VCC | VSS | VCC | VCC | VSS | VSS | VCC |
| AG | VCC | VCC | VCC | VCC | VCC | VCC | VSS | VSS | VCC | VCC | VSS | VCC | VCC | VSS | VSS | VCC |
| AF | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VCC | VCC | VSS | VCC | VCC | VSS | VSS | VCC |
| AE | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VCC | VCC | VCC | VSS | VCC | VCC | VSS | VSS | VCC |
| AD | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | | | | | | | | |
| AC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | | | | | | | | |
| AB | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | | | | | | | | |
| AA | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | | | | | | | | |
| Y | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | | | | | | | | |
| W | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | | | | | | | | |
| V | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | | | | | | | | |
| U | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | | | | | | | | |
| T | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | | | | | | | | |
| R | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | | | | | | | | |
| P | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | | | | | | | | |
| N | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | | | | | | | | |
| M | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | | | | | | | | |
| L | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | | | | | | | | |
| K | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | | | | | | | | |
| J | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | FC34 | FC31 | VCC |
| H | BSEL1 | FC15 | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | FC33 | FC32 |
| G | BSEL2 | BSEL0 | BCLK1 | TESTHI4 | TESTHI5 | TESTHI3 | TESTHI6 | RESET# | D47# | D44# | DSTBN2# | DSTBP2# | D35# | D36# | D32# | D31# |
| F | | RSVD | BCLK0 | VTT_SEL | TESTHI0 | TESTHI2 | TESTHI7 | RSVD | VSS | D43# | D41# | VSS | D38# | D37# | VSS | D30# |
| E | | FC26 | VSS | VSS | VSS | VSS | FC10 | RSVD | D45# | D42# | VSS | D40# | D39# | VSS | D34# | D33# |
| D | VTT | VTT | VTT | VTT | VTT | VTT | VSS | VCCPLL | D46# | VSS | D48# | DBI2# | VSS | D49# | RSVD | VSS |
| C | VTT | VTT | VTT | VTT | VTT | VTT | VSS | VCCIO PLL | VSS | D58# | DBI3# | VSS | D54# | DSTBP3# | VSS | D51# |
| B | VTT | VTT | VTT | VTT | VTT | VTT | VSS | VSSA | D63# | D59# | VSS | D60# | D57# | VSS | D55# | D53# |
| A | VTT | VTT | VTT | VTT | VTT | VTT | FC23 | VCCA | D62# | VSS | RSVD | D61# | VSS | D56# | DSTBN3# | VSS |
| | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15 |



Figure 14. land-out Diagram (Top View – Right Side)

| 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | | |
|------|-------|---------|-------|-------|---------|---------|----------------|-----------------------|-----------------------|------------------|------------------|----------------|-------------------|-------------------|----|
| VCC | VSS | VCC | VCC | VSS | VCC | VCC | VID_SELE CT | VSS_MB_ REGULATION | VCC_MB_ REGULATION | VSS_ SENSE | VCC_ SENSE | VSS | VSS | AN | |
| VCC | VSS | VCC | VCC | VSS | VCC | VCC | VID7 | FC40 | VID6 | VSS | VID2 | VID0 | VSS | AM | |
| VCC | VSS | VCC | VCC | VSS | VCC | VCC | VSS | VID3 | VID1 | VID5 | VRDSEL | PROCHOT# | THERMDA | AL | |
| VCC | VSS | VCC | VCC | VSS | VCC | VCC | VSS | FC8 | VSS | VID4 | ITP_CLK0 | VSS | THERMDC | AK | |
| VCC | VSS | VCC | VCC | VSS | VCC | VCC | VSS | A35# | A34# | VSS | ITP_CLK1 | BPM0# | BPM1# | AJ | |
| VCC | VSS | VCC | VCC | VSS | VCC | VCC | VSS | VSS | A33# | A32# | VSS | RSVD | VSS | AH | |
| VCC | VSS | VCC | VCC | VSS | VCC | VCC | VSS | A29# | A31# | A30# | BPM5# | BPM3# | TRST# | AG | |
| VCC | VSS | VCC | VCC | VSS | VCC | VCC | VSS | VSS | A27# | A28# | VSS | BPM4# | TDO | AF | |
| VCC | VSS | VCC | VCC | VSS | VCC | VCC | SKTOCC# | VSS | RSVD | VSS | RSVD | FC18 | TCK | AE | |
| | | | | | | | VCC | VSS | A22# | ADSTB1# | VSS | FC36 | BPM2# | TDI | AD |
| | | | | | | | VCC | VSS | VSS | A25# | RSVD | VSS | DBR# | TMS | AC |
| | | | | | | | VCC | VSS | A17# | A24# | A26# | FC37 | IERR# | VSS | AB |
| | | | | | | | VCC | VSS | VSS | A23# | A21# | VSS | FC39 | VTT_OUT_ RIGHT | AA |
| | | | | | | | VCC | VSS | A19# | VSS | A20# | FC17 | VSS | FC0 | Y |
| | | | | | | | VCC | VSS | A18# | A16# | VSS | TESTHI1 | TESTHI12/ FC44 | MSID0 | W |
| | | | | | | | VCC | VSS | VSS | A14# | A15# | VSS | RSVD | MSID1 | V |
| | | | | | | | VCC | VSS | A10# | A12# | A13# | FC30 | FC29 | FC28 | U |
| | | | | | | | VCC | VSS | VSS | A9# | A11# | VSS | FC4 | COMP1 | T |
| | | | | | | | VCC | VSS | ADSTB0# | VSS | A8# | FERR#/ PBE# | VSS | COMP3 | R |
| | | | | | | | VCC | VSS | A4# | RSVD | VSS | INIT# | SMI# | TESTHI11 | P |
| | | | | | | | VCC | VSS | VSS | RSVD | RSVD | VSS | IGNNE# | PWRGOOD | N |
| | | | | | | | VCC | VSS | REQ2# | A5# | A7# | STPCLK# | THERMTRIP# | VSS | M |
| | | | | | | | VCC | VSS | VSS | A3# | A6# | VSS | TESTHI13 | LINT1 | L |
| VCC | VSS | REQ3# | VSS | REQ0# | A20M# | VSS | LINT0 | K | | | | | | | |
| VCC | VCC | VCC | VCC | VCC | VCC | VCC | VSS | REQ4# | REQ1# | VSS | FC22 | FC3 | VTT_OUT_ LEFT | J | |
| VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | TESTHI10 | FC35 | VSS | GTLREF1 | GTLREF0 | H | |
| D29# | D27# | DSTBN1# | DBI1# | FC38 | D16# | BPRI# | DEFER# | RSVD | PECI | TESTHI9/ FC43 | TESTHI8/ FC42 | COMP2 | FC27 | G | |
| D28# | VSS | D24# | D23# | VSS | D18# | D17# | VSS | FC21 | RS1# | VSS | BR0# | FC5 | | F | |
| VSS | D26# | DSTBP1# | VSS | D21# | D19# | VSS | RSVD | RSVD | FC20 | HITM# | TRDY# | VSS | | E | |
| RSVD | D25# | VSS | D15# | D22# | VSS | D12# | D20# | VSS | VSS | HIT# | VSS | ADS# | RSVD | D | |
| D52# | VSS | D14# | D11# | VSS | FC38 | DSTBNO# | VSS | D3# | D1# | VSS | LOCK# | BNR# | DRDY# | C | |
| VSS | COMP8 | D13# | VSS | D10# | DSTBP0# | VSS | D6# | D5# | VSS | D0# | RS0# | DBSY# | VSS | B | |
| D50# | COMP0 | VSS | D9# | D8# | VSS | DBIO# | D7# | VSS | D4# | D2# | RS2# | VSS | | A | |



Table 23. Alphabetical Land Assignments

| Land Name | Land # | Signal Buffer Type | Direction |
|-----------|--------|--------------------|--------------|
| A3# | L5 | Source Synch | Input/Output |
| A4# | P6 | Source Synch | Input/Output |
| A5# | M5 | Source Synch | Input/Output |
| A6# | L4 | Source Synch | Input/Output |
| A7# | M4 | Source Synch | Input/Output |
| A8# | R4 | Source Synch | Input/Output |
| A9# | T5 | Source Synch | Input/Output |
| A10# | U6 | Source Synch | Input/Output |
| A11# | T4 | Source Synch | Input/Output |
| A12# | U5 | Source Synch | Input/Output |
| A13# | U4 | Source Synch | Input/Output |
| A14# | V5 | Source Synch | Input/Output |
| A15# | V4 | Source Synch | Input/Output |
| A16# | W5 | Source Synch | Input/Output |
| A17# | AB6 | Source Synch | Input/Output |
| A18# | W6 | Source Synch | Input/Output |
| A19# | Y6 | Source Synch | Input/Output |
| A20# | Y4 | Source Synch | Input/Output |
| A20M# | K3 | Asynch CMOS | Input |
| A21# | AA4 | Source Synch | Input/Output |
| A22# | AD6 | Source Synch | Input/Output |
| A23# | AA5 | Source Synch | Input/Output |
| A24# | AB5 | Source Synch | Input/Output |
| A25# | AC5 | Source Synch | Input/Output |
| A26# | AB4 | Source Synch | Input/Output |
| A27# | AF5 | Source Synch | Input/Output |
| A28# | AF4 | Source Synch | Input/Output |
| A29# | AG6 | Source Synch | Input/Output |
| A30# | AG4 | Source Synch | Input/Output |
| A31# | AG5 | Source Synch | Input/Output |
| A32# | AH4 | Source Synch | Input/Output |
| A33# | AH5 | Source Synch | Input/Output |
| A34# | AJ5 | Source Synch | Input/Output |
| A35# | AJ6 | Source Synch | Input/Output |
| ADS# | D2 | Common Clock | Input/Output |
| ADSTB0# | R6 | Source Synch | Input/Output |
| ADSTB1# | AD5 | Source Synch | Input/Output |
| BCLK0 | F28 | Clock | Input |
| BCLK1 | G28 | Clock | Input |

Table 23. Alphabetical Land Assignments

| Land Name | Land # | Signal Buffer Type | Direction |
|-----------|--------|--------------------|--------------|
| BNR# | C2 | Common Clock | Input/Output |
| BPM0# | AJ2 | Common Clock | Input/Output |
| BPM1# | AJ1 | Common Clock | Input/Output |
| BPM2# | AD2 | Common Clock | Input/Output |
| BPM3# | AG2 | Common Clock | Input/Output |
| BPM4# | AF2 | Common Clock | Input/Output |
| BPM5# | AG3 | Common Clock | Input/Output |
| BPRI# | G8 | Common Clock | Input |
| BR0# | F3 | Common Clock | Input/Output |
| BSEL0 | G29 | Power/Other | Output |
| BSEL1 | H30 | Power/Other | Output |
| BSEL2 | G30 | Power/Other | Output |
| COMP0 | A13 | Power/Other | Input |
| COMP1 | T1 | Power/Other | Input |
| COMP2 | G2 | Power/Other | Input |
| COMP3 | R1 | Power/Other | Input |
| COMP8 | B13 | Power/Other | Input |
| D0# | B4 | Source Synch | Input/Output |
| D1# | C5 | Source Synch | Input/Output |
| D2# | A4 | Source Synch | Input/Output |
| D3# | C6 | Source Synch | Input/Output |
| D4# | A5 | Source Synch | Input/Output |
| D5# | B6 | Source Synch | Input/Output |
| D6# | B7 | Source Synch | Input/Output |
| D7# | A7 | Source Synch | Input/Output |
| D8# | A10 | Source Synch | Input/Output |
| D9# | A11 | Source Synch | Input/Output |
| D10# | B10 | Source Synch | Input/Output |
| D11# | C11 | Source Synch | Input/Output |
| D12# | D8 | Source Synch | Input/Output |
| D13# | B12 | Source Synch | Input/Output |
| D14# | C12 | Source Synch | Input/Output |
| D15# | D11 | Source Synch | Input/Output |
| D16# | G9 | Source Synch | Input/Output |
| D17# | F8 | Source Synch | Input/Output |
| D18# | F9 | Source Synch | Input/Output |
| D19# | E9 | Source Synch | Input/Output |
| D20# | D7 | Source Synch | Input/Output |
| D21# | E10 | Source Synch | Input/Output |

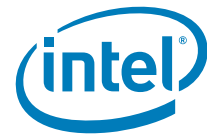


Table 23. Alphabetical Land Assignments

| Land Name | Land # | Signal Buffer Type | Direction |
|-----------|--------|--------------------|--------------|
| D22# | D10 | Source Synch | Input/Output |
| D23# | F11 | Source Synch | Input/Output |
| D24# | F12 | Source Synch | Input/Output |
| D25# | D13 | Source Synch | Input/Output |
| D26# | E13 | Source Synch | Input/Output |
| D27# | G13 | Source Synch | Input/Output |
| D28# | F14 | Source Synch | Input/Output |
| D29# | G14 | Source Synch | Input/Output |
| D30# | F15 | Source Synch | Input/Output |
| D31# | G15 | Source Synch | Input/Output |
| D32# | G16 | Source Synch | Input/Output |
| D33# | E15 | Source Synch | Input/Output |
| D34# | E16 | Source Synch | Input/Output |
| D35# | G18 | Source Synch | Input/Output |
| D36# | G17 | Source Synch | Input/Output |
| D37# | F17 | Source Synch | Input/Output |
| D38# | F18 | Source Synch | Input/Output |
| D39# | E18 | Source Synch | Input/Output |
| D40# | E19 | Source Synch | Input/Output |
| D41# | F20 | Source Synch | Input/Output |
| D42# | E21 | Source Synch | Input/Output |
| D43# | F21 | Source Synch | Input/Output |
| D44# | G21 | Source Synch | Input/Output |
| D45# | E22 | Source Synch | Input/Output |
| D46# | D22 | Source Synch | Input/Output |
| D47# | G22 | Source Synch | Input/Output |
| D48# | D20 | Source Synch | Input/Output |
| D49# | D17 | Source Synch | Input/Output |
| D50# | A14 | Source Synch | Input/Output |
| D51# | C15 | Source Synch | Input/Output |
| D52# | C14 | Source Synch | Input/Output |
| D53# | B15 | Source Synch | Input/Output |
| D54# | C18 | Source Synch | Input/Output |
| D55# | B16 | Source Synch | Input/Output |
| D56# | A17 | Source Synch | Input/Output |
| D57# | B18 | Source Synch | Input/Output |
| D58# | C21 | Source Synch | Input/Output |
| D59# | B21 | Source Synch | Input/Output |
| D60# | B19 | Source Synch | Input/Output |

Table 23. Alphabetical Land Assignments

| Land Name | Land # | Signal Buffer Type | Direction |
|-----------|--------|--------------------|--------------|
| D61# | A19 | Source Synch | Input/Output |
| D62# | A22 | Source Synch | Input/Output |
| D63# | B22 | Source Synch | Input/Output |
| DBI0# | A8 | Source Synch | Input/Output |
| DBI1# | G11 | Source Synch | Input/Output |
| DBI2# | D19 | Source Synch | Input/Output |
| DBI3# | C20 | Source Synch | Input/Output |
| DBR# | AC2 | Power/Other | Output |
| DBSY# | B2 | Common Clock | Input/Output |
| DEFER# | G7 | Common Clock | Input |
| DRDY# | C1 | Common Clock | Input/Output |
| DSTBN0# | C8 | Source Synch | Input/Output |
| DSTBN1# | G12 | Source Synch | Input/Output |
| DSTBN2# | G20 | Source Synch | Input/Output |
| DSTBN3# | A16 | Source Synch | Input/Output |
| DSTBP0# | B9 | Source Synch | Input/Output |
| DSTBP1# | E12 | Source Synch | Input/Output |
| DSTBP2# | G19 | Source Synch | Input/Output |
| DSTBP3# | C17 | Source Synch | Input/Output |
| FC0 | Y1 | Power/Other | |
| FC3 | J2 | Power/Other | |
| FC4 | T2 | Power/Other | |
| FC5 | F2 | Power/Other | |
| FC8 | AK6 | Power/Other | |
| FC10 | E24 | Power/Other | |
| FC15 | H29 | Power/Other | |
| FC17 | Y3 | Power/Other | |
| FC18 | AE3 | Power/Other | |
| FC20 | E5 | Power/Other | |
| FC21 | F6 | Power/Other | |
| FC22 | J3 | Power/Other | |
| FC23 | A24 | Power/Other | |
| FC26 | E29 | Power/Other | |
| FC27 | G1 | Power/Other | |
| FC28 | U1 | Power/Other | |
| FC29 | U2 | Power/Other | |
| FC30 | U3 | Power/Other | |
| FC31 | J16 | Power/Other | |
| FC32 | H15 | Power/Other | |



Table 23. Alphabetical Land Assignments

| Land Name | Land # | Signal Buffer Type | Direction |
|------------|--------|--------------------|--------------|
| FC33 | H16 | Power/Other | |
| FC34 | J17 | Power/Other | |
| FC35 | H4 | Power/Other | |
| FC36 | AD3 | Power/Other | |
| FC37 | AB3 | Power/Other | |
| FC38 | G10 | Power/Other | |
| FC38 | C9 | Power/Other | |
| FC39 | AA2 | Power/Other | |
| FC40 | AM6 | Power/Other | |
| FERR#/PBE# | R3 | Asynch CMOS | Output |
| GTLREF0 | H1 | Power/Other | Input |
| GTLREF1 | H2 | Power/Other | Input |
| HIT# | D4 | Common Clock | Input/Output |
| HITM# | E4 | Common Clock | Input/Output |
| IERR# | AB2 | Asynch CMOS | Output |
| IGNNE# | N2 | Asynch CMOS | Input |
| INIT# | P3 | Asynch CMOS | Input |
| ITP_CLK0 | AK3 | TAP | Input |
| ITP_CLK1 | AJ3 | TAP | Input |
| LINT0 | K1 | Asynch CMOS | Input |
| LINT1 | L1 | Asynch CMOS | Input |
| LOCK# | C3 | Common Clock | Input/Output |
| MSID0 | W1 | Power/Other | Output |
| MSID1 | V1 | Power/Other | Output |
| PECI | G5 | Power/Other | Input/Output |
| PROCHOT# | AL2 | Asynch CMOS | Input/Output |
| PWRGOOD | N1 | Power/Other | Input |
| REQ0# | K4 | Source Synch | Input/Output |
| REQ1# | J5 | Source Synch | Input/Output |
| REQ2# | M6 | Source Synch | Input/Output |
| REQ3# | K6 | Source Synch | Input/Output |
| REQ4# | J6 | Source Synch | Input/Output |
| RESERVED | A20 | | |
| RESERVED | AC4 | | |
| RESERVED | AE4 | | |
| RESERVED | AE6 | | |
| RESERVED | AH2 | | |
| RESERVED | D1 | | |
| RESERVED | D14 | | |

Table 23. Alphabetical Land Assignments

| Land Name | Land # | Signal Buffer Type | Direction |
|-------------------|--------|--------------------|-----------|
| RESERVED | D16 | | |
| RESERVED | E23 | | |
| RESERVED | E6 | | |
| RESERVED | E7 | | |
| RESERVED | F23 | | |
| RESERVED | F29 | | |
| RESERVED | G6 | | |
| RESERVED | N4 | | |
| RESERVED | N5 | | |
| RESERVED | P5 | | |
| RESERVED | V2 | | |
| RESET# | G23 | Common Clock | Input |
| RS0# | B3 | Common Clock | Input |
| RS1# | F5 | Common Clock | Input |
| RS2# | A3 | Common Clock | Input |
| SKTOCC# | AE8 | Power/Other | Output |
| SMI# | P2 | Asynch CMOS | Input |
| STPCLK# | M3 | Asynch CMOS | Input |
| TCK | AE1 | TAP | Input |
| TDI | AD1 | TAP | Input |
| TDO | AF1 | TAP | Output |
| TESTHI0 | F26 | Power/Other | Input |
| TESTHI1 | W3 | Power/Other | Input |
| TESTHI10 | H5 | Power/Other | Input |
| TESTHI11 | P1 | Power/Other | Input |
| TESTHI12/ FC44 | W2 | Power/Other | Input |
| TESTHI13 | L2 | Power/Other | Input |
| TESTHI2 | F25 | Power/Other | Input |
| TESTHI3 | G25 | Power/Other | Input |
| TESTHI4 | G27 | Power/Other | Input |
| TESTHI5 | G26 | Power/Other | Input |
| TESTHI6 | G24 | Power/Other | Input |
| TESTHI7 | F24 | Power/Other | Input |
| TESTHI8/FC42 | G3 | Power/Other | Input |
| TESTHI9/FC43 | G4 | Power/Other | Input |
| THERMDA | AL1 | Power/Other | |
| THERMDC | AK1 | Power/Other | |
| THERMTRIP# | M2 | Asynch CMOS | Output |
| TMS | AC1 | TAP | Input |



Table 23. Alphabetical Land Assignments

| Land Name | Land # | Signal Buffer Type | Direction |
|-----------|--------|--------------------|-----------|
| TRDY# | E3 | Common Clock | Input |
| TRST# | AG1 | TAP | Input |
| VCC | AA8 | Power/Other | |
| VCC | AB8 | Power/Other | |
| VCC | AC23 | Power/Other | |
| VCC | AC24 | Power/Other | |
| VCC | AC25 | Power/Other | |
| VCC | AC26 | Power/Other | |
| VCC | AC27 | Power/Other | |
| VCC | AC28 | Power/Other | |
| VCC | AC29 | Power/Other | |
| VCC | AC30 | Power/Other | |
| VCC | AC8 | Power/Other | |
| VCC | AD23 | Power/Other | |
| VCC | AD24 | Power/Other | |
| VCC | AD25 | Power/Other | |
| VCC | AD26 | Power/Other | |
| VCC | AD27 | Power/Other | |
| VCC | AD28 | Power/Other | |
| VCC | AD29 | Power/Other | |
| VCC | AD30 | Power/Other | |
| VCC | AD8 | Power/Other | |
| VCC | AE11 | Power/Other | |
| VCC | AE12 | Power/Other | |
| VCC | AE14 | Power/Other | |
| VCC | AE15 | Power/Other | |
| VCC | AE18 | Power/Other | |
| VCC | AE19 | Power/Other | |
| VCC | AE21 | Power/Other | |
| VCC | AE22 | Power/Other | |
| VCC | AE23 | Power/Other | |
| VCC | AE9 | Power/Other | |
| VCC | AF11 | Power/Other | |
| VCC | AF12 | Power/Other | |
| VCC | AF14 | Power/Other | |
| VCC | AF15 | Power/Other | |
| VCC | AF18 | Power/Other | |
| VCC | AF19 | Power/Other | |
| VCC | AF21 | Power/Other | |

Table 23. Alphabetical Land Assignments

| Land Name | Land # | Signal Buffer Type | Direction |
|-----------|--------|--------------------|-----------|
| VCC | AF22 | Power/Other | |
| VCC | AF8 | Power/Other | |
| VCC | AF9 | Power/Other | |
| VCC | AG11 | Power/Other | |
| VCC | AG12 | Power/Other | |
| VCC | AG14 | Power/Other | |
| VCC | AG15 | Power/Other | |
| VCC | AG18 | Power/Other | |
| VCC | AG19 | Power/Other | |
| VCC | AG21 | Power/Other | |
| VCC | AG22 | Power/Other | |
| VCC | AG25 | Power/Other | |
| VCC | AG26 | Power/Other | |
| VCC | AG27 | Power/Other | |
| VCC | AG28 | Power/Other | |
| VCC | AG29 | Power/Other | |
| VCC | AG30 | Power/Other | |
| VCC | AG8 | Power/Other | |
| VCC | AG9 | Power/Other | |
| VCC | AH11 | Power/Other | |
| VCC | AH12 | Power/Other | |
| VCC | AH14 | Power/Other | |
| VCC | AH15 | Power/Other | |
| VCC | AH18 | Power/Other | |
| VCC | AH19 | Power/Other | |
| VCC | AH21 | Power/Other | |
| VCC | AH22 | Power/Other | |
| VCC | AH25 | Power/Other | |
| VCC | AH26 | Power/Other | |
| VCC | AH27 | Power/Other | |
| VCC | AH28 | Power/Other | |
| VCC | AH29 | Power/Other | |
| VCC | AH30 | Power/Other | |
| VCC | AH8 | Power/Other | |
| VCC | AH9 | Power/Other | |
| VCC | AJ11 | Power/Other | |
| VCC | AJ12 | Power/Other | |
| VCC | AJ14 | Power/Other | |
| VCC | AJ15 | Power/Other | |



Table 23. Alphabetical Land Assignments

| Land Name | Land # | Signal Buffer Type | Direction |
|-----------|--------|--------------------|-----------|
| VCC | AJ18 | Power/Other | |
| VCC | AJ19 | Power/Other | |
| VCC | AJ21 | Power/Other | |
| VCC | AJ22 | Power/Other | |
| VCC | AJ25 | Power/Other | |
| VCC | AJ26 | Power/Other | |
| VCC | AJ8 | Power/Other | |
| VCC | AJ9 | Power/Other | |
| VCC | AK11 | Power/Other | |
| VCC | AK12 | Power/Other | |
| VCC | AK14 | Power/Other | |
| VCC | AK15 | Power/Other | |
| VCC | AK18 | Power/Other | |
| VCC | AK19 | Power/Other | |
| VCC | AK21 | Power/Other | |
| VCC | AK22 | Power/Other | |
| VCC | AK25 | Power/Other | |
| VCC | AK26 | Power/Other | |
| VCC | AK8 | Power/Other | |
| VCC | AK9 | Power/Other | |
| VCC | AL11 | Power/Other | |
| VCC | AL12 | Power/Other | |
| VCC | AL14 | Power/Other | |
| VCC | AL15 | Power/Other | |
| VCC | AL18 | Power/Other | |
| VCC | AL19 | Power/Other | |
| VCC | AL21 | Power/Other | |
| VCC | AL22 | Power/Other | |
| VCC | AL25 | Power/Other | |
| VCC | AL26 | Power/Other | |
| VCC | AL29 | Power/Other | |
| VCC | AL30 | Power/Other | |
| VCC | AL8 | Power/Other | |
| VCC | AL9 | Power/Other | |
| VCC | AM11 | Power/Other | |
| VCC | AM12 | Power/Other | |
| VCC | AM14 | Power/Other | |
| VCC | AM15 | Power/Other | |
| VCC | AM18 | Power/Other | |

Table 23. Alphabetical Land Assignments

| Land Name | Land # | Signal Buffer Type | Direction |
|-----------|--------|--------------------|-----------|
| VCC | AM19 | Power/Other | |
| VCC | AM21 | Power/Other | |
| VCC | AM22 | Power/Other | |
| VCC | AM25 | Power/Other | |
| VCC | AM26 | Power/Other | |
| VCC | AM29 | Power/Other | |
| VCC | AM30 | Power/Other | |
| VCC | AM8 | Power/Other | |
| VCC | AM9 | Power/Other | |
| VCC | AN11 | Power/Other | |
| VCC | AN12 | Power/Other | |
| VCC | AN14 | Power/Other | |
| VCC | AN15 | Power/Other | |
| VCC | AN18 | Power/Other | |
| VCC | AN19 | Power/Other | |
| VCC | AN21 | Power/Other | |
| VCC | AN22 | Power/Other | |
| VCC | AN25 | Power/Other | |
| VCC | AN26 | Power/Other | |
| VCC | AN29 | Power/Other | |
| VCC | AN30 | Power/Other | |
| VCC | AN8 | Power/Other | |
| VCC | AN9 | Power/Other | |
| VCC | J10 | Power/Other | |
| VCC | J11 | Power/Other | |
| VCC | J12 | Power/Other | |
| VCC | J13 | Power/Other | |
| VCC | J14 | Power/Other | |
| VCC | J15 | Power/Other | |
| VCC | J18 | Power/Other | |
| VCC | J19 | Power/Other | |
| VCC | J20 | Power/Other | |
| VCC | J21 | Power/Other | |
| VCC | J22 | Power/Other | |
| VCC | J23 | Power/Other | |
| VCC | J24 | Power/Other | |
| VCC | J25 | Power/Other | |
| VCC | J26 | Power/Other | |
| VCC | J27 | Power/Other | |



Table 23. Alphabetical Land Assignments

| Land Name | Land # | Signal Buffer Type | Direction |
|-----------|--------|--------------------|-----------|
| VCC | J28 | Power/Other | |
| VCC | J29 | Power/Other | |
| VCC | J30 | Power/Other | |
| VCC | J8 | Power/Other | |
| VCC | J9 | Power/Other | |
| VCC | K23 | Power/Other | |
| VCC | K24 | Power/Other | |
| VCC | K25 | Power/Other | |
| VCC | K26 | Power/Other | |
| VCC | K27 | Power/Other | |
| VCC | K28 | Power/Other | |
| VCC | K29 | Power/Other | |
| VCC | K30 | Power/Other | |
| VCC | K8 | Power/Other | |
| VCC | L8 | Power/Other | |
| VCC | M23 | Power/Other | |
| VCC | M24 | Power/Other | |
| VCC | M25 | Power/Other | |
| VCC | M26 | Power/Other | |
| VCC | M27 | Power/Other | |
| VCC | M28 | Power/Other | |
| VCC | M29 | Power/Other | |
| VCC | M30 | Power/Other | |
| VCC | M8 | Power/Other | |
| VCC | N23 | Power/Other | |
| VCC | N24 | Power/Other | |
| VCC | N25 | Power/Other | |
| VCC | N26 | Power/Other | |
| VCC | N27 | Power/Other | |
| VCC | N28 | Power/Other | |
| VCC | N29 | Power/Other | |
| VCC | N30 | Power/Other | |
| VCC | N8 | Power/Other | |
| VCC | P8 | Power/Other | |
| VCC | R8 | Power/Other | |
| VCC | T23 | Power/Other | |
| VCC | T24 | Power/Other | |
| VCC | T25 | Power/Other | |
| VCC | T26 | Power/Other | |

Table 23. Alphabetical Land Assignments

| Land Name | Land # | Signal Buffer Type | Direction |
|-------------------|--------|--------------------|-----------|
| VCC | T27 | Power/Other | |
| VCC | T28 | Power/Other | |
| VCC | T29 | Power/Other | |
| VCC | T30 | Power/Other | |
| VCC | T8 | Power/Other | |
| VCC | U23 | Power/Other | |
| VCC | U24 | Power/Other | |
| VCC | U25 | Power/Other | |
| VCC | U26 | Power/Other | |
| VCC | U27 | Power/Other | |
| VCC | U28 | Power/Other | |
| VCC | U29 | Power/Other | |
| VCC | U30 | Power/Other | |
| VCC | U8 | Power/Other | |
| VCC | V8 | Power/Other | |
| VCC | W23 | Power/Other | |
| VCC | W24 | Power/Other | |
| VCC | W25 | Power/Other | |
| VCC | W26 | Power/Other | |
| VCC | W27 | Power/Other | |
| VCC | W28 | Power/Other | |
| VCC | W29 | Power/Other | |
| VCC | W30 | Power/Other | |
| VCC | W8 | Power/Other | |
| VCC | Y23 | Power/Other | |
| VCC | Y24 | Power/Other | |
| VCC | Y25 | Power/Other | |
| VCC | Y26 | Power/Other | |
| VCC | Y27 | Power/Other | |
| VCC | Y28 | Power/Other | |
| VCC | Y29 | Power/Other | |
| VCC | Y30 | Power/Other | |
| VCC | Y8 | Power/Other | |
| VCC_MB_REGULATION | AN5 | Power/Other | Output |
| VCC_SENSE | AN3 | Power/Other | Output |
| VCCA | A23 | Power/Other | |
| VCCIOPLL | C23 | Power/Other | |
| VCCPLL | D23 | Power/Other | |
| VID_SELECT | AN7 | Power/Other | Output |



Table 23. Alphabetical Land Assignments

| Land Name | Land # | Signal Buffer Type | Direction |
|-----------|--------|--------------------|-----------|
| VID0 | AM2 | Power/Other | Output |
| VID1 | AL5 | Power/Other | Output |
| VID2 | AM3 | Power/Other | Output |
| VID3 | AL6 | Power/Other | Output |
| VID4 | AK4 | Power/Other | Output |
| VID5 | AL4 | Power/Other | Output |
| VID6 | AM5 | Power/Other | Output |
| VID7 | AM7 | Power/Other | Output |
| VRDSEL | AL3 | Power/Other | |
| VSS | A12 | Power/Other | |
| VSS | A15 | Power/Other | |
| VSS | A18 | Power/Other | |
| VSS | A2 | Power/Other | |
| VSS | A21 | Power/Other | |
| VSS | A6 | Power/Other | |
| VSS | A9 | Power/Other | |
| VSS | AA23 | Power/Other | |
| VSS | AA24 | Power/Other | |
| VSS | AA25 | Power/Other | |
| VSS | AA26 | Power/Other | |
| VSS | AA27 | Power/Other | |
| VSS | AA28 | Power/Other | |
| VSS | AA29 | Power/Other | |
| VSS | AA3 | Power/Other | |
| VSS | AA30 | Power/Other | |
| VSS | AA6 | Power/Other | |
| VSS | AA7 | Power/Other | |
| VSS | AB1 | Power/Other | |
| VSS | AB23 | Power/Other | |
| VSS | AB24 | Power/Other | |
| VSS | AB25 | Power/Other | |
| VSS | AB26 | Power/Other | |
| VSS | AB27 | Power/Other | |
| VSS | AB28 | Power/Other | |
| VSS | AB29 | Power/Other | |
| VSS | AB30 | Power/Other | |
| VSS | AB7 | Power/Other | |
| VSS | AC3 | Power/Other | |
| VSS | AC6 | Power/Other | |

Table 23. Alphabetical Land Assignments

| Land Name | Land # | Signal Buffer Type | Direction |
|-----------|--------|--------------------|-----------|
| VSS | AC7 | Power/Other | |
| VSS | AD4 | Power/Other | |
| VSS | AD7 | Power/Other | |
| VSS | AE10 | Power/Other | |
| VSS | AE13 | Power/Other | |
| VSS | AE16 | Power/Other | |
| VSS | AE17 | Power/Other | |
| VSS | AE2 | Power/Other | |
| VSS | AE20 | Power/Other | |
| VSS | AE24 | Power/Other | |
| VSS | AE25 | Power/Other | |
| VSS | AE26 | Power/Other | |
| VSS | AE27 | Power/Other | |
| VSS | AE28 | Power/Other | |
| VSS | AE29 | Power/Other | |
| VSS | AE30 | Power/Other | |
| VSS | AE5 | Power/Other | |
| VSS | AE7 | Power/Other | |
| VSS | AF10 | Power/Other | |
| VSS | AF13 | Power/Other | |
| VSS | AF16 | Power/Other | |
| VSS | AF17 | Power/Other | |
| VSS | AF20 | Power/Other | |
| VSS | AF23 | Power/Other | |
| VSS | AF24 | Power/Other | |
| VSS | AF25 | Power/Other | |
| VSS | AF26 | Power/Other | |
| VSS | AF27 | Power/Other | |
| VSS | AF28 | Power/Other | |
| VSS | AF29 | Power/Other | |
| VSS | AF3 | Power/Other | |
| VSS | AF30 | Power/Other | |
| VSS | AF6 | Power/Other | |
| VSS | AF7 | Power/Other | |
| VSS | AG10 | Power/Other | |
| VSS | AG13 | Power/Other | |
| VSS | AG16 | Power/Other | |
| VSS | AG17 | Power/Other | |
| VSS | AG20 | Power/Other | |

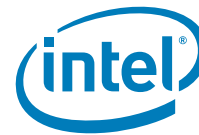


Table 23. Alphabetical Land Assignments

| Land Name | Land # | Signal Buffer Type | Direction |
|-----------|--------|--------------------|-----------|
| VSS | AG23 | Power/Other | |
| VSS | AG24 | Power/Other | |
| VSS | AG7 | Power/Other | |
| VSS | AH1 | Power/Other | |
| VSS | AH10 | Power/Other | |
| VSS | AH13 | Power/Other | |
| VSS | AH16 | Power/Other | |
| VSS | AH17 | Power/Other | |
| VSS | AH20 | Power/Other | |
| VSS | AH23 | Power/Other | |
| VSS | AH24 | Power/Other | |
| VSS | AH3 | Power/Other | |
| VSS | AH6 | Power/Other | |
| VSS | AH7 | Power/Other | |
| VSS | AJ10 | Power/Other | |
| VSS | AJ13 | Power/Other | |
| VSS | AJ16 | Power/Other | |
| VSS | AJ17 | Power/Other | |
| VSS | AJ20 | Power/Other | |
| VSS | AJ23 | Power/Other | |
| VSS | AJ24 | Power/Other | |
| VSS | AJ27 | Power/Other | |
| VSS | AJ28 | Power/Other | |
| VSS | AJ29 | Power/Other | |
| VSS | AJ30 | Power/Other | |
| VSS | AJ4 | Power/Other | |
| VSS | AJ7 | Power/Other | |
| VSS | AK10 | Power/Other | |
| VSS | AK13 | Power/Other | |
| VSS | AK16 | Power/Other | |
| VSS | AK17 | Power/Other | |
| VSS | AK2 | Power/Other | |
| VSS | AK20 | Power/Other | |
| VSS | AK23 | Power/Other | |
| VSS | AK24 | Power/Other | |
| VSS | AK27 | Power/Other | |
| VSS | AK28 | Power/Other | |
| VSS | AK29 | Power/Other | |
| VSS | AK30 | Power/Other | |

Table 23. Alphabetical Land Assignments

| Land Name | Land # | Signal Buffer Type | Direction |
|-----------|--------|--------------------|-----------|
| VSS | AK5 | Power/Other | |
| VSS | AK7 | Power/Other | |
| VSS | AL10 | Power/Other | |
| VSS | AL13 | Power/Other | |
| VSS | AL16 | Power/Other | |
| VSS | AL17 | Power/Other | |
| VSS | AL20 | Power/Other | |
| VSS | AL23 | Power/Other | |
| VSS | AL24 | Power/Other | |
| VSS | AL27 | Power/Other | |
| VSS | AL28 | Power/Other | |
| VSS | AL7 | Power/Other | |
| VSS | AM1 | Power/Other | |
| VSS | AM10 | Power/Other | |
| VSS | AM13 | Power/Other | |
| VSS | AM16 | Power/Other | |
| VSS | AM17 | Power/Other | |
| VSS | AM20 | Power/Other | |
| VSS | AM23 | Power/Other | |
| VSS | AM24 | Power/Other | |
| VSS | AM27 | Power/Other | |
| VSS | AM28 | Power/Other | |
| VSS | AM4 | Power/Other | |
| VSS | AN1 | Power/Other | |
| VSS | AN10 | Power/Other | |
| VSS | AN13 | Power/Other | |
| VSS | AN16 | Power/Other | |
| VSS | AN17 | Power/Other | |
| VSS | AN2 | Power/Other | |
| VSS | AN20 | Power/Other | |
| VSS | AN23 | Power/Other | |
| VSS | AN24 | Power/Other | |
| VSS | AN27 | Power/Other | |
| VSS | AN28 | Power/Other | |
| VSS | B1 | Power/Other | |
| VSS | B11 | Power/Other | |
| VSS | B14 | Power/Other | |
| VSS | B17 | Power/Other | |
| VSS | B20 | Power/Other | |



Table 23. Alphabetical Land Assignments

| Land Name | Land # | Signal Buffer Type | Direction |
|-----------|--------|--------------------|-----------|
| VSS | B24 | Power/Other | |
| VSS | B5 | Power/Other | |
| VSS | B8 | Power/Other | |
| VSS | C10 | Power/Other | |
| VSS | C13 | Power/Other | |
| VSS | C16 | Power/Other | |
| VSS | C19 | Power/Other | |
| VSS | C22 | Power/Other | |
| VSS | C24 | Power/Other | |
| VSS | C4 | Power/Other | |
| VSS | C7 | Power/Other | |
| VSS | D12 | Power/Other | |
| VSS | D15 | Power/Other | |
| VSS | D18 | Power/Other | |
| VSS | D21 | Power/Other | |
| VSS | D24 | Power/Other | |
| VSS | D3 | Power/Other | |
| VSS | D5 | Power/Other | |
| VSS | D6 | Power/Other | |
| VSS | D9 | Power/Other | |
| VSS | E11 | Power/Other | |
| VSS | E14 | Power/Other | |
| VSS | E17 | Power/Other | |
| VSS | E2 | Power/Other | |
| VSS | E20 | Power/Other | |
| VSS | E25 | Power/Other | |
| VSS | E26 | Power/Other | |
| VSS | E27 | Power/Other | |
| VSS | E28 | Power/Other | |
| VSS | E8 | Power/Other | |
| VSS | F10 | Power/Other | |
| VSS | F13 | Power/Other | |
| VSS | F16 | Power/Other | |
| VSS | F19 | Power/Other | |
| VSS | F22 | Power/Other | |
| VSS | F4 | Power/Other | |
| VSS | F7 | Power/Other | |
| VSS | H10 | Power/Other | |
| VSS | H11 | Power/Other | |

Table 23. Alphabetical Land Assignments

| Land Name | Land # | Signal Buffer Type | Direction |
|-----------|--------|--------------------|-----------|
| VSS | H12 | Power/Other | |
| VSS | H13 | Power/Other | |
| VSS | H14 | Power/Other | |
| VSS | H17 | Power/Other | |
| VSS | H18 | Power/Other | |
| VSS | H19 | Power/Other | |
| VSS | H20 | Power/Other | |
| VSS | H21 | Power/Other | |
| VSS | H22 | Power/Other | |
| VSS | H23 | Power/Other | |
| VSS | H24 | Power/Other | |
| VSS | H25 | Power/Other | |
| VSS | H26 | Power/Other | |
| VSS | H27 | Power/Other | |
| VSS | H28 | Power/Other | |
| VSS | H3 | Power/Other | |
| VSS | H6 | Power/Other | |
| VSS | H7 | Power/Other | |
| VSS | H8 | Power/Other | |
| VSS | H9 | Power/Other | |
| VSS | J4 | Power/Other | |
| VSS | J7 | Power/Other | |
| VSS | K2 | Power/Other | |
| VSS | K5 | Power/Other | |
| VSS | K7 | Power/Other | |
| VSS | L23 | Power/Other | |
| VSS | L24 | Power/Other | |
| VSS | L25 | Power/Other | |
| VSS | L26 | Power/Other | |
| VSS | L27 | Power/Other | |
| VSS | L28 | Power/Other | |
| VSS | L29 | Power/Other | |
| VSS | L3 | Power/Other | |
| VSS | L30 | Power/Other | |
| VSS | L6 | Power/Other | |
| VSS | L7 | Power/Other | |
| VSS | M1 | Power/Other | |
| VSS | M7 | Power/Other | |
| VSS | N3 | Power/Other | |



Table 23. Alphabetical Land Assignments

| Land Name | Land # | Signal Buffer Type | Direction |
|-----------|--------|--------------------|-----------|
| VSS | N6 | Power/Other | |
| VSS | N7 | Power/Other | |
| VSS | P23 | Power/Other | |
| VSS | P24 | Power/Other | |
| VSS | P25 | Power/Other | |
| VSS | P26 | Power/Other | |
| VSS | P27 | Power/Other | |
| VSS | P28 | Power/Other | |
| VSS | P29 | Power/Other | |
| VSS | P30 | Power/Other | |
| VSS | P4 | Power/Other | |
| VSS | P7 | Power/Other | |
| VSS | R2 | Power/Other | |
| VSS | R23 | Power/Other | |
| VSS | R24 | Power/Other | |
| VSS | R25 | Power/Other | |
| VSS | R26 | Power/Other | |
| VSS | R27 | Power/Other | |
| VSS | R28 | Power/Other | |
| VSS | R29 | Power/Other | |
| VSS | R30 | Power/Other | |
| VSS | R5 | Power/Other | |
| VSS | R7 | Power/Other | |
| VSS | T3 | Power/Other | |
| VSS | T6 | Power/Other | |
| VSS | T7 | Power/Other | |
| VSS | U7 | Power/Other | |
| VSS | V23 | Power/Other | |
| VSS | V24 | Power/Other | |
| VSS | V25 | Power/Other | |
| VSS | V26 | Power/Other | |
| VSS | V27 | Power/Other | |
| VSS | V28 | Power/Other | |
| VSS | V29 | Power/Other | |
| VSS | V3 | Power/Other | |
| VSS | V30 | Power/Other | |
| VSS | V6 | Power/Other | |
| VSS | V7 | Power/Other | |
| VSS | W4 | Power/Other | |

Table 23. Alphabetical Land Assignments

| Land Name | Land # | Signal Buffer Type | Direction |
|-------------------|--------|--------------------|-----------|
| VSS | W7 | Power/Other | |
| VSS | Y2 | Power/Other | |
| VSS | Y5 | Power/Other | |
| VSS | Y7 | Power/Other | |
| VSS_MB_REGULATION | AN6 | Power/Other | Output |
| VSS_SENSE | AN4 | Power/Other | Output |
| VSSA | B23 | Power/Other | |
| VTT | A25 | Power/Other | |
| VTT | A26 | Power/Other | |
| VTT | A27 | Power/Other | |
| VTT | A28 | Power/Other | |
| VTT | A29 | Power/Other | |
| VTT | A30 | Power/Other | |
| VTT | B25 | Power/Other | |
| VTT | B26 | Power/Other | |
| VTT | B27 | Power/Other | |
| VTT | B28 | Power/Other | |
| VTT | B29 | Power/Other | |
| VTT | B30 | Power/Other | |
| VTT | C25 | Power/Other | |
| VTT | C26 | Power/Other | |
| VTT | C27 | Power/Other | |
| VTT | C28 | Power/Other | |
| VTT | C29 | Power/Other | |
| VTT | C30 | Power/Other | |
| VTT | D25 | Power/Other | |
| VTT | D26 | Power/Other | |
| VTT | D27 | Power/Other | |
| VTT | D28 | Power/Other | |
| VTT | D29 | Power/Other | |
| VTT | D30 | Power/Other | |
| VTT_OUT_LEFT | J1 | Power/Other | Output |
| VTT_OUT_RIG HT | AA1 | Power/Other | Output |
| VTT_SEL | F27 | Power/Other | Output |



Table 24. Numerical Land Assignment

| Land # | Land Name | Signal Buffer Type | Direction |
|--------|-----------|--------------------|--------------|
| A2 | VSS | Power/Other | |
| A3 | RS2# | Common Clock | Input |
| A4 | D02# | Source Synch | Input/Output |
| A5 | D04# | Source Synch | Input/Output |
| A6 | VSS | Power/Other | |
| A7 | D07# | Source Synch | Input/Output |
| A8 | DBI0# | Source Synch | Input/Output |
| A9 | VSS | Power/Other | |
| A10 | D08# | Source Synch | Input/Output |
| A11 | D09# | Source Synch | Input/Output |
| A12 | VSS | Power/Other | |
| A13 | COMP0 | Power/Other | Input |
| A14 | D50# | Source Synch | Input/Output |
| A15 | VSS | Power/Other | |
| A16 | DSTBN3# | Source Synch | Input/Output |
| A17 | D56# | Source Synch | Input/Output |
| A18 | VSS | Power/Other | |
| A19 | D61# | Source Synch | Input/Output |
| A20 | RESERVED | | |
| A21 | VSS | Power/Other | |
| A22 | D62# | Source Synch | Input/Output |
| A23 | VCCA | Power/Other | |
| A24 | FC23 | Power/Other | |
| A25 | VTT | Power/Other | |
| A26 | VTT | Power/Other | |
| A27 | VTT | Power/Other | |
| A28 | VTT | Power/Other | |
| A29 | VTT | Power/Other | |
| A30 | VTT | Power/Other | |
| B1 | VSS | Power/Other | |
| B2 | DBSY# | Common Clock | Input/Output |
| B3 | RS0# | Common Clock | Input |
| B4 | D00# | Source Synch | Input/Output |
| B5 | VSS | Power/Other | |
| B6 | D05# | Source Synch | Input/Output |
| B7 | D06# | Source Synch | Input/Output |
| B8 | VSS | Power/Other | |
| B9 | DSTBP0# | Source Synch | Input/Output |
| B10 | D10# | Source Synch | Input/Output |

Table 24. Numerical Land Assignment

| Land # | Land Name | Signal Buffer Type | Direction |
|--------|-----------|--------------------|--------------|
| B11 | VSS | Power/Other | |
| B12 | D13# | Source Synch | Input/Output |
| B13 | COMP8 | Power/Other | Input |
| B14 | VSS | Power/Other | |
| B15 | D53# | Source Synch | Input/Output |
| B16 | D55# | Source Synch | Input/Output |
| B17 | VSS | Power/Other | |
| B18 | D57# | Source Synch | Input/Output |
| B19 | D60# | Source Synch | Input/Output |
| B20 | VSS | Power/Other | |
| B21 | D59# | Source Synch | Input/Output |
| B22 | D63# | Source Synch | Input/Output |
| B23 | VSSA | Power/Other | |
| B24 | VSS | Power/Other | |
| B25 | VTT | Power/Other | |
| B26 | VTT | Power/Other | |
| B27 | VTT | Power/Other | |
| B28 | VTT | Power/Other | |
| B29 | VTT | Power/Other | |
| B30 | VTT | Power/Other | |
| C1 | DRDY# | Common Clock | Input/Output |
| C2 | BNR# | Common Clock | Input/Output |
| C3 | LOCK# | Common Clock | Input/Output |
| C4 | VSS | Power/Other | |
| C5 | D01# | Source Synch | Input/Output |
| C6 | D03# | Source Synch | Input/Output |
| C7 | VSS | Power/Other | |
| C8 | DSTBN0# | Source Synch | Input/Output |
| C9 | FC38 | Power/Other | |
| C10 | VSS | Power/Other | |
| C11 | D11# | Source Synch | Input/Output |
| C12 | D14# | Source Synch | Input/Output |
| C13 | VSS | Power/Other | |
| C14 | D52# | Source Synch | Input/Output |
| C15 | D51# | Source Synch | Input/Output |
| C16 | VSS | Power/Other | |
| C17 | DSTBP3# | Source Synch | Input/Output |
| C18 | D54# | Source Synch | Input/Output |
| C19 | VSS | Power/Other | |



Table 24. Numerical Land Assignment

| Land # | Land Name | Signal Buffer Type | Direction |
|--------|-----------|--------------------|--------------|
| C20 | DBI3# | Source Synch | Input/Output |
| C21 | D58# | Source Synch | Input/Output |
| C22 | VSS | Power/Other | |
| C23 | VCCIOPLL | Power/Other | |
| C24 | VSS | Power/Other | |
| C25 | VTT | Power/Other | |
| C26 | VTT | Power/Other | |
| C27 | VTT | Power/Other | |
| C28 | VTT | Power/Other | |
| C29 | VTT | Power/Other | |
| C30 | VTT | Power/Other | |
| D1 | RESERVED | | |
| D2 | ADS# | Common Clock | Input/Output |
| D3 | VSS | Power/Other | |
| D4 | HIT# | Common Clock | Input/Output |
| D5 | VSS | Power/Other | |
| D6 | VSS | Power/Other | |
| D7 | D20# | Source Synch | Input/Output |
| D8 | D12# | Source Synch | Input/Output |
| D9 | VSS | Power/Other | |
| D10 | D22# | Source Synch | Input/Output |
| D11 | D15# | Source Synch | Input/Output |
| D12 | VSS | Power/Other | |
| D13 | D25# | Source Synch | Input/Output |
| D14 | RESERVED | | |
| D15 | VSS | Power/Other | |
| D16 | RESERVED | | |
| D17 | D49# | Source Synch | Input/Output |
| D18 | VSS | Power/Other | |
| D19 | DBI2# | Source Synch | Input/Output |
| D20 | D48# | Source Synch | Input/Output |
| D21 | VSS | Power/Other | |
| D22 | D46# | Source Synch | Input/Output |
| D23 | VCCPLL | Power/Other | |
| D24 | VSS | Power/Other | |
| D25 | VTT | Power/Other | |
| D26 | VTT | Power/Other | |
| D27 | VTT | Power/Other | |
| D28 | VTT | Power/Other | |

Table 24. Numerical Land Assignment

| Land # | Land Name | Signal Buffer Type | Direction |
|--------|-----------|--------------------|--------------|
| D29 | VTT | Power/Other | |
| D30 | VTT | Power/Other | |
| E2 | VSS | Power/Other | |
| E3 | TRDY# | Common Clock | Input |
| E4 | HITM# | Common Clock | Input/Output |
| E5 | FC20 | Power/Other | |
| E6 | RESERVED | | |
| E7 | RESERVED | | |
| E8 | VSS | Power/Other | |
| E9 | D19# | Source Synch | Input/Output |
| E10 | D21# | Source Synch | Input/Output |
| E11 | VSS | Power/Other | |
| E12 | DSTBP1# | Source Synch | Input/Output |
| E13 | D26# | Source Synch | Input/Output |
| E14 | VSS | Power/Other | |
| E15 | D33# | Source Synch | Input/Output |
| E16 | D34# | Source Synch | Input/Output |
| E17 | VSS | Power/Other | |
| E18 | D39# | Source Synch | Input/Output |
| E19 | D40# | Source Synch | Input/Output |
| E20 | VSS | Power/Other | |
| E21 | D42# | Source Synch | Input/Output |
| E22 | D45# | Source Synch | Input/Output |
| E23 | RESERVED | | |
| E24 | FC10 | Power/Other | |
| E25 | VSS | Power/Other | |
| E26 | VSS | Power/Other | |
| E27 | VSS | Power/Other | |
| E28 | VSS | Power/Other | |
| E29 | FC26 | Power/Other | |
| F2 | FC5 | Power/Other | |
| F3 | BR0# | Common Clock | Input/Output |
| F4 | VSS | Power/Other | |
| F5 | RS1# | Common Clock | Input |
| F6 | FC21 | Power/Other | |
| F7 | VSS | Power/Other | |
| F8 | D17# | Source Synch | Input/Output |
| F9 | D18# | Source Synch | Input/Output |
| F10 | VSS | Power/Other | |



Table 24. Numerical Land Assignment

| Land # | Land Name | Signal Buffer Type | Direction |
|--------|--------------|--------------------|--------------|
| F11 | D23# | Source Synch | Input/Output |
| F12 | D24# | Source Synch | Input/Output |
| F13 | VSS | Power/Other | |
| F14 | D28# | Source Synch | Input/Output |
| F15 | D30# | Source Synch | Input/Output |
| F16 | VSS | Power/Other | |
| F17 | D37# | Source Synch | Input/Output |
| F18 | D38# | Source Synch | Input/Output |
| F19 | VSS | Power/Other | |
| F20 | D41# | Source Synch | Input/Output |
| F21 | D43# | Source Synch | Input/Output |
| F22 | VSS | Power/Other | |
| F23 | RESERVED | | |
| F24 | TESTHI7 | Power/Other | Input |
| F25 | TESTHI2 | Power/Other | Input |
| F26 | TESTHI0 | Power/Other | Input |
| F27 | VTT_SEL | Power/Other | Output |
| F28 | BCLK0 | Clock | Input |
| F29 | RESERVED | | |
| G1 | FC27 | Power/Other | |
| G2 | COMP2 | Power/Other | Input |
| G3 | TESTHI8/FC42 | Power/Other | Input |
| G4 | TESTHI9/FC43 | Power/Other | Input |
| G5 | PECI | Power/Other | Input/Output |
| G6 | RESERVED | | |
| G7 | DEFER# | Common Clock | Input |
| G8 | BPRI# | Common Clock | Input |
| G9 | D16# | Source Synch | Input/Output |
| G10 | FC38 | Power/Other | |
| G11 | DBI1# | Source Synch | Input/Output |
| G12 | DSTBN1# | Source Synch | Input/Output |
| G13 | D27# | Source Synch | Input/Output |
| G14 | D29# | Source Synch | Input/Output |
| G15 | D31# | Source Synch | Input/Output |
| G16 | D32# | Source Synch | Input/Output |
| G17 | D36# | Source Synch | Input/Output |
| G18 | D35# | Source Synch | Input/Output |
| G19 | DSTBP2# | Source Synch | Input/Output |
| G20 | DSTBN2# | Source Synch | Input/Output |

Table 24. Numerical Land Assignment

| Land # | Land Name | Signal Buffer Type | Direction |
|--------|-----------|--------------------|--------------|
| G21 | D44# | Source Synch | Input/Output |
| G22 | D47# | Source Synch | Input/Output |
| G23 | RESET# | Common Clock | Input |
| G24 | TESTHI6 | Power/Other | Input |
| G25 | TESTHI3 | Power/Other | Input |
| G26 | TESTHI5 | Power/Other | Input |
| G27 | TESTHI4 | Power/Other | Input |
| G28 | BCLK1 | Clock | Input |
| G29 | BSEL0 | Power/Other | Output |
| G30 | BSEL2 | Power/Other | Output |
| H1 | GTLREF0 | Power/Other | Input |
| H2 | GTLREF1 | Power/Other | Input |
| H3 | VSS | Power/Other | |
| H4 | FC35 | Power/Other | |
| H5 | TESTHI10 | Power/Other | Input |
| H6 | VSS | Power/Other | |
| H7 | VSS | Power/Other | |
| H8 | VSS | Power/Other | |
| H9 | VSS | Power/Other | |
| H10 | VSS | Power/Other | |
| H11 | VSS | Power/Other | |
| H12 | VSS | Power/Other | |
| H13 | VSS | Power/Other | |
| H14 | VSS | Power/Other | |
| H15 | FC32 | Power/Other | |
| H16 | FC33 | Power/Other | |
| H17 | VSS | Power/Other | |
| H18 | VSS | Power/Other | |
| H19 | VSS | Power/Other | |
| H20 | VSS | Power/Other | |
| H21 | VSS | Power/Other | |
| H22 | VSS | Power/Other | |
| H23 | VSS | Power/Other | |
| H24 | VSS | Power/Other | |
| H25 | VSS | Power/Other | |
| H26 | VSS | Power/Other | |
| H27 | VSS | Power/Other | |
| H28 | VSS | Power/Other | |
| H29 | FC15 | Power/Other | |



Table 24. Numerical Land Assignment

| Land # | Land Name | Signal Buffer Type | Direction |
|--------|--------------|--------------------|--------------|
| H30 | BSEL1 | Power/Other | Output |
| J1 | VTT_OUT_LEFT | Power/Other | Output |
| J2 | FC3 | Power/Other | |
| J3 | FC22 | Power/Other | |
| J4 | VSS | Power/Other | |
| J5 | REQ1# | Source Synch | Input/Output |
| J6 | REQ4# | Source Synch | Input/Output |
| J7 | VSS | Power/Other | |
| J8 | VCC | Power/Other | |
| J9 | VCC | Power/Other | |
| J10 | VCC | Power/Other | |
| J11 | VCC | Power/Other | |
| J12 | VCC | Power/Other | |
| J13 | VCC | Power/Other | |
| J14 | VCC | Power/Other | |
| J15 | VCC | Power/Other | |
| J16 | FC31 | Power/Other | |
| J17 | FC34 | Power/Other | |
| J18 | VCC | Power/Other | |
| J19 | VCC | Power/Other | |
| J20 | VCC | Power/Other | |
| J21 | VCC | Power/Other | |
| J22 | VCC | Power/Other | |
| J23 | VCC | Power/Other | |
| J24 | VCC | Power/Other | |
| J25 | VCC | Power/Other | |
| J26 | VCC | Power/Other | |
| J27 | VCC | Power/Other | |
| J28 | VCC | Power/Other | |
| J29 | VCC | Power/Other | |
| J30 | VCC | Power/Other | |
| K1 | LINT0 | Asynch CMOS | Input |
| K2 | VSS | Power/Other | |
| K3 | A20M# | Asynch CMOS | Input |
| K4 | REQ0# | Source Synch | Input/Output |
| K5 | VSS | Power/Other | |
| K6 | REQ3# | Source Synch | Input/Output |
| K7 | VSS | Power/Other | |
| K8 | VCC | Power/Other | |

Table 24. Numerical Land Assignment

| Land # | Land Name | Signal Buffer Type | Direction |
|--------|------------|--------------------|--------------|
| K23 | VCC | Power/Other | |
| K24 | VCC | Power/Other | |
| K25 | VCC | Power/Other | |
| K26 | VCC | Power/Other | |
| K27 | VCC | Power/Other | |
| K28 | VCC | Power/Other | |
| K29 | VCC | Power/Other | |
| K30 | VCC | Power/Other | |
| L1 | LINT1 | Asynch CMOS | Input |
| L2 | TESTHI13 | Power/Other | Input |
| L3 | VSS | Power/Other | |
| L4 | A06# | Source Synch | Input/Output |
| L5 | A03# | Source Synch | Input/Output |
| L6 | VSS | Power/Other | |
| L7 | VSS | Power/Other | |
| L8 | VCC | Power/Other | |
| L23 | VSS | Power/Other | |
| L24 | VSS | Power/Other | |
| L25 | VSS | Power/Other | |
| L26 | VSS | Power/Other | |
| L27 | VSS | Power/Other | |
| L28 | VSS | Power/Other | |
| L29 | VSS | Power/Other | |
| L30 | VSS | Power/Other | |
| M1 | VSS | Power/Other | |
| M2 | THERMTRIP# | Asynch CMOS | Output |
| M3 | STPCLK# | Asynch CMOS | Input |
| M4 | A07# | Source Synch | Input/Output |
| M5 | A05# | Source Synch | Input/Output |
| M6 | REQ2# | Source Synch | Input/Output |
| M7 | VSS | Power/Other | |
| M8 | VCC | Power/Other | |
| M23 | VCC | Power/Other | |
| M24 | VCC | Power/Other | |
| M25 | VCC | Power/Other | |
| M26 | VCC | Power/Other | |
| M27 | VCC | Power/Other | |
| M28 | VCC | Power/Other | |
| M29 | VCC | Power/Other | |



Table 24. Numerical Land Assignment

| Land # | Land Name | Signal Buffer Type | Direction |
|--------|------------|--------------------|--------------|
| M30 | VCC | Power/Other | |
| N1 | PWRGOOD | Power/Other | Input |
| N2 | IGNNE# | Asynch CMOS | Input |
| N3 | VSS | Power/Other | |
| N4 | RESERVED | | |
| N5 | RESERVED | | |
| N6 | VSS | Power/Other | |
| N7 | VSS | Power/Other | |
| N8 | VCC | Power/Other | |
| N23 | VCC | Power/Other | |
| N24 | VCC | Power/Other | |
| N25 | VCC | Power/Other | |
| N26 | VCC | Power/Other | |
| N27 | VCC | Power/Other | |
| N28 | VCC | Power/Other | |
| N29 | VCC | Power/Other | |
| N30 | VCC | Power/Other | |
| P1 | TESTHI11 | Power/Other | Input |
| P2 | SMI# | Asynch CMOS | Input |
| P3 | INIT# | Asynch CMOS | Input |
| P4 | VSS | Power/Other | |
| P5 | RESERVED | | |
| P6 | A04# | Source Synch | Input/Output |
| P7 | VSS | Power/Other | |
| P8 | VCC | Power/Other | |
| P23 | VSS | Power/Other | |
| P24 | VSS | Power/Other | |
| P25 | VSS | Power/Other | |
| P26 | VSS | Power/Other | |
| P27 | VSS | Power/Other | |
| P28 | VSS | Power/Other | |
| P29 | VSS | Power/Other | |
| P30 | VSS | Power/Other | |
| R1 | COMP3 | Power/Other | Input |
| R2 | VSS | Power/Other | |
| R3 | FERR#/PBE# | Asynch CMOS | Output |
| R4 | A08# | Source Synch | Input/Output |
| R5 | VSS | Power/Other | |
| R6 | ADSTB0# | Source Synch | Input/Output |

Table 24. Numerical Land Assignment

| Land # | Land Name | Signal Buffer Type | Direction |
|--------|-----------|--------------------|--------------|
| R7 | VSS | Power/Other | |
| R8 | VCC | Power/Other | |
| R23 | VSS | Power/Other | |
| R24 | VSS | Power/Other | |
| R25 | VSS | Power/Other | |
| R26 | VSS | Power/Other | |
| R27 | VSS | Power/Other | |
| R28 | VSS | Power/Other | |
| R29 | VSS | Power/Other | |
| R30 | VSS | Power/Other | |
| T1 | COMP1 | Power/Other | Input |
| T2 | FC4 | Power/Other | |
| T3 | VSS | Power/Other | |
| T4 | A11# | Source Synch | Input/Output |
| T5 | A09# | Source Synch | Input/Output |
| T6 | VSS | Power/Other | |
| T7 | VSS | Power/Other | |
| T8 | VCC | Power/Other | |
| T23 | VCC | Power/Other | |
| T24 | VCC | Power/Other | |
| T25 | VCC | Power/Other | |
| T26 | VCC | Power/Other | |
| T27 | VCC | Power/Other | |
| T28 | VCC | Power/Other | |
| T29 | VCC | Power/Other | |
| T30 | VCC | Power/Other | |
| U1 | FC28 | Power/Other | |
| U2 | FC29 | Power/Other | |
| U3 | FC30 | Power/Other | |
| U4 | A13# | Source Synch | Input/Output |
| U5 | A12# | Source Synch | Input/Output |
| U6 | A10# | Source Synch | Input/Output |
| U7 | VSS | Power/Other | |
| U8 | VCC | Power/Other | |
| U23 | VCC | Power/Other | |
| U24 | VCC | Power/Other | |
| U25 | VCC | Power/Other | |
| U26 | VCC | Power/Other | |
| U27 | VCC | Power/Other | |



Table 24. Numerical Land Assignment

| Land # | Land Name | Signal Buffer Type | Direction |
|--------|---------------|--------------------|--------------|
| U28 | VCC | Power/Other | |
| U29 | VCC | Power/Other | |
| U30 | VCC | Power/Other | |
| V1 | MSID1 | Power/Other | Output |
| V2 | RESERVED | | |
| V3 | VSS | Power/Other | |
| V4 | A15# | Source Synch | Input/Output |
| V5 | A14# | Source Synch | Input/Output |
| V6 | VSS | Power/Other | |
| V7 | VSS | Power/Other | |
| V8 | VCC | Power/Other | |
| V23 | VSS | Power/Other | |
| V24 | VSS | Power/Other | |
| V25 | VSS | Power/Other | |
| V26 | VSS | Power/Other | |
| V27 | VSS | Power/Other | |
| V28 | VSS | Power/Other | |
| V29 | VSS | Power/Other | |
| V30 | VSS | Power/Other | |
| W1 | MSID0 | Power/Other | Output |
| W2 | TESTHI12/FC44 | Power/Other | Input |
| W3 | TESTHI1 | Power/Other | Input |
| W4 | VSS | Power/Other | |
| W5 | A16# | Source Synch | Input/Output |
| W6 | A18# | Source Synch | Input/Output |
| W7 | VSS | Power/Other | |
| W8 | VCC | Power/Other | |
| W23 | VCC | Power/Other | |
| W24 | VCC | Power/Other | |
| W25 | VCC | Power/Other | |
| W26 | VCC | Power/Other | |
| W27 | VCC | Power/Other | |
| W28 | VCC | Power/Other | |
| W29 | VCC | Power/Other | |
| W30 | VCC | Power/Other | |
| Y1 | FC0 | Power/Other | |
| Y2 | VSS | Power/Other | |
| Y3 | FC17 | Power/Other | |
| Y4 | A20# | Source Synch | Input/Output |

Table 24. Numerical Land Assignment

| Land # | Land Name | Signal Buffer Type | Direction |
|--------|---------------|--------------------|--------------|
| Y5 | VSS | Power/Other | |
| Y6 | A19# | Source Synch | Input/Output |
| Y7 | VSS | Power/Other | |
| Y8 | VCC | Power/Other | |
| Y23 | VCC | Power/Other | |
| Y24 | VCC | Power/Other | |
| Y25 | VCC | Power/Other | |
| Y26 | VCC | Power/Other | |
| Y27 | VCC | Power/Other | |
| Y28 | VCC | Power/Other | |
| Y29 | VCC | Power/Other | |
| Y30 | VCC | Power/Other | |
| AA1 | VTT_OUT_RIGHT | Power/Other | Output |
| AA2 | FC39 | Power/Other | |
| AA3 | VSS | Power/Other | |
| AA4 | A21# | Source Synch | Input/Output |
| AA5 | A23# | Source Synch | Input/Output |
| AA6 | VSS | Power/Other | |
| AA7 | VSS | Power/Other | |
| AA8 | VCC | Power/Other | |
| AA23 | VSS | Power/Other | |
| AA24 | VSS | Power/Other | |
| AA25 | VSS | Power/Other | |
| AA26 | VSS | Power/Other | |
| AA27 | VSS | Power/Other | |
| AA28 | VSS | Power/Other | |
| AA29 | VSS | Power/Other | |
| AA30 | VSS | Power/Other | |
| AB1 | VSS | Power/Other | |
| AB2 | IERR# | Asynch CMOS | Output |
| AB3 | FC37 | Power/Other | |
| AB4 | A26# | Source Synch | Input/Output |
| AB5 | A24# | Source Synch | Input/Output |
| AB6 | A17# | Source Synch | Input/Output |
| AB7 | VSS | Power/Other | |
| AB8 | VCC | Power/Other | |
| AB23 | VSS | Power/Other | |
| AB24 | VSS | Power/Other | |
| AB25 | VSS | Power/Other | |



Table 24. Numerical Land Assignment

| Land # | Land Name | Signal Buffer Type | Direction |
|--------|-----------|--------------------|--------------|
| AB26 | VSS | Power/Other | |
| AB27 | VSS | Power/Other | |
| AB28 | VSS | Power/Other | |
| AB29 | VSS | Power/Other | |
| AB30 | VSS | Power/Other | |
| AC1 | TMS | TAP | Input |
| AC2 | DBR# | Power/Other | Output |
| AC3 | VSS | Power/Other | |
| AC4 | RESERVED | | |
| AC5 | A25# | Source Synch | Input/Output |
| AC6 | VSS | Power/Other | |
| AC7 | VSS | Power/Other | |
| AC8 | VCC | Power/Other | |
| AC23 | VCC | Power/Other | |
| AC24 | VCC | Power/Other | |
| AC25 | VCC | Power/Other | |
| AC26 | VCC | Power/Other | |
| AC27 | VCC | Power/Other | |
| AC28 | VCC | Power/Other | |
| AC29 | VCC | Power/Other | |
| AC30 | VCC | Power/Other | |
| AD1 | TDI | TAP | Input |
| AD2 | BPM2# | Common Clock | Input/Output |
| AD3 | FC36 | Power/Other | |
| AD4 | VSS | Power/Other | |
| AD5 | ADSTB1# | Source Synch | Input/Output |
| AD6 | A22# | Source Synch | Input/Output |
| AD7 | VSS | Power/Other | |
| AD8 | VCC | Power/Other | |
| AD23 | VCC | Power/Other | |
| AD24 | VCC | Power/Other | |
| AD25 | VCC | Power/Other | |
| AD26 | VCC | Power/Other | |
| AD27 | VCC | Power/Other | |
| AD28 | VCC | Power/Other | |
| AD29 | VCC | Power/Other | |
| AD30 | VCC | Power/Other | |
| AE1 | TCK | TAP | Input |
| AE2 | VSS | Power/Other | |

Table 24. Numerical Land Assignment

| Land # | Land Name | Signal Buffer Type | Direction |
|--------|-----------|--------------------|--------------|
| AE3 | FC18 | Power/Other | |
| AE4 | RESERVED | | |
| AE5 | VSS | Power/Other | |
| AE6 | RESERVED | | |
| AE7 | VSS | Power/Other | |
| AE8 | SKTOCC# | Power/Other | Output |
| AE9 | VCC | Power/Other | |
| AE10 | VSS | Power/Other | |
| AE11 | VCC | Power/Other | |
| AE12 | VCC | Power/Other | |
| AE13 | VSS | Power/Other | |
| AE14 | VCC | Power/Other | |
| AE15 | VCC | Power/Other | |
| AE16 | VSS | Power/Other | |
| AE17 | VSS | Power/Other | |
| AE18 | VCC | Power/Other | |
| AE19 | VCC | Power/Other | |
| AE20 | VSS | Power/Other | |
| AE21 | VCC | Power/Other | |
| AE22 | VCC | Power/Other | |
| AE23 | VCC | Power/Other | |
| AE24 | VSS | Power/Other | |
| AE25 | VSS | Power/Other | |
| AE26 | VSS | Power/Other | |
| AE27 | VSS | Power/Other | |
| AE28 | VSS | Power/Other | |
| AE29 | VSS | Power/Other | |
| AE30 | VSS | Power/Other | |
| AF1 | TDO | TAP | Output |
| AF2 | BPM4# | Common Clock | Input/Output |
| AF3 | VSS | Power/Other | |
| AF4 | A28# | Source Synch | Input/Output |
| AF5 | A27# | Source Synch | Input/Output |
| AF6 | VSS | Power/Other | |
| AF7 | VSS | Power/Other | |
| AF8 | VCC | Power/Other | |
| AF9 | VCC | Power/Other | |
| AF10 | VSS | Power/Other | |
| AF11 | VCC | Power/Other | |



Table 24. Numerical Land Assignment

| Land # | Land Name | Signal Buffer Type | Direction |
|--------|-----------|--------------------|--------------|
| AF12 | VCC | Power/Other | |
| AF13 | VSS | Power/Other | |
| AF14 | VCC | Power/Other | |
| AF15 | VCC | Power/Other | |
| AF16 | VSS | Power/Other | |
| AF17 | VSS | Power/Other | |
| AF18 | VCC | Power/Other | |
| AF19 | VCC | Power/Other | |
| AF20 | VSS | Power/Other | |
| AF21 | VCC | Power/Other | |
| AF22 | VCC | Power/Other | |
| AF23 | VSS | Power/Other | |
| AF24 | VSS | Power/Other | |
| AF25 | VSS | Power/Other | |
| AF26 | VSS | Power/Other | |
| AF27 | VSS | Power/Other | |
| AF28 | VSS | Power/Other | |
| AF29 | VSS | Power/Other | |
| AF30 | VSS | Power/Other | |
| AG1 | TRST# | TAP | Input |
| AG2 | BPM3# | Common Clock | Input/Output |
| AG3 | BPM5# | Common Clock | Input/Output |
| AG4 | A30# | Source Synch | Input/Output |
| AG5 | A31# | Source Synch | Input/Output |
| AG6 | A29# | Source Synch | Input/Output |
| AG7 | VSS | Power/Other | |
| AG8 | VCC | Power/Other | |
| AG9 | VCC | Power/Other | |
| AG10 | VSS | Power/Other | |
| AG11 | VCC | Power/Other | |
| AG12 | VCC | Power/Other | |
| AG13 | VSS | Power/Other | |
| AG14 | VCC | Power/Other | |
| AG15 | VCC | Power/Other | |
| AG16 | VSS | Power/Other | |
| AG17 | VSS | Power/Other | |
| AG18 | VCC | Power/Other | |
| AG19 | VCC | Power/Other | |
| AG20 | VSS | Power/Other | |

Table 24. Numerical Land Assignment

| Land # | Land Name | Signal Buffer Type | Direction |
|--------|-----------|--------------------|--------------|
| AG21 | VCC | Power/Other | |
| AG22 | VCC | Power/Other | |
| AG23 | VSS | Power/Other | |
| AG24 | VSS | Power/Other | |
| AG25 | VCC | Power/Other | |
| AG26 | VCC | Power/Other | |
| AG27 | VCC | Power/Other | |
| AG28 | VCC | Power/Other | |
| AG29 | VCC | Power/Other | |
| AG30 | VCC | Power/Other | |
| AH1 | VSS | Power/Other | |
| AH2 | RESERVED | | |
| AH3 | VSS | Power/Other | |
| AH4 | A32# | Source Synch | Input/Output |
| AH5 | A33# | Source Synch | Input/Output |
| AH6 | VSS | Power/Other | |
| AH7 | VSS | Power/Other | |
| AH8 | VCC | Power/Other | |
| AH9 | VCC | Power/Other | |
| AH10 | VSS | Power/Other | |
| AH11 | VCC | Power/Other | |
| AH12 | VCC | Power/Other | |
| AH13 | VSS | Power/Other | |
| AH14 | VCC | Power/Other | |
| AH15 | VCC | Power/Other | |
| AH16 | VSS | Power/Other | |
| AH17 | VSS | Power/Other | |
| AH18 | VCC | Power/Other | |
| AH19 | VCC | Power/Other | |
| AH20 | VSS | Power/Other | |
| AH21 | VCC | Power/Other | |
| AH22 | VCC | Power/Other | |
| AH23 | VSS | Power/Other | |
| AH24 | VSS | Power/Other | |
| AH25 | VCC | Power/Other | |
| AH26 | VCC | Power/Other | |
| AH27 | VCC | Power/Other | |
| AH28 | VCC | Power/Other | |
| AH29 | VCC | Power/Other | |



Table 24. Numerical Land Assignment

| Land # | Land Name | Signal Buffer Type | Direction |
|--------|-----------|--------------------|--------------|
| AH30 | VCC | Power/Other | |
| AJ1 | BPM1# | Common Clock | Input/Output |
| AJ2 | BPM0# | Common Clock | Input/Output |
| AJ3 | ITP_CLK1 | TAP | Input |
| AJ4 | VSS | Power/Other | |
| AJ5 | A34# | Source Synch | Input/Output |
| AJ6 | A35# | Source Synch | Input/Output |
| AJ7 | VSS | Power/Other | |
| AJ8 | VCC | Power/Other | |
| AJ9 | VCC | Power/Other | |
| AJ10 | VSS | Power/Other | |
| AJ11 | VCC | Power/Other | |
| AJ12 | VCC | Power/Other | |
| AJ13 | VSS | Power/Other | |
| AJ14 | VCC | Power/Other | |
| AJ15 | VCC | Power/Other | |
| AJ16 | VSS | Power/Other | |
| AJ17 | VSS | Power/Other | |
| AJ18 | VCC | Power/Other | |
| AJ19 | VCC | Power/Other | |
| AJ20 | VSS | Power/Other | |
| AJ21 | VCC | Power/Other | |
| AJ22 | VCC | Power/Other | |
| AJ23 | VSS | Power/Other | |
| AJ24 | VSS | Power/Other | |
| AJ25 | VCC | Power/Other | |
| AJ26 | VCC | Power/Other | |
| AJ27 | VSS | Power/Other | |
| AJ28 | VSS | Power/Other | |
| AJ29 | VSS | Power/Other | |
| AJ30 | VSS | Power/Other | |
| AK1 | THERMDC | Power/Other | |
| AK2 | VSS | Power/Other | |
| AK3 | ITP_CLK0 | TAP | Input |
| AK4 | VID4 | Power/Other | Output |
| AK5 | VSS | Power/Other | |
| AK6 | FC8 | Power/Other | |
| AK7 | VSS | Power/Other | |
| AK8 | VCC | Power/Other | |

Table 24. Numerical Land Assignment

| Land # | Land Name | Signal Buffer Type | Direction |
|--------|-----------|--------------------|--------------|
| AK9 | VCC | Power/Other | |
| AK10 | VSS | Power/Other | |
| AK11 | VCC | Power/Other | |
| AK12 | VCC | Power/Other | |
| AK13 | VSS | Power/Other | |
| AK14 | VCC | Power/Other | |
| AK15 | VCC | Power/Other | |
| AK16 | VSS | Power/Other | |
| AK17 | VSS | Power/Other | |
| AK18 | VCC | Power/Other | |
| AK19 | VCC | Power/Other | |
| AK20 | VSS | Power/Other | |
| AK21 | VCC | Power/Other | |
| AK22 | VCC | Power/Other | |
| AK23 | VSS | Power/Other | |
| AK24 | VSS | Power/Other | |
| AK25 | VCC | Power/Other | |
| AK26 | VCC | Power/Other | |
| AK27 | VSS | Power/Other | |
| AK28 | VSS | Power/Other | |
| AK29 | VSS | Power/Other | |
| AK30 | VSS | Power/Other | |
| AL1 | THERMDA | Power/Other | |
| AL2 | PROCHOT# | Asynch CMOS | Input/Output |
| AL3 | VRDSEL | Power/Other | |
| AL4 | VID5 | Power/Other | Output |
| AL5 | VID1 | Power/Other | Output |
| AL6 | VID3 | Power/Other | Output |
| AL7 | VSS | Power/Other | |
| AL8 | VCC | Power/Other | |
| AL9 | VCC | Power/Other | |
| AL10 | VSS | Power/Other | |
| AL11 | VCC | Power/Other | |
| AL12 | VCC | Power/Other | |
| AL13 | VSS | Power/Other | |
| AL14 | VCC | Power/Other | |
| AL15 | VCC | Power/Other | |
| AL16 | VSS | Power/Other | |
| AL17 | VSS | Power/Other | |



Table 24. Numerical Land Assignment

| Land # | Land Name | Signal Buffer Type | Direction |
|--------|-----------|--------------------|-----------|
| AL18 | VCC | Power/Other | |
| AL19 | VCC | Power/Other | |
| AL20 | VSS | Power/Other | |
| AL21 | VCC | Power/Other | |
| AL22 | VCC | Power/Other | |
| AL23 | VSS | Power/Other | |
| AL24 | VSS | Power/Other | |
| AL25 | VCC | Power/Other | |
| AL26 | VCC | Power/Other | |
| AL27 | VSS | Power/Other | |
| AL28 | VSS | Power/Other | |
| AL29 | VCC | Power/Other | |
| AL30 | VCC | Power/Other | |
| AM1 | VSS | Power/Other | |
| AM2 | VID0 | Power/Other | Output |
| AM3 | VID2 | Power/Other | Output |
| AM4 | VSS | Power/Other | |
| AM5 | VID6 | Power/Other | Output |
| AM6 | FC40 | Power/Other | |
| AM7 | VID7 | Power/Other | Output |
| AM8 | VCC | Power/Other | |
| AM9 | VCC | Power/Other | |
| AM10 | VSS | Power/Other | |
| AM11 | VCC | Power/Other | |
| AM12 | VCC | Power/Other | |
| AM13 | VSS | Power/Other | |
| AM14 | VCC | Power/Other | |
| AM15 | VCC | Power/Other | |
| AM16 | VSS | Power/Other | |
| AM17 | VSS | Power/Other | |
| AM18 | VCC | Power/Other | |
| AM19 | VCC | Power/Other | |
| AM20 | VSS | Power/Other | |
| AM21 | VCC | Power/Other | |
| AM22 | VCC | Power/Other | |
| AM23 | VSS | Power/Other | |
| AM24 | VSS | Power/Other | |
| AM25 | VCC | Power/Other | |
| AM26 | VCC | Power/Other | |

Table 24. Numerical Land Assignment

| Land # | Land Name | Signal Buffer Type | Direction |
|--------|-------------------|--------------------|-----------|
| AM27 | VSS | Power/Other | |
| AM28 | VSS | Power/Other | |
| AM29 | VCC | Power/Other | |
| AM30 | VCC | Power/Other | |
| AN1 | VSS | Power/Other | |
| AN2 | VSS | Power/Other | |
| AN3 | VCC_SENSE | Power/Other | Output |
| AN4 | VSS_SENSE | Power/Other | Output |
| AN5 | VCC_MB_REGULATION | Power/Other | Output |
| AN6 | VSS_MB_REGULATION | Power/Other | Output |
| AN7 | VID_SELECT | Power/Other | Output |
| AN8 | VCC | Power/Other | |
| AN9 | VCC | Power/Other | |
| AN10 | VSS | Power/Other | |
| AN11 | VCC | Power/Other | |
| AN12 | VCC | Power/Other | |
| AN13 | VSS | Power/Other | |
| AN14 | VCC | Power/Other | |
| AN15 | VCC | Power/Other | |
| AN16 | VSS | Power/Other | |
| AN17 | VSS | Power/Other | |
| AN18 | VCC | Power/Other | |
| AN19 | VCC | Power/Other | |
| AN20 | VSS | Power/Other | |
| AN21 | VCC | Power/Other | |
| AN22 | VCC | Power/Other | |
| AN23 | VSS | Power/Other | |
| AN24 | VSS | Power/Other | |
| AN25 | VCC | Power/Other | |
| AN26 | VCC | Power/Other | |
| AN27 | VSS | Power/Other | |
| AN28 | VSS | Power/Other | |
| AN29 | VCC | Power/Other | |
| AN30 | VCC | Power/Other | |



4.2 Alphabetical Signals Reference

Table 25. Signal Description (Sheet 1 of 9)

| Name | Type | Description | | | | | | |
|---------------------|--------------------------|---|----------------|--------------------------|---------------------|---------|-----------|---------|
| A[35:3]# | Input/Output | A[35:3]# (Address) define a 2 ³⁶ -byte physical memory address space. In sub-phase 1 of the address phase, these signals transmit the address of a transaction. In sub-phase 2, these signals transmit transaction type information. These signals must connect the appropriate pins/lands of all agents on the processor FSB. A[35:3]# are source synchronous signals and are latched into the receiving buffers by ADSTB[1:0]#. On the active-to-inactive transition of RESET#, the processor samples a subset of the A[35:3]# signals to determine power-on configuration. See Section 6.1 for more details. | | | | | | |
| A20M# | Input | If A20M# (Address-20 Mask) is asserted, the processor masks physical address bit 20 (A20#) before looking up a line in any internal cache and before driving a read/write transaction on the bus. Asserting A20M# emulates the 8086 processor's address wrap-around at the 1-MB boundary. Assertion of A20M# is only supported in real mode. A20M# is an asynchronous signal. However, to ensure recognition of this signal following an Input/Output write instruction, it must be valid along with the TRDY# assertion of the corresponding Input/Output Write bus transaction. | | | | | | |
| ADS# | Input/Output | ADS# (Address Strobe) is asserted to indicate the validity of the transaction address on the A[35:3]# and REQ[4:0]# signals. All bus agents observe the ADS# activation to begin protocol checking, address decode, internal snoop, or deferred reply ID match operations associated with the new transaction. | | | | | | |
| ADSTB[1:0]# | Input/Output | Address strobes are used to latch A[35:3]# and REQ[4:0]# on their rising and falling edges. Strobes are associated with signals as shown below. <table border="0" style="width: 100%;"> <tr> <td style="text-align: left;">Signals</td> <td style="text-align: left;">Associated Strobe</td> </tr> <tr> <td>REQ[4:0]#, A[16:3]#</td> <td>ADSTB0#</td> </tr> <tr> <td>A[35:17]#</td> <td>ADSTB1#</td> </tr> </table> | Signals | Associated Strobe | REQ[4:0]#, A[16:3]# | ADSTB0# | A[35:17]# | ADSTB1# |
| Signals | Associated Strobe | | | | | | | |
| REQ[4:0]#, A[16:3]# | ADSTB0# | | | | | | | |
| A[35:17]# | ADSTB1# | | | | | | | |
| BCLK[1:0] | Input | The differential pair BCLK (Bus Clock) determines the FSB frequency. All processor FSB agents must receive these signals to drive their outputs and latch their inputs. All external timing parameters are specified with respect to the rising edge of BCLK0 crossing V _{CROSS} . | | | | | | |
| BNR# | Input/Output | BNR# (Block Next Request) is used to assert a bus stall by any bus agent unable to accept new bus transactions. During a bus stall, the current bus owner cannot issue any new transactions. | | | | | | |



Table 25. Signal Description (Sheet 2 of 9)

| Name | Type | Description |
|--------------------|------------------|--|
| BPM[5:0]# | Input/ Output | <p>BPM[5:0]# (Breakpoint Monitor) are breakpoint and performance monitor signals. They are outputs from the processor which indicate the status of breakpoints and programmable counters used for monitoring processor performance. BPM[5:0]# should connect the appropriate pins/lands of all processor FSB agents.</p> <p>BPM4# provides PRDY# (Probe Ready) functionality for the TAP port. PRDY# is a processor output used by debug tools to determine processor debug readiness.</p> <p>BPM5# provides PREQ# (Probe Request) functionality for the TAP port. PREQ# is used by debug tools to request debug operation of the processor.</p> <p>These signals do not have on-die termination. Refer to Section 2.6.2 for termination requirements.</p> |
| BPRI# | Input | <p>BPRI# (Bus Priority Request) is used to arbitrate for ownership of the processor FSB. It must connect the appropriate pins/lands of all processor FSB agents. Observing BPRI# active (as asserted by the priority agent) causes all other agents to stop issuing new requests, unless such requests are part of an ongoing locked operation. The priority agent keeps BPRI# asserted until all of its requests are completed, then releases the bus by de-asserting BPRI#.</p> |
| BRO# | Input/ Output | <p>BRO# drives the BREQ0# signal in the system and is used by the processor to request the bus. During power-on configuration this signal is sampled to determine the agent ID = 0.</p> <p>This signal does not have on-die termination and must be terminated.</p> |
| BSEL[2:0] | Output | <p>The BCLK[1:0] frequency select signals BSEL[2:0] are used to select the processor input clock frequency. Table 16 defines the possible combinations of the signals and the frequency associated with each combination. The required frequency is determined by the processor, chipset and clock synthesizer. All agents must operate at the same frequency. For more information about these signals, including termination recommendations refer to Section 2.8.2.</p> |
| COMP8 COMP[3:0] | Analog | <p>COMP[3:0] and COMP8 must be terminated to V_{SS} on the system board using precision resistors.</p> |



Table 25. Signal Description (Sheet 3 of 9)

| Name | Type | Description | | | | | | | | | | | | | | | |
|------------|------------------|---|------------|------------------|-------|-----------|-------|-----------|-----------|-----------|-------|-----------|---|---|-----------|---|---|
| D[63:0]# | Input/Output | <p>D[63:0]# (Data) are the data signals. These signals provide a 64-bit data path between the processor FSB agents, and must connect the appropriate pins/lands on all such agents. The data driver asserts DRDY# to indicate a valid data transfer.</p> <p>D[63:0]# are quad-pumped signals and will, thus, be driven four times in a common clock period. D[63:0]# are latched off the falling edge of both DSTBP[3:0]# and DSTBN[3:0]#. Each group of 16 data signals correspond to a pair of one DSTBP# and one DSTBN#. The following table shows the grouping of data signals to data strobes and DBI#.</p> <p>Quad-Pumped Signal Groups</p> <table border="1"> <thead> <tr> <th>Data Group</th> <th>DSTBN# / DSTBP#</th> <th>DBI#</th> </tr> </thead> <tbody> <tr> <td>D[15:0]#</td> <td>0</td> <td>0</td> </tr> <tr> <td>D[31:16]#</td> <td>1</td> <td>1</td> </tr> <tr> <td>D[47:32]#</td> <td>2</td> <td>2</td> </tr> <tr> <td>D[63:48]#</td> <td>3</td> <td>3</td> </tr> </tbody> </table> <p>Furthermore, the DBI# signals determine the polarity of the data signals. Each group of 16 data signals corresponds to one DBI# signal. When the DBI# signal is active, the corresponding data group is inverted and therefore sampled active high.</p> | Data Group | DSTBN# / DSTBP# | DBI# | D[15:0]# | 0 | 0 | D[31:16]# | 1 | 1 | D[47:32]# | 2 | 2 | D[63:48]# | 3 | 3 |
| Data Group | DSTBN# / DSTBP# | DBI# | | | | | | | | | | | | | | | |
| D[15:0]# | 0 | 0 | | | | | | | | | | | | | | | |
| D[31:16]# | 1 | 1 | | | | | | | | | | | | | | | |
| D[47:32]# | 2 | 2 | | | | | | | | | | | | | | | |
| D[63:48]# | 3 | 3 | | | | | | | | | | | | | | | |
| DBI[3:0]# | Input/Output | <p>DBI[3:0]# (Data Bus Inversion) are source synchronous and indicate the polarity of the D[63:0]# signals. The DBI[3:0]# signals are activated when the data on the data bus is inverted. If more than half the data bits, within a 16-bit group, would have been asserted electrically low, the bus agent may invert the data bus signals for that particular sub-phase for that 16-bit group.</p> <p>DBI[3:0] Assignment To Data Bus</p> <table border="1"> <thead> <tr> <th>Bus Signal</th> <th>Data Bus Signals</th> </tr> </thead> <tbody> <tr> <td>DBI3#</td> <td>D[63:48]#</td> </tr> <tr> <td>DBI2#</td> <td>D[47:32]#</td> </tr> <tr> <td>DBI1#</td> <td>D[31:16]#</td> </tr> <tr> <td>DBI0#</td> <td>D[15:0]#</td> </tr> </tbody> </table> | Bus Signal | Data Bus Signals | DBI3# | D[63:48]# | DBI2# | D[47:32]# | DBI1# | D[31:16]# | DBI0# | D[15:0]# | | | | | |
| Bus Signal | Data Bus Signals | | | | | | | | | | | | | | | | |
| DBI3# | D[63:48]# | | | | | | | | | | | | | | | | |
| DBI2# | D[47:32]# | | | | | | | | | | | | | | | | |
| DBI1# | D[31:16]# | | | | | | | | | | | | | | | | |
| DBI0# | D[15:0]# | | | | | | | | | | | | | | | | |
| DBR# | Output | <p>DBR# (Debug Reset) is used only in processor systems where no debug port is implemented on the system board. DBR# is used by a debug port interposer so that an in-target probe can drive system reset. If a debug port is implemented in the system, DBR# is a no connect in the system. DBR# is not a processor signal.</p> | | | | | | | | | | | | | | | |
| DBSY# | Input/Output | <p>DBSY# (Data Bus Busy) is asserted by the agent responsible for driving data on the processor FSB to indicate that the data bus is in use. The data bus is released after DBSY# is de-asserted. This signal must connect the appropriate pins/lands on all processor FSB agents.</p> | | | | | | | | | | | | | | | |



Table 25. Signal Description (Sheet 4 of 9)

| Name | Type | Description | | | | | | | | | | |
|------------------|-------------------|--|---------|-------------------|-----------------|---------|------------------|---------|------------------|---------|------------------|---------|
| DEFER# | Input | DEFER# is asserted by an agent to indicate that a transaction cannot be ensured in-order completion. Assertion of DEFER# is normally the responsibility of the addressed memory or input/output agent. This signal must connect the appropriate pins/lands of all processor FSB agents. | | | | | | | | | | |
| DRDY# | Input/Output | DRDY# (Data Ready) is asserted by the data driver on each data transfer, indicating valid data on the data bus. In a multi-common clock data transfer, DRDY# may be de-asserted to insert idle clocks. This signal must connect the appropriate pins/lands of all processor FSB agents. | | | | | | | | | | |
| DSTBN[3:0]# | Input/Output | DSTBN[3:0]# are the data strobes used to latch in D[63:0]#. <table border="1" style="width: 100%; margin-top: 10px;"> <thead> <tr> <th>Signals</th> <th>Associated Strobe</th> </tr> </thead> <tbody> <tr> <td>D[15:0]#, DBI0#</td> <td>DSTBN0#</td> </tr> <tr> <td>D[31:16]#, DBI1#</td> <td>DSTBN1#</td> </tr> <tr> <td>D[47:32]#, DBI2#</td> <td>DSTBN2#</td> </tr> <tr> <td>D[63:48]#, DBI3#</td> <td>DSTBN3#</td> </tr> </tbody> </table> | Signals | Associated Strobe | D[15:0]#, DBI0# | DSTBN0# | D[31:16]#, DBI1# | DSTBN1# | D[47:32]#, DBI2# | DSTBN2# | D[63:48]#, DBI3# | DSTBN3# |
| Signals | Associated Strobe | | | | | | | | | | | |
| D[15:0]#, DBI0# | DSTBN0# | | | | | | | | | | | |
| D[31:16]#, DBI1# | DSTBN1# | | | | | | | | | | | |
| D[47:32]#, DBI2# | DSTBN2# | | | | | | | | | | | |
| D[63:48]#, DBI3# | DSTBN3# | | | | | | | | | | | |
| DSTBP[3:0]# | Input/Output | DSTBP[3:0]# are the data strobes used to latch in D[63:0]#. <table border="1" style="width: 100%; margin-top: 10px;"> <thead> <tr> <th>Signals</th> <th>Associated Strobe</th> </tr> </thead> <tbody> <tr> <td>D[15:0]#, DBI0#</td> <td>DSTBP0#</td> </tr> <tr> <td>D[31:16]#, DBI1#</td> <td>DSTBP1#</td> </tr> <tr> <td>D[47:32]#, DBI2#</td> <td>DSTBP2#</td> </tr> <tr> <td>D[63:48]#, DBI3#</td> <td>DSTBP3#</td> </tr> </tbody> </table> | Signals | Associated Strobe | D[15:0]#, DBI0# | DSTBP0# | D[31:16]#, DBI1# | DSTBP1# | D[47:32]#, DBI2# | DSTBP2# | D[63:48]#, DBI3# | DSTBP3# |
| Signals | Associated Strobe | | | | | | | | | | | |
| D[15:0]#, DBI0# | DSTBP0# | | | | | | | | | | | |
| D[31:16]#, DBI1# | DSTBP1# | | | | | | | | | | | |
| D[47:32]#, DBI2# | DSTBP2# | | | | | | | | | | | |
| D[63:48]#, DBI3# | DSTBP3# | | | | | | | | | | | |
| FCx | Other | FC signals are signals that are available for compatibility with other processors. | | | | | | | | | | |
| FERR#/PBE# | Output | FERR#/PBE# (floating point error/pending break event) is a multiplexed signal and its meaning is qualified by STPCLK#. When STPCLK# is not asserted, FERR#/PBE# indicates a floating-point error and will be asserted when the processor detects an unmasked floating-point error. When STPCLK# is not asserted, FERR#/PBE# is similar to the ERROR# signal on the Intel 387 coprocessor, and is included for compatibility with systems using MS-DOS*-type floating-point error reporting. When STPCLK# is asserted, an assertion of FERR#/PBE# indicates that the processor has a pending break event waiting for service. The assertion of FERR#/PBE# indicates that the processor should be returned to the Normal state. For additional information on the pending break event functionality, including the identification of support of the feature and enable/disable information, refer to volume 3 of the <i>Intel Architecture Software Developer's Manual</i> and the <i>Intel Processor Identification and the CPUID Instruction</i> application note. | | | | | | | | | | |
| GTLREF[1:0] | Input | GTLREF[1:0] determine the signal reference level for GTL+ input signals. GTLREF is used by the GTL+ receivers to determine if a signal is a logical 0 or logical 1. | | | | | | | | | | |



Table 25. Signal Description (Sheet 5 of 9)

| Name | Type | Description |
|--------------|--------------|--|
| HIT# | Input/Output | HIT# (Snoop Hit) and HITM# (Hit Modified) convey transaction snoop operation results. Any FSB agent may assert both HIT# and HITM# together to indicate that it requires a snoop stall, which can be continued by reasserting HIT# and HITM# together. |
| HITM# | Input/Output | |
| IERR# | Output | IERR# (Internal Error) is asserted by a processor as the result of an internal error. Assertion of IERR# is usually accompanied by a SHUTDOWN transaction on the processor FSB. This transaction may optionally be converted to an external error signal (e.g., NMI) by system core logic. The processor will keep IERR# asserted until the assertion of RESET#. This signal does not have on-die termination. Refer to Section 2.6.2 for termination requirements. |
| IGNNE# | Input | IGNNE# (Ignore Numeric Error) is asserted to the processor to ignore a numeric error and continue to execute noncontrol floating-point instructions. If IGNNE# is de-asserted, the processor generates an exception on a noncontrol floating-point instruction if a previous floating-point instruction caused an error. IGNNE# has no effect when the NE bit in control register 0 (CR0) is set. IGNNE# is an asynchronous signal. However, to ensure recognition of this signal following an Input/Output write instruction, it must be valid along with the TRDY# assertion of the corresponding Input/Output Write bus transaction. |
| INIT# | Input | INIT# (Initialization), when asserted, resets integer registers inside the processor without affecting its internal caches or floating-point registers. The processor then begins execution at the power-on Reset vector configured during power-on configuration. The processor continues to handle snoop requests during INIT# assertion. INIT# is an asynchronous signal and must connect the appropriate pins/lands of all processor FSB agents. |
| ITP_CLK[1:0] | Input | ITP_CLK[1:0] are copies of BCLK that are used only in processor systems where no debug port is implemented on the system board. ITP_CLK[1:0] are used as BCLK[1:0] references for a debug port implemented on an interposer. If a debug port is implemented in the system, ITP_CLK[1:0] are no connects in the system. These are not processor signals. |
| LINT[1:0] | Input | LINT[1:0] (Local APIC Interrupt) must connect the appropriate pins/lands of all APIC Bus agents. When the APIC is disabled, the LINT0 signal becomes INTR, a maskable interrupt request signal, and LINT1 becomes NMI, a nonmaskable interrupt. INTR and NMI are backward compatible with the signals of those names on the Pentium processor. Both signals are asynchronous. Both of these signals must be software configured via BIOS programming of the APIC register space to be used either as NMI/INTR or LINT[1:0]. Because the APIC is enabled by default after Reset, operation of these signals as LINT[1:0] is the default configuration. |



Table 25. Signal Description (Sheet 6 of 9)

| Name | Type | Description |
|-----------|------------------|---|
| LOCK# | Input/ Output | LOCK# indicates to the system that a transaction must occur atomically. This signal must connect the appropriate pins/lands of all processor FSB agents. For a locked sequence of transactions, LOCK# is asserted from the beginning of the first transaction to the end of the last transaction. When the priority agent asserts BPRI# to arbitrate for ownership of the processor FSB, it will wait until it observes LOCK# de-asserted. This enables symmetric agents to retain ownership of the processor FSB throughout the bus locked operation and ensure the atomicity of lock. |
| MSID[1:0] | Output | These signals indicate the Market Segment for the processor. Refer to Table 3 for additional information. |
| PECI | Input/ Output | PECI is a proprietary one-wire bus interface. See Section 5.4 for details. |
| PROCHOT# | Input/ Output | As an output, PROCHOT# (Processor Hot) will go active when the processor temperature monitoring sensor detects that the processor has reached its maximum safe operating temperature. This indicates that the processor Thermal Control Circuit (TCC) has been activated, if enabled. As an input, assertion of PROCHOT# by the system will activate the TCC, if enabled. The TCC will remain active until the system de-asserts PROCHOT#. See Section 5.2.4 for more details. |
| PWRGOOD | Input | PWRGOOD (Power Good) is a processor input. The processor requires this signal to be a clean indication that the clocks and power supplies are stable and within their specifications. 'Clean' implies that the signal will remain low (capable of sinking leakage current), without glitches, from the time that the power supplies are turned on until they come within specification. The signal must then transition monotonically to a high state. PWRGOOD can be driven inactive at any time, but clocks and power must again be stable before a subsequent rising edge of PWRGOOD. The PWRGOOD signal must be supplied to the processor; it is used to protect internal circuits against voltage sequencing issues. It should be driven high throughout boundary scan operation. |
| REQ[4:0]# | Input/ Output | REQ[4:0]# (Request Command) must connect the appropriate pins/lands of all processor FSB agents. They are asserted by the current bus owner to define the currently active transaction type. These signals are source synchronous to ADSTB0#. |
| RESET# | Input | Asserting the RESET# signal resets the processor to a known state and invalidates its internal caches without writing back any of their contents. For a power-on Reset, RESET# must stay active for at least one millisecond after V _{CC} and BCLK have reached their proper specifications. On observing active RESET#, all FSB agents will de-assert their outputs within two clocks. RESET# must not be kept asserted for more than 10 ms while PWRGOOD is asserted. A number of bus signals are sampled at the active-to-inactive transition of RESET# for power-on configuration. These configuration options are described in the Section 6.1 . This signal does not have on-die termination and must be terminated on the system board. |
| RESERVED | | All RESERVED lands must remain unconnected. Connection of these lands to V _{CC} , V _{SS} , VTT, or to any other signal (including each other) can result in component malfunction or incompatibility with future processors. |



Table 25. Signal Description (Sheet 7 of 9)

| Name | Type | Description |
|--------------|--------|---|
| RS[2:0]# | Input | RS[2:0]# (Response Status) are driven by the response agent (the agent responsible for completion of the current transaction), and must connect the appropriate pins/lands of all processor FSB agents. |
| SKTOCC# | Output | SKTOCC# (Socket Occupied) will be pulled to ground by the processor. System board designers may use this signal to determine if the processor is present. |
| SMI# | Input | SMI# (System Management Interrupt) is asserted asynchronously by system logic. On accepting a System Management Interrupt, the processor saves the current state and enter System Management Mode (SMM). An SMI Acknowledge transaction is issued, and the processor begins program execution from the SMM handler. If SMI# is asserted during the de-assertion of RESET#, the processor will tri-state its outputs. |
| STPCLK# | Input | STPCLK# (Stop Clock), when asserted, causes the processor to enter a low power Stop-Grant state. The processor issues a Stop-Grant Acknowledge transaction, and stops providing internal clock signals to all processor core units except the FSB and APIC units. The processor continues to snoop bus transactions and service interrupts while in Stop-Grant state. When STPCLK# is de-asserted, the processor restarts its internal clock to all units and resumes execution. The assertion of STPCLK# has no effect on the bus clock; STPCLK# is an asynchronous input. |
| TCK | Input | TCK (Test Clock) provides the clock input for the processor Test Bus (also known as the Test Access Port). |
| TDI | Input | TDI (Test Data In) transfers serial test data into the processor. TDI provides the serial input needed for JTAG specification support. |
| TDO | Output | TDO (Test Data Out) transfers serial test data out of the processor. TDO provides the serial output needed for JTAG specification support. |
| TESTHI[13:0] | Input | TESTHI[13:0] must be connected to the processor's appropriate power source (refer to VTT_OUT_LEFT and VTT_OUT_RIGHT signal description) through a resistor for proper processor operation. See Section 2.5 for more details. |
| THERMDA | Other | Thermal Diode Anode. See Section 5.3 . |
| THERMDC | Other | Thermal Diode Cathode. See Section 5.3 . |



Table 25. Signal Description (Sheet 8 of 9)

| Name | Type | Description |
|-------------------|--------|---|
| THERMTRIP# | Output | In the event of a catastrophic cooling failure, the processor will automatically shut down when the silicon has reached a temperature approximately 20 °C above the maximum T_C . Assertion of THERMTRIP# (Thermal Trip) indicates the processor junction temperature has reached a level beyond where permanent silicon damage may occur. Upon assertion of THERMTRIP#, the processor will shut off its internal clocks (thus, halting program execution) in an attempt to reduce the processor junction temperature. To protect the processor, its core voltage (V_{CC}) must be removed following the assertion of THERMTRIP#. Driving of the THERMTRIP# signal is enabled within 10 μ s of the assertion of PWRGOOD (provided V_{TT} and V_{CC} are valid) and is disabled on de-assertion of PWRGOOD (if V_{TT} or V_{CC} are not valid, THERMTRIP# may also be disabled). Once activated, THERMTRIP# remains latched until PWRGOOD, V_{TT} , or V_{CC} is de-asserted. While the de-assertion of the PWRGOOD, V_{TT} , or V_{CC} will de-assert THERMTRIP#, if the processor's junction temperature remains at or above the trip level, THERMTRIP# will again be asserted within 10 μ s of the assertion of PWRGOOD (provided V_{TT} and V_{CC} are valid). |
| TMS | Input | TMS (Test Mode Select) is a JTAG specification support signal used by debug tools. |
| TRDY# | Input | TRDY# (Target Ready) is asserted by the target to indicate that it is ready to receive a write or implicit writeback data transfer. TRDY# must connect the appropriate pins/lands of all FSB agents. |
| TRST# | Input | TRST# (Test Reset) resets the Test Access Port (TAP) logic. TRST# must be driven low during power on Reset. |
| VCC | Input | VCC are the power pins for the processor. The voltage supplied to these pins is determined by the VID[7:0] pins. |
| VCCPLL | Input | VCCPLL provides isolated power for internal processor FSB PLLs. |
| VCC_SENSE | Output | VCC_SENSE is an isolated low impedance connection to processor core power (V_{CC}). It can be used to sense or measure voltage near the silicon with little noise. |
| VCC_MB_REGULATION | Output | This land is provided as a voltage regulator feedback sense point for V_{CC} . It is connected internally in the processor package to the sense point land U27 as described in the <i>Voltage Regulator-Down (VRD) 11.0 Processor Power Delivery Design Guidelines For Desktop LGA775 Socket</i> . |
| VID[7:0] | Output | VID[7:0] (Voltage ID) signals are used to support automatic selection of power supply voltages (V_{CC}). Refer to the <i>Voltage Regulator-Down (VRD) 11.0 Processor Power Delivery Design Guidelines For Desktop LGA775 Socket</i> for more information. The voltage supply for these signals must be valid before the VR can supply V_{CC} to the processor. Conversely, the VR output must be disabled until the voltage supply for the VID signals becomes valid. The VID signals are needed to support the processor voltage specification variations. See Table 2 for definitions of these signals. The VR must supply the voltage that is requested by the signals, or disable itself. |
| VID_SELECT | Output | This land is tied high on the processor package and is used by the VR to choose the proper VID table. Refer to the <i>Voltage Regulator-Down (VRD) 11.0 Processor Power Delivery Design Guidelines For Desktop LGA775 Socket</i> for more information. |



Table 25. Signal Description (Sheet 9 of 9)

| Name | Type | Description |
|-------------------------------|--------|--|
| VRDSEL | Input | This input should be left as a no connect in order for the processor to boot. The processor will not boot on legacy platforms where this land is connected to V_{SS} . |
| VSS | Input | VSS are the ground pins for the processor and should be connected to the system ground plane. |
| VSSA | Input | VSSA is the isolated ground for internal PLLs. |
| VSS_SENSE | Output | VSS_SENSE is an isolated low impedance connection to processor core V_{SS} . It can be used to sense or measure ground near the silicon with little noise. |
| VSS_MB_REGULATION | Output | This land is provided as a voltage regulator feedback sense point for V_{SS} . It is connected internally in the processor package to the sense point land V27 as described in the <i>Voltage Regulator-Down (VRD) 11.0 Processor Power Delivery Design Guidelines For Desktop LGA775 Socket</i> . |
| VTT | Input | Miscellaneous voltage supply. |
| VTT_OUT_LEFT VTT_OUT_RIGHT | Output | The VTT_OUT_LEFT and VTT_OUT_RIGHT signals are included to provide a voltage supply for some signals that require termination to V_{TT} on the motherboard. |
| VTT_SEL | Output | The VTT_SEL signal is used to select the correct V_{TT} voltage level for the processor. This land is connected internally in the package to V_{TT} . |

§ §



5 Thermal Specifications and Design Considerations

5.1 Processor Thermal Specifications

The processor requires a thermal solution to maintain temperatures within the operating limits as described in [Section 5.1.1](#). Any attempt to operate the processor outside these operating limits may result in permanent damage to the processor and potentially other components within the system. As processor technology changes, thermal management becomes increasingly crucial when building computer systems. Maintaining the proper thermal environment is key to reliable, long-term system operation.

A complete thermal solution includes both component and system level thermal management features. Component level thermal solutions can include active or passive heatsinks attached to the processor Integrated Heat Spreader (IHS). Typical system level thermal solutions may consist of system fans combined with ducting and venting.

For more information on designing a component level thermal solution, refer to the appropriate Thermal and Mechanical Design Guidelines (see [Section 1.2](#)).

Note: The boxed processor will ship with a component thermal solution. Refer to [Chapter 7](#) for details on the boxed processor.

5.1.1 Thermal Specifications

To allow for the optimal operation and long-term reliability of Intel processor-based systems, the system/processor thermal solution should be designed such that the processor remains within the minimum and maximum case temperature (T_C) specifications when operating at or below the Thermal Design Power (TDP) value listed per frequency in [Table 26](#). Thermal solutions not designed to provide this level of thermal capability may affect the long-term reliability of the processor and system. For more details on thermal solution design, refer to the appropriate Thermal and Mechanical Design Guidelines (see [Section 1.2](#)).

The processor uses a methodology for managing processor temperatures which is intended to support acoustic noise reduction through fan speed control. Selection of the appropriate fan speed is based on the relative temperature data reported by the processor's Platform Environment Control Interface (PECI) bus as described in [Section 5.4.1.1](#). The temperature reported over Peci is always a negative value and represents a delta below the onset of thermal control circuit (TCC) activation, as indicated by PROCHOT# (see [Section 5.2](#)). Systems that implement fan speed control must be designed to take these conditions in to account. Systems that do not alter the fan speed only need to ensure the case temperature meets the thermal profile specifications.

To determine a processor's case temperature specification based on the thermal profile, it is necessary to accurately measure processor power dissipation. Intel has developed a methodology for accurate power measurement that correlates to Intel test temperature and voltage conditions. Refer to the appropriate Thermal and Mechanical Design Guidelines (see [Section 1.2](#)) and the *Processor Power Characterization Methodology* for the details of this methodology.



The case temperature is defined at the geometric top center of the processor. Analysis indicates that real applications are unlikely to cause the processor to consume maximum power dissipation for sustained time periods. Intel recommends that complete thermal solution designs target the Thermal Design Power (TDP) indicated in [Table 26](#) instead of the maximum processor power consumption. The Thermal Monitor feature is designed to protect the processor in the unlikely event that an application exceeds the TDP recommendation for a sustained periods of time. For more details on the usage of this feature, refer to [Section 5.2](#). To ensure maximum flexibility for future requirements, systems should be designed to the 775_VR_CONFIG_06 guidelines, even if a processor with a lower thermal dissipation is currently planned. **In all cases the Thermal Monitor and Thermal Monitor 2 feature must be enabled for the processor to remain within specification.**

Table 26. Processor Thermal Specifications

| Processor Number | Core Frequency (GHz) | Thermal Design Power (W) ^{1,2} | Extended HALT Power (w) ³ | 775_VR_CONFIG_06 Guidance ⁴ | Minimum T _C (°C) | Maximum T _C (°C) | Notes |
|------------------|----------------------|---|--------------------------------------|--|-----------------------------|-----------------------------|-------|
| E2220 | 2.4 | 65.0 | 8 | 775_VR_CONFIG_06 Guidance | 5 | Table 28, Figure 16 | 5 |
| E2200 | 2.2 | 65.0 | 8 | | 5 | | 5 |
| E2180 | 2.0 | 65.0 | 8 | | 5 | | 5 |
| E2160 | 1.8 | 65.0 | 8 | | 5 | | 5 |
| E2140 | 1.6 | 65.0 | 8 | | 5 | | 5 |
| E2160 | 1.8 | 65.0 | 8 | 775_VR_CONFIG_06 Guidance | 5 | Table 27, Figure 15 | 6 |
| E2140 | 1.6 | 65.0 | 8 | | 5 | | 6 |

NOTES:

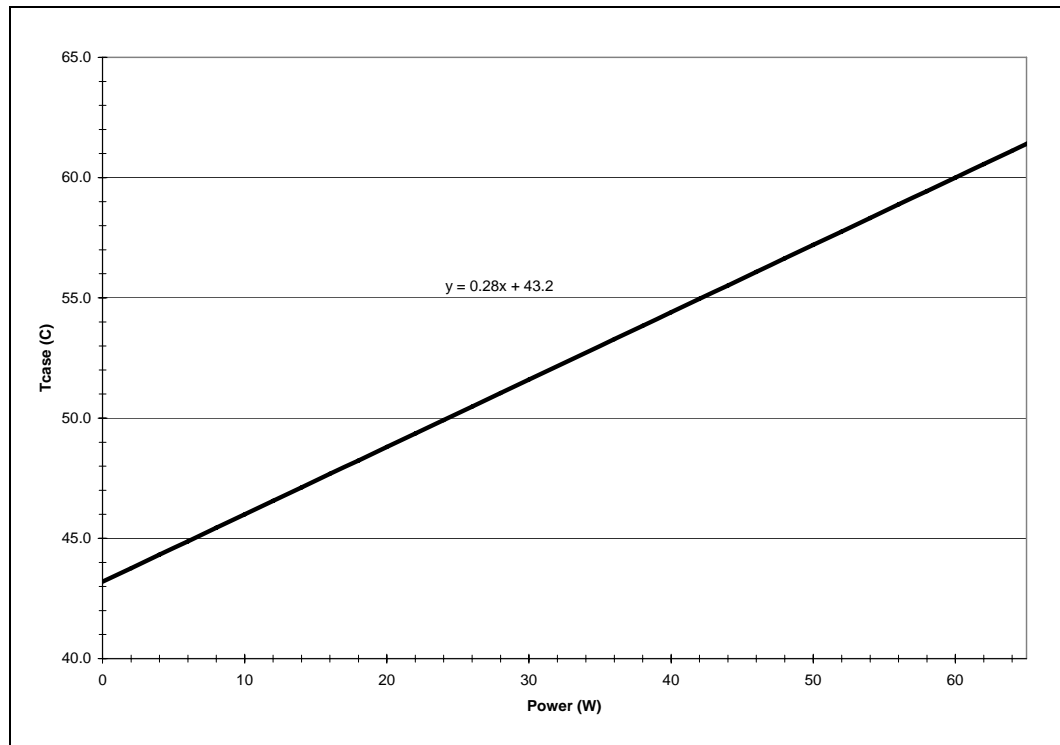
1. Thermal Design Power (TDP) should be used for processor thermal solution design targets. The TDP is not the maximum power that the processor can dissipate.
2. This table shows the maximum TDP for a given frequency range. Individual processors may have a lower TDP. Therefore, the maximum T_C will vary depending on the TDP of the individual processor. Refer to thermal profile figure and associated table for the allowed combinations of power and T_C.
3. Specification is at 35 °C T_C and typical voltage loadline. Specification is ensured by design characterization and not 100% tested.
4. 775_VR_CONFIG_06 guidelines provide a design target for meeting future thermal requirements.
5. These processors have CPUID = 06FDh.
6. These processors have CPUID = 06F2h.



Table 27. Thermal Profile (Intel® Pentium® Dual-Core Processors with CPUID = 06F2h)

| Power (W) | Maximum Tc (°C) | Power (W) | Maximum Tc (°C) | Power (W) | Maximum Tc (°C) |
|-----------|-----------------|-----------|-----------------|-----------|-----------------|
| 0 | 43.2 | 24 | 49.9 | 48 | 56.6 |
| 2 | 43.8 | 26 | 50.5 | 50 | 57.2 |
| 4 | 44.3 | 28 | 51.0 | 52 | 57.8 |
| 6 | 44.9 | 30 | 51.6 | 54 | 58.3 |
| 8 | 45.4 | 32 | 52.2 | 56 | 58.9 |
| 10 | 46.0 | 34 | 52.7 | 58 | 59.4 |
| 12 | 46.6 | 36 | 53.3 | 60 | 60.0 |
| 14 | 47.1 | 38 | 53.8 | 62 | 60.6 |
| 16 | 47.7 | 40 | 54.4 | 64 | 61.1 |
| 18 | 48.2 | 42 | 55.0 | 65 | 61.4 |
| 20 | 48.8 | 44 | 55.5 | | |
| 22 | 49.4 | 46 | 56.1 | | |

Figure 15. Thermal Profile (Intel® Pentium® Dual-Core Processors with CPUID = 06F2h)



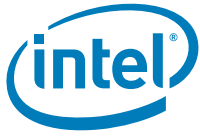
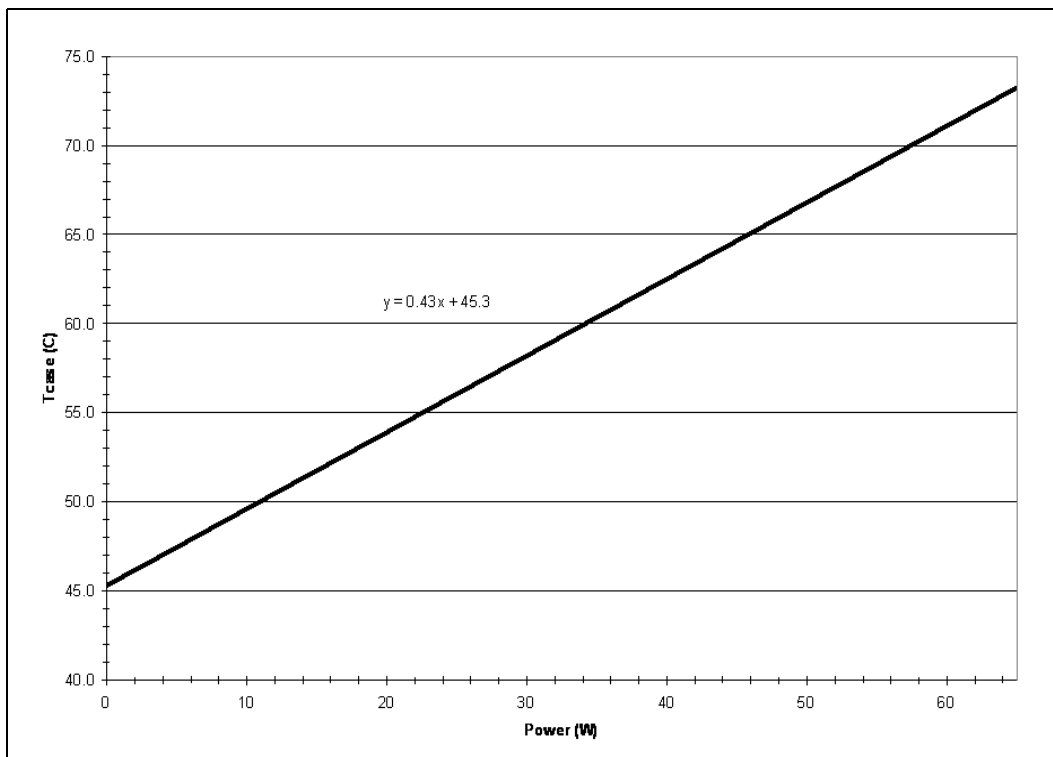


Table 28. Thermal Profile (Intel® Pentium® Dual-Core Processors with CPUID = 06FDh)

| Power (W) | Maximum Tc (°C) | Power (W) | Maximum Tc (°C) | Power (W) | Maximum Tc (°C) |
|-----------|-----------------|-----------|-----------------|-----------|-----------------|
| 0 | 45.3 | 24 | 55.6 | 48 | 65.9 |
| 2 | 46.2 | 26 | 56.5 | 50 | 66.8 |
| 4 | 47.0 | 28 | 57.3 | 52 | 67.7 |
| 6 | 47.9 | 30 | 58.2 | 54 | 68.5 |
| 8 | 48.7 | 32 | 59.1 | 56 | 69.4 |
| 10 | 49.6 | 34 | 59.9 | 58 | 70.2 |
| 12 | 50.5 | 36 | 60.8 | 60 | 71.1 |
| 14 | 51.3 | 38 | 61.6 | 62 | 72.0 |
| 16 | 52.2 | 40 | 62.5 | 64 | 72.8 |
| 18 | 53.0 | 42 | 63.4 | 65 | 73.3 |
| 20 | 53.9 | 44 | 64.2 | | |
| 22 | 54.8 | 46 | 65.1 | | |

Figure 16. Thermal Profile (Intel® Pentium® Dual-Core Processors with CPUID = 06FDh)

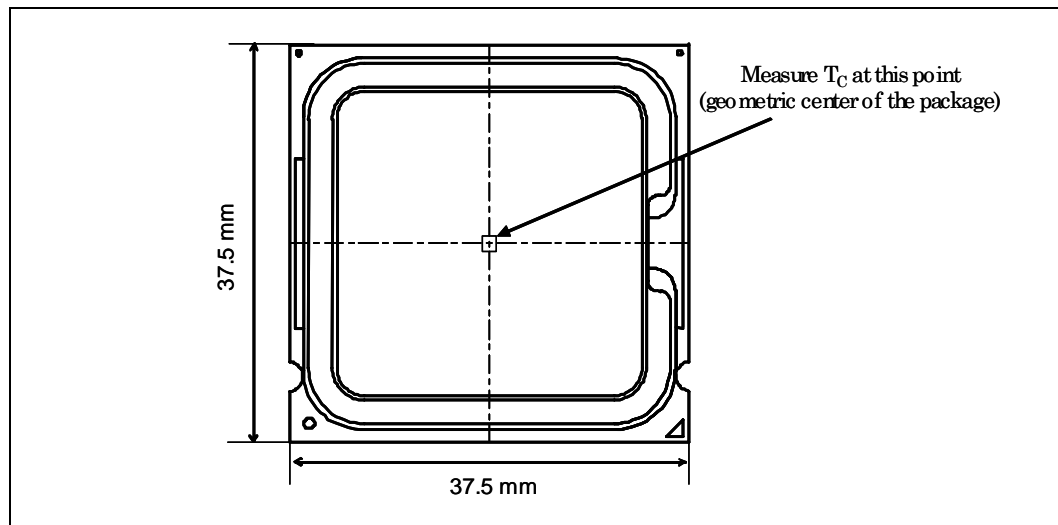




5.1.2 Thermal Metrology

The maximum and minimum case temperatures (T_C) for the processor is specified in Table 26. This temperature specification is meant to help ensure proper operation of the processor. Figure 17 illustrates where Intel recommends T_C thermal measurements should be made. For detailed guidelines on temperature measurement methodology, refer to the appropriate Thermal and Mechanical Design Guidelines (see Section 1.2).

Figure 17. Case Temperature (T_C) Measurement Location



5.2 Processor Thermal Features

5.2.1 Thermal Monitor

The Thermal Monitor feature helps control the processor temperature by activating the thermal control circuit (TCC) when the processor silicon reaches its maximum operating temperature. The TCC reduces processor power consumption by modulating (starting and stopping) the internal processor core clocks. **The Thermal Monitor feature must be enabled for the processor to be operating within specifications.** The temperature at which Thermal Monitor activates the thermal control circuit is not user configurable and is not software visible. Bus traffic is snooped in the normal manner, and interrupt requests are latched (and serviced during the time that the clocks are on) while the TCC is active.

When the Thermal Monitor feature is enabled, and a high temperature situation exists (i.e., TCC is active), the clocks will be modulated by alternately turning the clocks off and on at a duty cycle specific to the processor (typically 30–50%). Clocks often will not be off for more than 3.0 microseconds when the TCC is active. Cycle times are processor speed dependent and will decrease as processor core frequencies increase. A small amount of hysteresis has been included to prevent rapid active/inactive transitions of the TCC when the processor temperature is near its maximum operating temperature. Once the temperature has dropped below the maximum operating temperature, and the hysteresis timer has expired, the TCC goes inactive and clock modulation ceases.

With a properly designed and characterized thermal solution, it is anticipated that the TCC would only be activated for very short periods of time when running the most power intensive applications. The processor performance impact due to these brief periods of TCC activation is expected to be so minor that it would be immeasurable. An



under-designed thermal solution that is not able to prevent excessive activation of the TCC in the anticipated ambient environment may cause a noticeable performance loss, and in some cases may result in a T_c that exceeds the specified maximum temperature and may affect the long-term reliability of the processor. In addition, a thermal solution that is significantly under-designed may not be capable of cooling the processor even when the TCC is active continuously. Refer to the appropriate Thermal and Mechanical Design Guidelines (see [Section 1.2](#)) for information on designing a thermal solution.

The duty cycle for the TCC, when activated by the Thermal Monitor, is factory configured and cannot be modified. The Thermal Monitor does not require any additional hardware, software drivers, or interrupt handling routines.

5.2.2 Thermal Monitor 2

The processor also supports an additional power reduction capability known as Thermal Monitor 2. This mechanism provides an efficient means for limiting the processor temperature by reducing the power consumption within the processor.

When Thermal Monitor 2 is enabled, and a high temperature situation is detected, the Thermal Control Circuit (TCC) will be activated. The TCC causes the processor to adjust its operating frequency (via the bus multiplier) and input voltage (via the VID signals). This combination of reduced frequency and VID results in a reduction to the processor power consumption.

A processor enabled for Thermal Monitor 2 includes two operating points, each consisting of a specific operating frequency and voltage. The first operating point represents the normal operating condition for the processor. Under this condition, the core-frequency-to-FSB multiple used by the processor is that contained in the CLOCK_FLEX_MAX MSR and the VID is that specified in [Table 5](#). These parameters represent normal system operation.

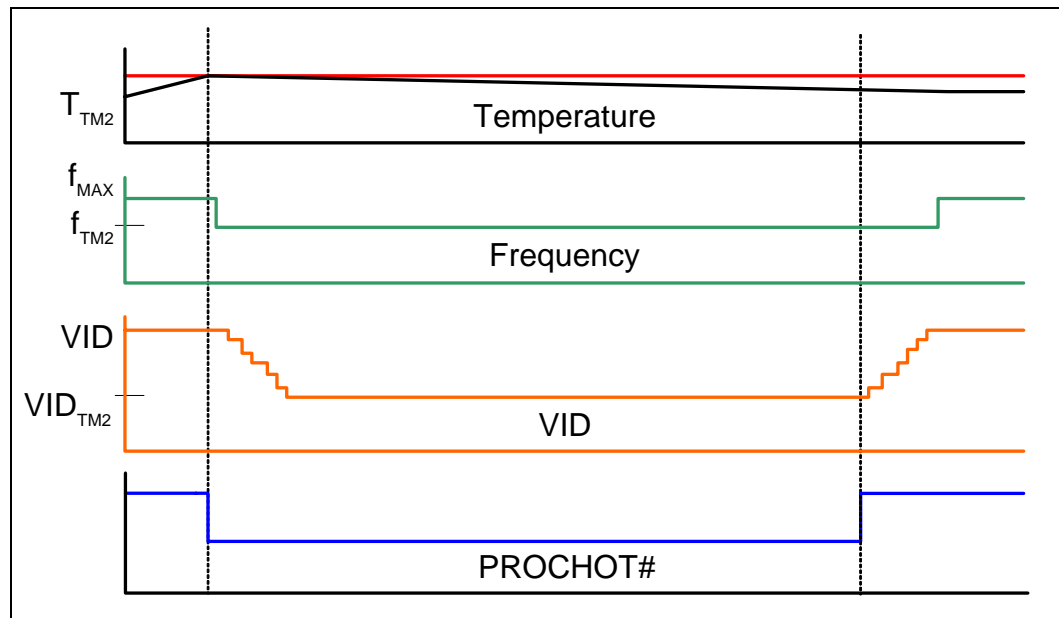
The second operating point consists of both a lower operating frequency and voltage. When the TCC is activated, the processor automatically transitions to the new frequency. This transition occurs very rapidly (on the order of 5 μ s). During the frequency transition, the processor is unable to service any bus requests, and consequently, all bus traffic is blocked. Edge-triggered interrupts will be latched and kept pending until the processor resumes operation at the new frequency.

Once the new operating frequency is engaged, the processor will transition to the new core operating voltage by issuing a new VID code to the voltage regulator. The voltage regulator must support dynamic VID steps to support Thermal Monitor 2. During the voltage change, it will be necessary to transition through multiple VID codes to reach the target operating voltage. Each step will likely be one VID table entry (see [Table 5](#)). The processor continues to execute instructions during the voltage transition. Operation at the lower voltage reduces the power consumption of the processor.

A small amount of hysteresis has been included to prevent rapid active/inactive transitions of the TCC when the processor temperature is near its maximum operating temperature. Once the temperature has dropped below the maximum operating temperature, and the hysteresis timer has expired, the operating frequency and voltage transition back to the normal system operating point. Transition of the VID code will occur first, to ensure proper operation once the processor reaches its normal operating frequency. Refer to [Figure 18](#) for an illustration of this ordering.



Figure 18. Thermal Monitor 2 Frequency and Voltage Ordering



The PROCHOT# signal is asserted when a high temperature situation is detected, regardless of whether Thermal Monitor or Thermal Monitor 2 is enabled.

It should be noted that the Thermal Monitor 2 TCC cannot be activated via the on demand mode. The Thermal Monitor TCC, however, can be activated through the use of the on demand mode.

5.2.3 On-Demand Mode

The processor provides an auxiliary mechanism that allows system software to force the processor to reduce its power consumption. This mechanism is referred to as “On-Demand” mode and is distinct from the Thermal Monitor feature. On-Demand mode is intended as a means to reduce system level power consumption. Systems using the processor must not rely on software usage of this mechanism to limit the processor temperature.

The processor provides an auxiliary mechanism that allows system software to force the processor to reduce its power consumption. This mechanism is referred to as “On-Demand” mode and is distinct from the Thermal Monitor and Thermal Monitor 2 features. On-Demand mode is intended as a means to reduce system level power consumption. Systems must not rely on software usage of this mechanism to limit the processor temperature. If bit 4 of the IA32_CLOCK_MODULATION MSR is set to a ‘1’, the processor will immediately reduce its power consumption via modulation (starting and stopping) of the internal core clock, independent of the processor temperature. When using On-Demand mode, the duty cycle of the clock modulation is programmable via bits 3:1 of the same IA32_CLOCK_MODULATION MSR. In On-Demand mode, the duty cycle can be programmed from 12.5% on/ 87.5% off to 87.5% on/ 12.5% off in 12.5% increments. On-Demand mode may be used in conjunction with the Thermal Monitor; however, if the system tries to enable On-Demand mode at the same time the TCC is engaged, the factory configured duty cycle of the TCC will override the duty cycle selected by the On-Demand mode.



5.2.4 PROCHOT# Signal

An external signal, PROCHOT# (processor hot), is asserted when the processor core temperature has reached its maximum operating temperature. If the Thermal Monitor is enabled (note that the Thermal Monitor must be enabled for the processor to be operating within specification), the TCC will be active when PROCHOT# is asserted. The processor can be configured to generate an interrupt upon the assertion or de-assertion of PROCHOT#.

As an output, PROCHOT# (Processor Hot) will go active when the processor temperature monitoring sensor detects that one or both cores has reached its maximum safe operating temperature. This indicates that the processor Thermal Control Circuit (TCC) has been activated, if enabled. As an input, assertion of PROCHOT# by the system will activate the TCC, if enabled, for both cores. The TCC will remain active until the system de-asserts PROCHOT#.

PROCHOT# allows for some protection of various components from over-temperature situations. The PROCHOT# signal is bi-directional in that it can either signal when the processor (either core) has reached its maximum operating temperature or be driven from an external source to activate the TCC. The ability to activate the TCC via PROCHOT# can provide a means for thermal protection of system components.

PROCHOT# can allow VR thermal designs to target maximum sustained current instead of maximum current. Systems should still provide proper cooling for the VR, and rely on PROCHOT# only as a backup in case of system cooling failure. The system thermal design should allow the power delivery circuitry to operate within its temperature specification even while the processor is operating at its Thermal Design Power. With a properly designed and characterized thermal solution, it is anticipated that PROCHOT# would only be asserted for very short periods of time when running the most power intensive applications. An under-designed thermal solution that is not able to prevent excessive assertion of PROCHOT# in the anticipated ambient environment may cause a noticeable performance loss. Refer to the *Voltage Regulator-Down (VRD) 11.0 Processor Power Delivery Design Guidelines For Desktop LGA775 Socket* for details on implementing the bi-directional PROCHOT# feature.

5.2.5 THERMTRIP# Signal

Regardless of whether or not Thermal Monitor or Thermal Monitor 2 is enabled, in the event of a catastrophic cooling failure, the processor will automatically shut down when the silicon has reached an elevated temperature (refer to the THERMTRIP# definition in [Table 25](#)). At this point, the FSB signal THERMTRIP# will go active and stay active as described in [Table 25](#). THERMTRIP# activation is independent of processor activity and does not generate any bus cycles. If THERMTRIP# is asserted, processor core voltage (V_{CC}) must be removed within the timeframe defined in [Table 11](#).



5.3 Thermal Diode

The processor incorporates an on-die PNP transistor where the base emitter junction is used as a thermal "diode", with its collector shorted to ground. A thermal sensor located on the system board may monitor the die temperature of the processor for thermal management and fan speed control. Table 29, Table 30, and Table 31 provide the "diode" parameter and interface specifications. Two different sets of "diode" parameters are listed in Table 29 and Table 30. The Diode Model parameters (Table 29) apply to traditional thermal sensors that use the Diode Equation to determine the processor temperature. Transistor Model parameters (Table 30) have been added to support thermal sensors that use the transistor equation method. The Transistor Model may provide more accurate temperature measurements when the diode ideality factor is closer to the maximum or minimum limits. This thermal "diode" is separate from the Thermal Monitor's thermal sensor and cannot be used to predict the behavior of the Thermal Monitor.

T_{CONTROL} is a temperature specification based on a temperature reading from the thermal diode. The value for T_{CONTROL} will be calibrated in manufacturing and configured for each processor. The T_{CONTROL} temperature for a given processor can be obtained by reading a MSR in the processor. The T_{CONTROL} value that is read from the MSR needs to be converted from Hexadecimal to Decimal and added to a base value of 50 °C.

The value of T_{CONTROL} may vary from 00 h to 1E h (0 to 30 °C).

When T_{DIODE} is above T_{CONTROL} , then T_{C} must be at or below $T_{\text{C_MAX}}$ as defined by the thermal profile in Table 27; otherwise, the processor temperature can be maintained at T_{CONTROL} (or lower) as measured by the thermal diode.

Table 29. Thermal "Diode" Parameters using Diode Model

| Symbol | Parameter | Min | Typ | Max | Unit | Notes |
|-----------------|-----------------------|-------|-------|-------|------|---------|
| I_{FW} | Forward Bias Current | 5 | — | 200 | μA | 1 |
| n | Diode Ideality Factor | 1.000 | 1.009 | 1.050 | - | 2, 3, 4 |
| R_{T} | Series Resistance | 2.79 | 4.52 | 6.24 | Ω | 2, 3, 5 |

NOTES:

- Intel does not support or recommend operation of the thermal diode under reverse bias.
- Preliminary data. Will be characterized across a temperature range of 50 – 80 °C.
- Not 100% tested. Specified by design characterization.
- The ideality factor, n , represents the deviation from ideal diode behavior as exemplified by the diode equation:

$$I_{\text{FW}} = I_{\text{S}} * (e^{qV_{\text{D}}/nkT} - 1)$$

where I_{S} = saturation current, q = electronic charge, V_{D} = voltage across the diode, k = Boltzmann Constant, and T = absolute temperature (Kelvin).

- The series resistance, R_{T} , is provided to allow for a more accurate measurement of the junction temperature. R_{T} , as defined, includes the lands of the processor but does not include any socket resistance or board trace resistance between the socket and the external remote diode thermal sensor. R_{T} can be used by remote diode thermal sensors with automatic series resistance cancellation to calibrate out this error term. Another application is that a temperature offset can be manually calculated and programmed into an offset register in the remote diode thermal sensors as exemplified by the equation:

$$T_{\text{error}} = [R_{\text{T}} * (N-1) * I_{\text{FWmin}}] / [nk/q * \ln N]$$

where T_{error} = sensor temperature error, N = sensor current ratio, k = Boltzmann Constant, q = electronic charge.



Table 30. Thermal “Diode” Parameters using Transistor Model

| Symbol | Parameter | Min | Typ | Max | Unit | Notes |
|-----------------|----------------------|-------|-------|-------|------|---------|
| I _{FW} | Forward Bias Current | 5 | — | 200 | μA | 1, 2 |
| I _E | Emitter Current | 5 | — | 200 | | |
| n _Q | Transistor Ideality | 0.997 | 1.001 | 1.005 | - | 3, 4, 5 |
| Beta | | 0.391 | — | 0.760 | | 3, 4 |
| R _T | Series Resistance | 2.79 | 4.52 | 6.24 | Ω | 3, 6 |

NOTES:

1. Intel does not support or recommend operation of the thermal diode under reverse bias.
2. Same as I_{FW} in Table 29.
3. Preliminary data. Will be characterized across a temperature range of 50–80 °C.
4. Not 100% tested. Specified by design characterization.
5. The ideality factor, n_Q, represents the deviation from ideal transistor model behavior as exemplified by the equation for the collector current:

$$I_C = I_S * (e^{qV_{BE}/nkT} - 1)$$

Where I_S = saturation current, q = electronic charge, V_{BE} = voltage across the transistor base emitter junction (same nodes as VD), k = Boltzmann Constant, and T = absolute temperature (Kelvin).

6. The series resistance, R_T, provided in the Diode Model Table (Table 29) can be used for more accurate readings as needed.

The Intel® Pentium® Dual-Core Desktop processor E2000 series does not support the diode correction offset that exists on other Intel processors.

Table 31. Thermal Diode Interface

| Signal Name | Land Number | Signal Description |
|-------------|-------------|--------------------|
| THERMDA | AL1 | diode anode |
| THERMDC | AK1 | diode cathode |

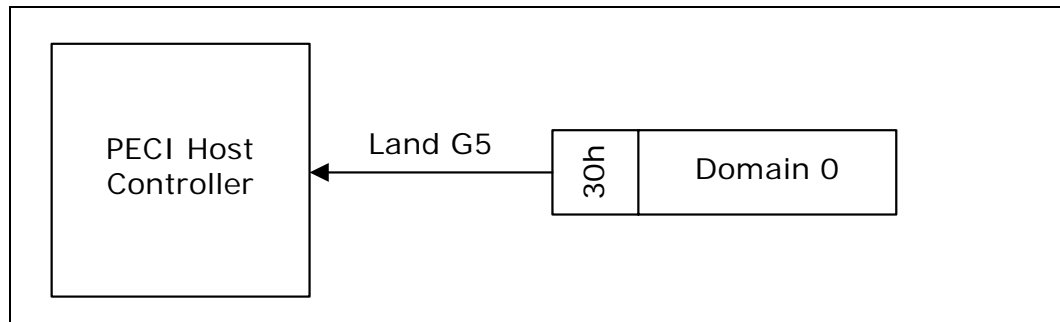


5.4 Platform Environment Control Interface (PECI)

5.4.1 Introduction

PECI offers an interface for thermal monitoring of Intel processor and chipset components. It uses a single wire, thus alleviating routing congestion issues. Figure 19 shows an example of the PECI topology in a system. PECI uses CRC checking on the host side to ensure reliable transfers between the host and client devices. Also, data transfer speeds across the PECI interface are negotiable within a wide range (2 Kbps to 2 Mbps). The PECI interface on the processor is disabled by default and must be enabled through BIOS.

Figure 19. Processor PECI Topology



5.4.1.1 Key Difference with Legacy Diode-Based Thermal Management

Fan speed control solutions based on PECI uses a T_{CONTROL} value stored in the processor IA32_TEMPERATURE_TARGET MSR. The T_{CONTROL} MSR uses the same offset temperature format as PECI though it contains no sign bit. Thermal management devices should infer the T_{CONTROL} value as negative. Thermal management algorithms should use the relative temperature value delivered over PECI in conjunction with the T_{CONTROL} MSR value to control or optimize fan speeds. Figure 20 shows a conceptual fan control diagram using PECI temperatures.

The relative temperature value reported over PECI represents the delta below the onset of thermal control circuit (TCC) activation as indicated by PROCHOT# assertions. As the temperature approaches TCC activation, the PECI value approaches zero. TCC activates at a PECI count of zero.

Figure 20. Conceptual Fan Control on PECCI-Based Platforms

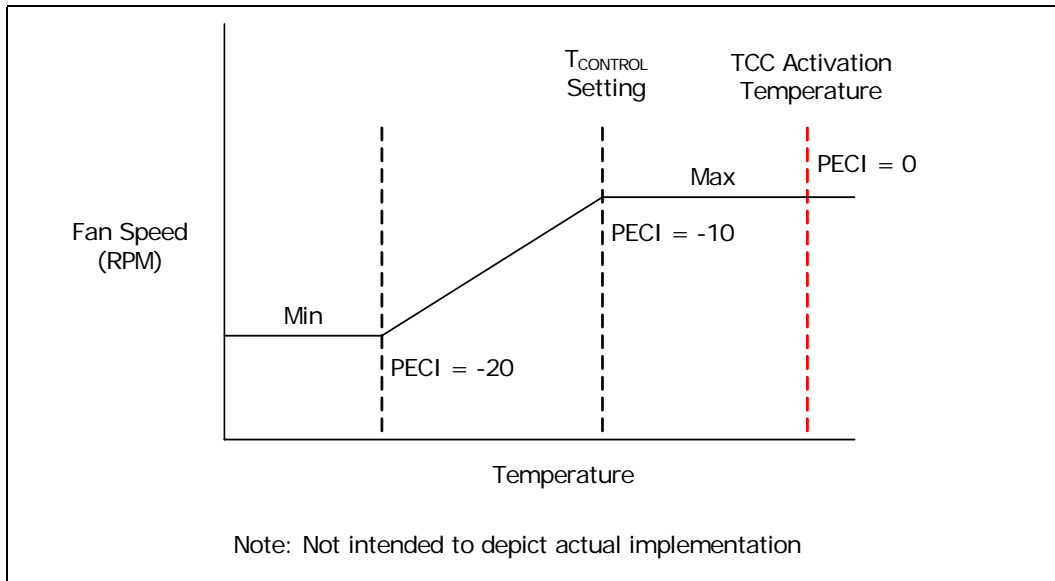
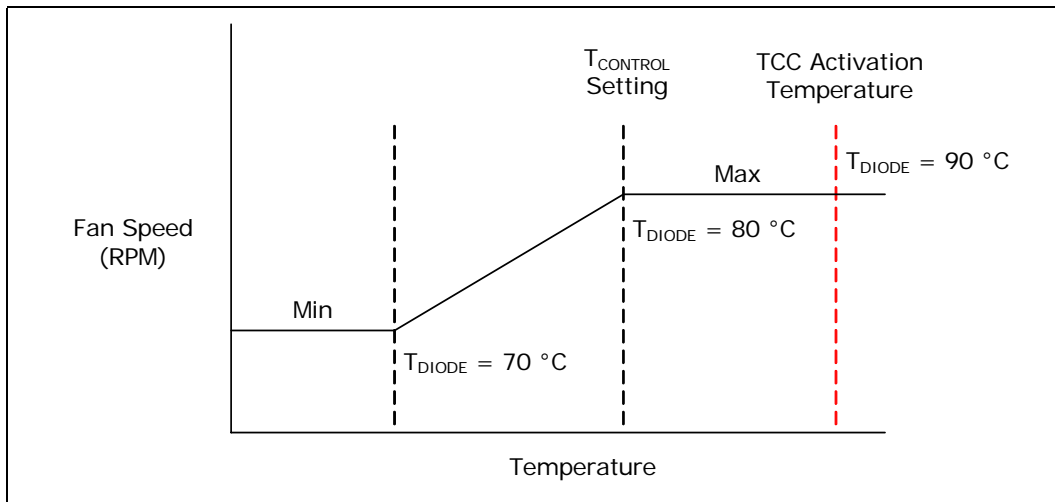


Figure 21. Conceptual Fan Control on Thermal Diode-Based Platforms





5.4.2 PECCI Specifications

5.4.2.1 PECCI Device Address

The PECCI device address for the socket is 30h. For more information on PECCI domains, refer to the *Platform Environment Control Interface Specification*.

5.4.2.2 PECCI Command Support

PECCI command support is covered in detail in the *Platform Environment Control Interface Specification*. Refer to this document for details on supported PECCI command function and codes.

5.4.2.3 PECCI Fault Handling Requirements

PECCI is largely a fault tolerant interface, including noise immunity and error checking improvements over other comparable industry standard interfaces. The PECCI client is as reliable as the device that it is embedded in, and thus given operating conditions that fall under the specification, the PECCI will always respond to requests and the protocol itself can be relied upon to detect any transmission failures. There are, however, certain scenarios where the PECCI is known to be unresponsive.

Prior to a power on RESET# and during RESET# assertion, PECCI is not ensured to provide reliable thermal data. System designs should implement a default power-on condition that ensures proper processor operation during the time frame when reliable data is not available via PECCI.

To protect platforms from potential operational or safety issues due to an abnormal condition on PECCI, the Host controller should take action to protect the system from possible damaging states. It is recommended that the PECCI host controller take appropriate action to protect the client processor device if valid temperature readings have not been obtained in response to three consecutive gettemp()s or for a one second time interval. The host controller may also implement an alert to software in the event of a critical or continuous fault condition.

5.4.2.4 PECCI GetTemp0() Error Code Support

The error codes supported for the processor GetTemp() command are listed in Table 32.

Table 32. GetTemp0() Error Codes

| Error Code | Description |
|------------|--|
| 8000h | General sensor error |
| 8002h | Sensor is operational, but has detected a temperature below its operational range (underflow). |

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6 Features

6.1 Power-On Configuration Options

Several configuration options can be configured by hardware. The processor samples the hardware configuration at reset, on the active-to-inactive transition of RESET#. For specifications on these options, refer to [Table 33](#).

The sampled information configures the processor for subsequent operation. These configuration options cannot be changed except by another reset. All resets reconfigure the processor; for reset purposes, the processor does not distinguish between a "warm" reset and a "power-on" reset.

Table 33. Power-On Configuration Option Signals

| Configuration Option | Signal ^{1,2,3} |
|--------------------------------|-------------------------------|
| Output tristate | SMI# |
| Execute BIST | A3# |
| Disable dynamic bus parking | A25# |
| Symmetric agent arbitration ID | BRO# |
| RESERVED | A[8:5]#, A[24:11]#, A[35:26]# |

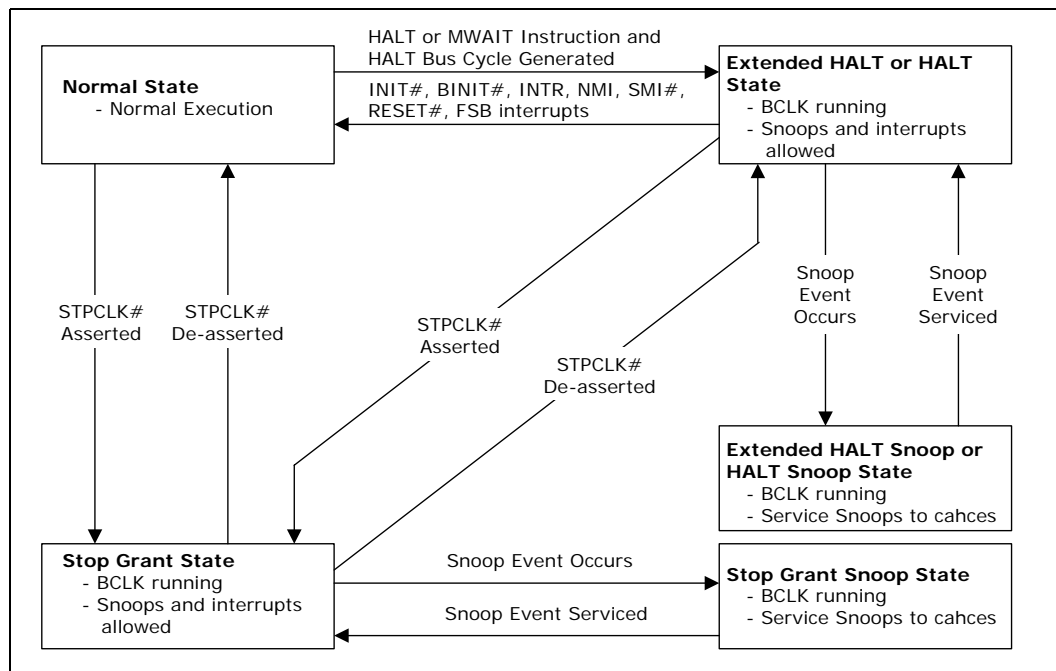
NOTES:

1. Asserting this signal during RESET# will select the corresponding option.
2. Address signals not identified in this table as configuration options should not be asserted during RESET#.
3. Disabling of any of the cores within the processor must be handled by configuring the EXT_CONFIG Model Specific Register (MSR). This MSR will allow for the disabling of a single core.

6.2 Clock Control and Low Power States

The processor allows the use of AutoHALT and Stop-Grant states to reduce power consumption by stopping the clock to internal sections of the processor, depending on each particular state. See Figure 22 for a visual representation of the processor low power states.

Figure 22. Processor Low Power State Machine



6.2.1 Normal State

This is the normal operating state for the processor.

6.2.2 HALT and Extended HALT Powerdown States

The processor supports the HALT or Extended HALT powerdown state. The Extended HALT powerdown must be enabled via the BIOS for the processor to remain within its specification.

The Extended HALT state is a lower power state as compared to the Stop Grant State.

If Extended HALT is not enabled, the default powerdown state entered will be HALT. Refer to the sections below for details about the HALT and Extended HALT states.



6.2.2.1 HALT Powerdown State

HALT is a low power state entered when all the processor cores have executed the HALT or MWAIT instructions. When one of the processor cores executes the HALT instruction, that processor core is halted, however, the other processor continues normal operation. The processor will transition to the Normal state upon the occurrence of SMI#, INIT#, or LINT[1:0] (NMI, INTR). RESET# will cause the processor to immediately initialize itself.

The return from a System Management Interrupt (SMI) handler can be to either Normal Mode or the HALT Power Down state. See the *Intel Architecture Software Developer's Manual, Volume III: System Programmer's Guide* for more information.

The system can generate a STPCLK# while the processor is in the HALT powerdown state. When the system de-asserts the STPCLK# interrupt, the processor will return execution to the HALT state.

While in HALT powerdown state, the processor will process bus snoops.

6.2.2.2 Extended HALT Powerdown State

Extended HALT is a low power state entered when all processor cores have executed the HALT or MWAIT instructions and Extended HALT has been enabled via the BIOS. When one of the processor cores executes the HALT instruction, that logical processor is halted; however, the other processor continues normal operation. The Extended HALT powerdown state must be enabled via the BIOS for the processor to remain within its specification.

The processor will automatically transition to a lower frequency and voltage operating point before entering the Extended HALT state. Note that the processor FSB frequency is not altered; only the internal core frequency is changed. When entering the low power state, the processor will first switch to the lower bus ratio and then transition to the lower VID.

While in Extended HALT state, the processor will process bus snoops.

The processor exits the Extended HALT state when a break event occurs. When the processor exits the Extended HALT state, it will resume operation at the lower frequency, transition the VID to the original value, and then change the bus ratio back to the original value.

6.2.3 Stop Grant and Extended Stop Grant States

The processor supports the Stop Grant and Extended Stop Grant states. The Extended Stop Grant state is a feature that must be configured and enabled via the BIOS. Refer to the following sections for details about the Stop Grant and Extended Stop Grant states.



6.2.3.1 Stop-Grant State

When the STPCLK# signal is asserted, the Stop Grant state of the processor is entered 20 bus clocks after the response phase of the processor-issued Stop Grant Acknowledge special bus cycle.

Since the GTL+ signals receive power from the FSB, these signals should not be driven (allowing the level to return to V_{TT}) for minimum power drawn by the termination resistors in this state. In addition, all other input signals on the FSB should be driven to the inactive state.

RESET# will cause the processor to immediately initialize itself, but the processor will stay in Stop-Grant state. A transition back to the Normal state will occur with the de-assertion of the STPCLK# signal.

A transition to the Grant Snoop state will occur when the processor detects a snoop on the FSB (see [Section 6.2.4](#)).

While in the Stop-Grant State, SMI#, INIT#, and LINT[1:0] will be latched by the processor, and only serviced when the processor returns to the Normal State. Only one occurrence of each event will be recognized upon return to the Normal state.

While in Stop-Grant state, the processor will process a FSB snoop.

6.2.3.2 Extended Stop Grant State

Extended Stop Grant is a low power state entered when the STPCLK# signal is asserted and Extended Stop Grant has been enabled via the BIOS.

The processor will automatically transition to a lower frequency and voltage operating point before entering the Extended Stop Grant state. When entering the low power state, the processor will first switch to the lower bus ratio and then transition to the lower VID.

The processor exits the Extended Stop Grant state when a break event occurs. When the processor exits the Extended Stop Grant state, it will resume operation at the lower frequency, transition the VID to the original value, and then change the bus ratio back to the original value.

6.2.4 Extended HALT Snoop State, HALT Snoop State, Extended Stop Grant Snoop State, and Stop Grant Snoop State

The Extended HALT Snoop State is used in conjunction with the new Extended HALT state. If Extended HALT state is not enabled in the BIOS, the default Snoop State entered will be the HALT Snoop State. Refer to the following sections for details on HALT Snoop State, Stop Grant Snoop State, Extended HALT Snoop State, and Extended Stop Grant Snoop State.

6.2.4.1 HALT Snoop State, Stop Grant Snoop State

The processor will respond to snoop transactions on the FSB while in Stop-Grant state or in HALT powerdown state. During a snoop transaction, the processor enters the HALT Snoop State: Stop Grant Snoop state. The processor will stay in this state until the snoop on the FSB has been serviced (whether by the processor or another agent on the FSB). After the snoop is serviced, the processor will return to the Stop Grant state or HALT powerdown state, as appropriate.



6.2.4.2 Extended HALT Snoop State, Extended Stop Grant Snoop State

The processor will remain in the lower bus ratio and VID operating point of the Extended HALT state or Extended Stop Grant state. While in the Extended HALT Snoop State or Extended Stop Grant Snoop State, snoops are handled the same way as in the HALT Snoop State or Stop Grant Snoop State. After the snoop is serviced, the processor will return to the Extended HALT state or Extended Stop Grant state.

6.3 Enhanced Intel SpeedStep[®] Technology

The processor supports Enhanced Intel SpeedStep technology. This technology enables the processor to switch between multiple frequency and voltage points, which results in platform power savings. Enhanced Intel SpeedStep Technology requires support for dynamic VID transitions in the platform. Switching between voltage/frequency states is software controlled.

Note: Not all processors are capable of supporting Enhanced Intel SpeedStep Technology. More details on which processor frequencies will support this feature will be provided in future releases of the *Intel[®] Pentium[®] Dual-Core Desktop Processor E2000 Series Specification Update* when available.

Enhanced Intel SpeedStep Technology creates processor performance states (P-states) or voltage/frequency operating points. P-states are lower power capability states within the Normal state as shown in [Figure 22](#). Enhanced Intel SpeedStep Technology enables real-time dynamic switching between frequency and voltage points. It alters the performance of the processor by changing the bus to core frequency ratio and voltage. This allows the processor to run at different core frequencies and voltages to best serve the performance and power requirements of the processor and system. The processor has hardware logic that coordinates the requested voltage (VID) between the processor cores. The highest voltage that is requested for either of the processor cores is selected for that processor package. Note that the front side bus is not altered; only the internal core frequency is changed. To run at reduced power consumption, the voltage is altered in step with the bus ratio.

The following are key features of Enhanced Intel SpeedStep Technology:

- Multiple voltage/frequency operating points provide optimal performance at reduced power consumption.
- Voltage/frequency selection is software controlled by writing to processor MSR's (Model Specific Registers), thus eliminating chipset dependency.
 - If the target frequency is higher than the current frequency, V_{CC} is incremented in steps (+12.5 mV) by placing a new value on the VID signals and the processor shifts to the new frequency. Note that the top frequency for the processor can not be exceeded.
 - If the target frequency is lower than the current frequency, the processor shifts to the new frequency and V_{CC} is then decremented in steps (-12.5 mV) by changing the target VID through the VID signals.



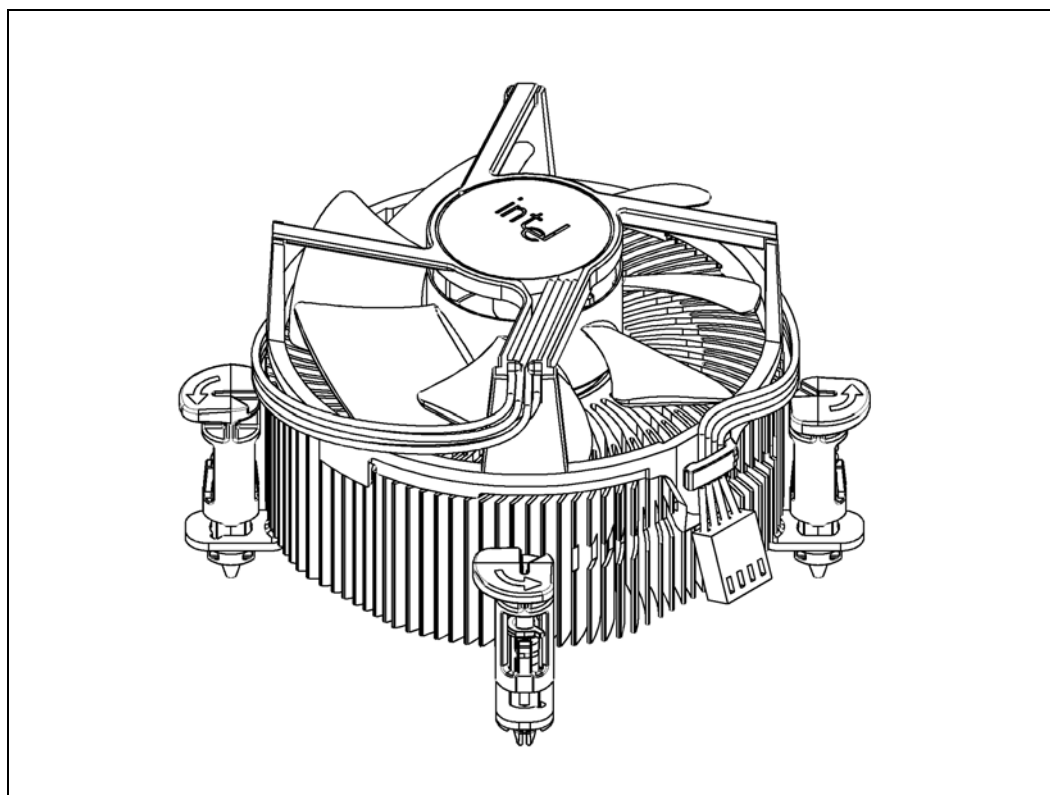


7 *Boxed Processor Specifications*

The processor will also be offered as an Intel boxed processor. Intel boxed processors are intended for system integrators who build systems from baseboards and standard components. The boxed processor will be supplied with a cooling solution. This chapter documents baseboard and system requirements for the cooling solution that will be supplied with the boxed processor. This chapter is particularly important for OEMs that manufacture baseboards for system integrators. Unless otherwise noted, all figures in this chapter are dimensioned in millimeters and inches [in brackets]. [Figure 23](#) shows a mechanical representation of a boxed processor.

Note: Drawings in this section reflect only the specifications on the Intel boxed processor product. These dimensions should not be used as a generic keep-out zone for all cooling solutions. It is the system designers' responsibility to consider their proprietary cooling solution when designing to the required keep-out zone on their system platforms and chassis. Refer to the appropriate Thermal and Mechanical Design Guidelines (see [Section 1.2](#)) for further guidance. Contact your local Intel Sales Representative for this document.

Figure 23. Mechanical Representation of the Boxed Processor



NOTE: The airflow of the fan heatsink is into the center and out of the sides of the fan heatsink.

7.1 Mechanical Specifications

7.1.1 Boxed Processor Cooling Solution Dimensions

This section documents the mechanical specifications of the boxed processor. The boxed processor will be shipped with an unattached fan heatsink. [Figure 23](#) shows a mechanical representation of the boxed processor.

Clearance is required around the fan heatsink to ensure unimpeded airflow for proper cooling. The physical space requirements and dimensions for the boxed processor with assembled fan heatsink are shown in [Figure 24](#) (Side View), and [Figure 25](#) (Top View). The airspace requirements for the boxed processor fan heatsink must also be incorporated into new baseboard and system designs. Airspace requirements are shown in [Figure 29](#) and [Figure 30](#). Note that some figures have centerlines shown (marked with alphabetic designations) to clarify relative dimensioning.

Figure 24. Space Requirements for the Boxed Processor (Side View)

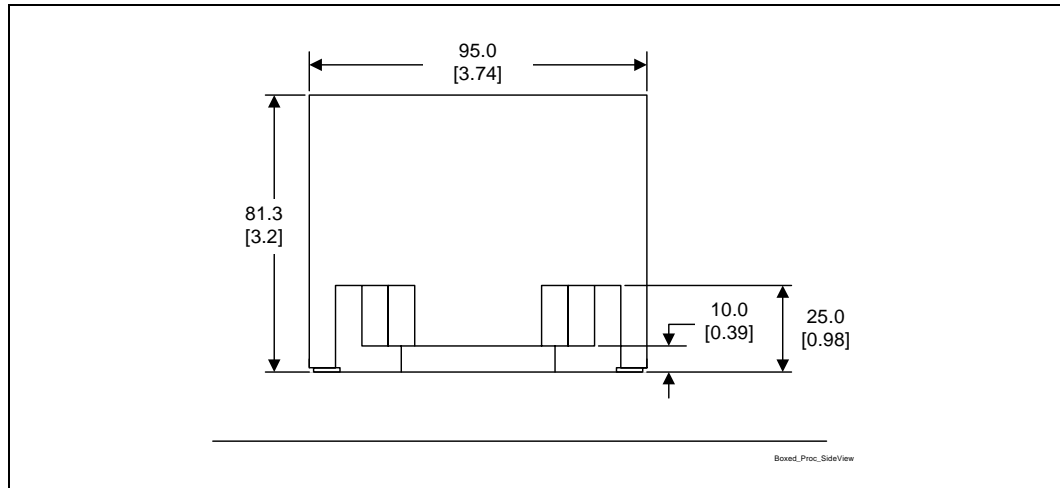
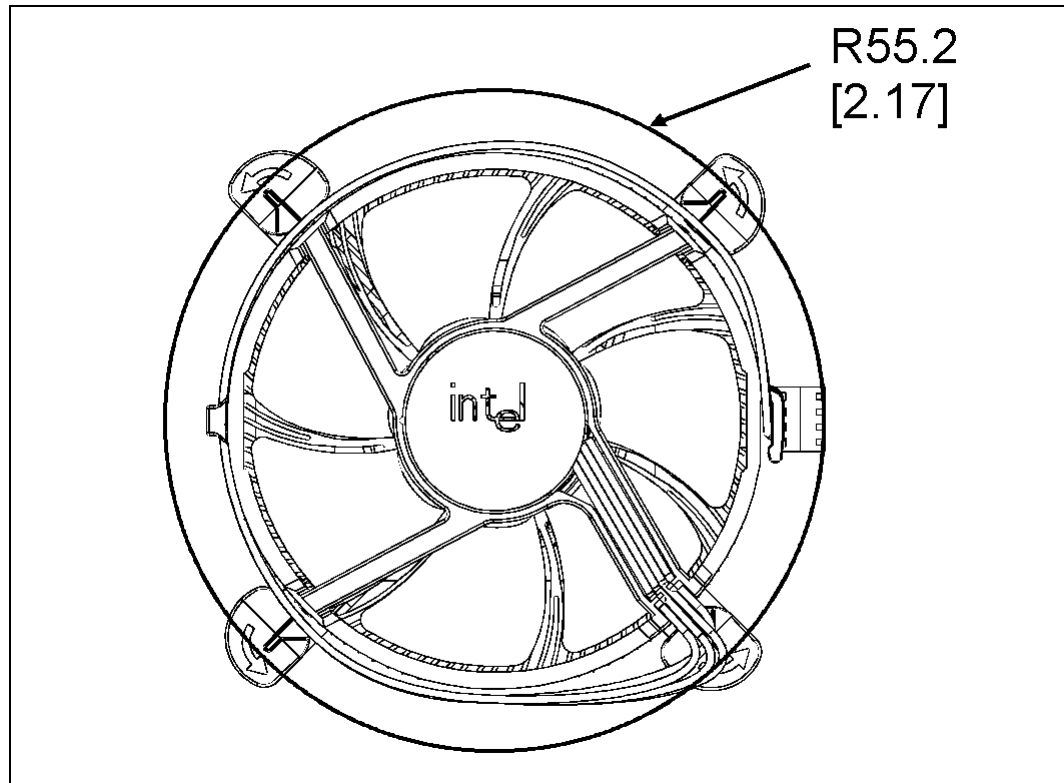




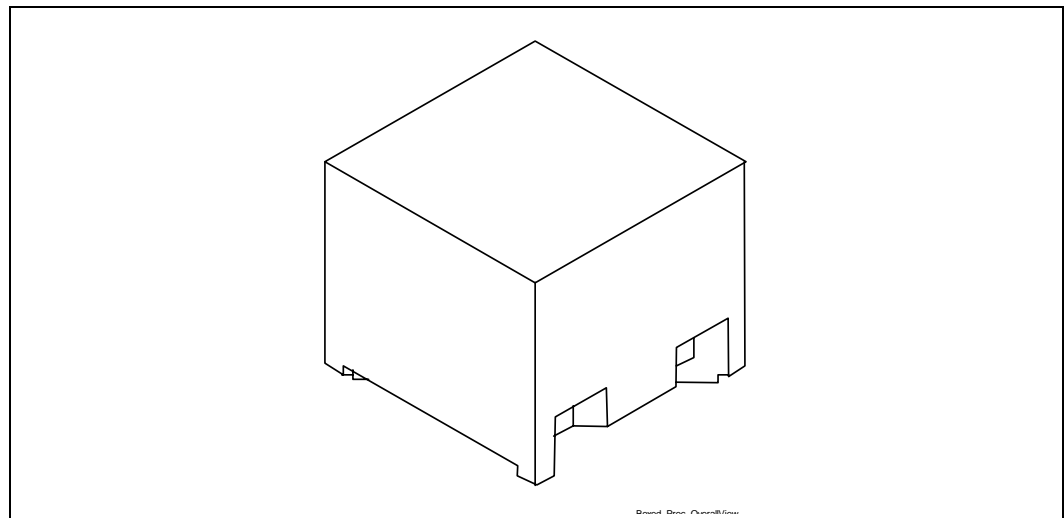
Figure 25. Space Requirements for the Boxed Processor (Top View)



NOTES:

1. Diagram does not show the attached hardware for the clip design and is provided only as a mechanical representation.

Figure 26. Space Requirements for the Boxed Processor (Overall View)





7.1.2 Boxed Processor Fan Heatsink Weight

The boxed processor fan heatsink will not weigh more than 550 grams. See [Chapter 5](#) and the appropriate Thermal and Mechanical Design Guidelines (see [Section 1.2](#)) for details on the processor weight and heatsink requirements.

7.1.3 Boxed Processor Retention Mechanism and Heatsink Attach Clip Assembly

The boxed processor thermal solution requires a heatsink attach clip assembly, to secure the processor and fan heatsink in the baseboard socket. The boxed processor will ship with the heatsink attach clip assembly.

7.2 Electrical Requirements

7.2.1 Fan Heatsink Power Supply

The processor's fan heatsink requires a +12 V power supply. A fan power cable will be shipped with the boxed processor to draw power from a power header on the baseboard. The power cable connector and pinout are shown in [Figure 27](#). Baseboards must provide a matched power header to support the boxed processor. [Table 34](#) contains specifications for the input and output signals at the fan heatsink connector.

The fan heatsink outputs a SENSE signal, which is an open-collector output that pulses at a rate of 2 pulses per fan revolution. A baseboard pull-up resistor provides V_{OH} to match the system board-mounted fan speed monitor requirements, if applicable. Use of the SENSE signal is optional. If the SENSE signal is not used, pin 3 of the connector should be tied to GND.

The fan heatsink receives a PWM signal from the motherboard from the 4th pin of the connector labeled as CONTROL.

The processor's fan heatsink requires a constant +12 V supplied to pin 2 and does not support variable voltage control or 3-pin PWM control.

The power header on the baseboard must be positioned to allow the fan heatsink power cable to reach it. The power header identification and location should be documented in the platform documentation, or on the system board itself. [Figure 28](#) shows the location of the fan power connector relative to the processor socket. The baseboard power header should be positioned within 110 mm [4.33 inches] from the center of the processor socket.



Figure 27. Boxed Processor Fan Heatsink Power Cable Connector Description

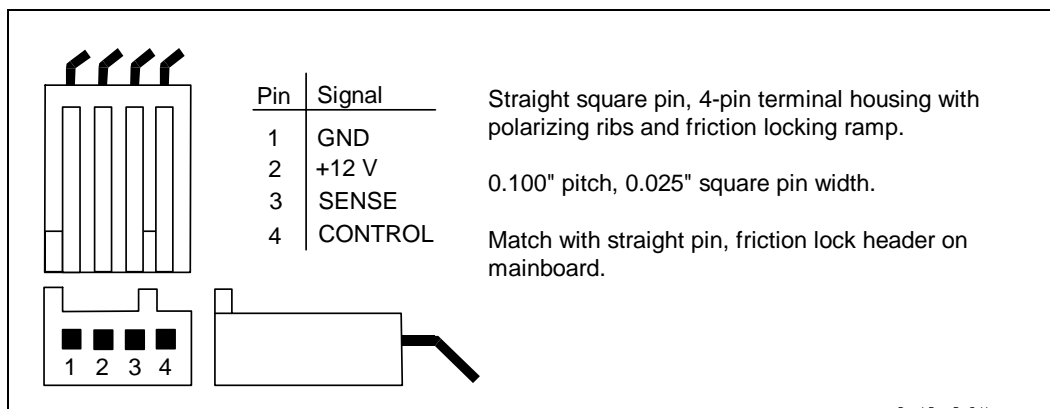


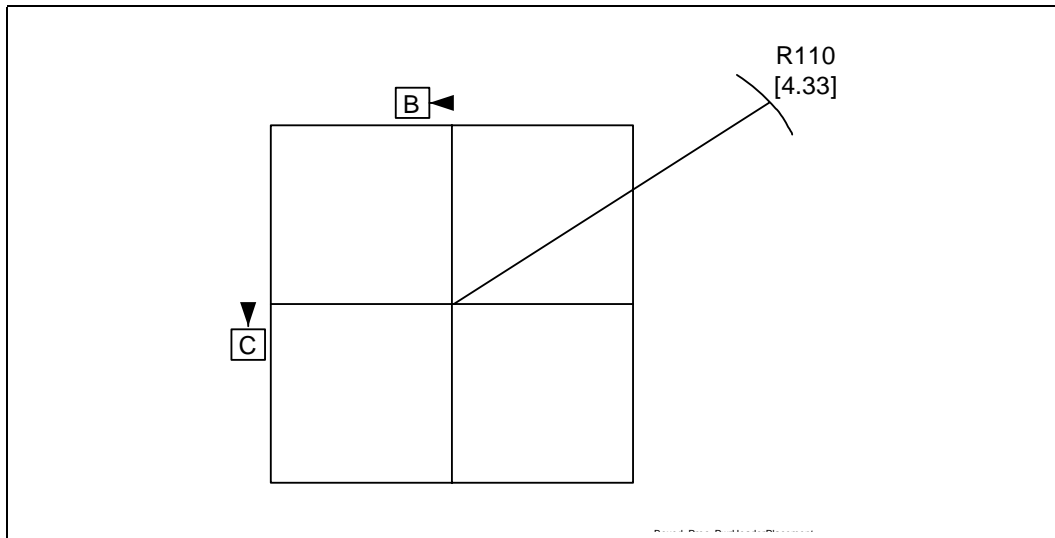
Table 34. Fan Heatsink Power and Signal Specifications

| Description | Min | Typ | Max | Unit | Notes |
|--|------|-----|------|---------------------------|-------|
| +12 V: 12 volt fan power supply | 11.4 | 12 | 12.6 | V | - |
| IC: | | | | | |
| - Maximum fan steady-state current draw | — | 1.2 | — | A | - |
| - Average fan steady-state current draw | — | 0.5 | — | A | |
| - Maximum fan start-up current draw | — | 2.2 | — | A | |
| - Fan start-up current draw maximum duration | — | 1.0 | — | Second | |
| SENSE: SENSE frequency | — | 2 | — | pulses per fan revolution | 1 |
| CONTROL | 21 | 25 | 28 | kHz | 2, 3 |

NOTES:

1. Baseboard should pull this pin up to 5 V with a resistor.
2. Open drain type, pulse width modulated.
3. Fan will have pull-up resistor for this signal to maximum of 5.25 V.

Figure 28. Baseboard Power Header Placement Relative to Processor Socket



7.3 Thermal Specifications

This section describes the cooling requirements of the fan heatsink solution used by the boxed processor.

7.3.1 Boxed Processor Cooling Requirements

The boxed processor may be directly cooled with a fan heatsink. However, meeting the processor's temperature specification is also a function of the thermal design of the entire system, and ultimately the responsibility of the system integrator. The processor temperature specification is listed in [Chapter 5](#). The boxed processor fan heatsink is able to keep the processor temperature within the specifications (see [Table 26](#)) in chassis that provide good thermal management. For the boxed processor fan heatsink to operate properly, it is critical that the airflow provided to the fan heatsink is unimpeded. Airflow of the fan heatsink is into the center and out of the sides of the fan heatsink. Airspace is required around the fan to ensure that the airflow through the fan heatsink is not blocked. Blocking the airflow to the fan heatsink reduces the cooling efficiency and decreases fan life. [Figure 29](#) and [Figure 30](#) illustrate an acceptable airspace clearance for the fan heatsink. The air temperature entering the fan should be kept below 38 °C. Again, meeting the processor's temperature specification is the responsibility of the system integrator.



Figure 29. Boxed Processor Fan Heatsink Airspace Keepout Requirements (side 1 view)

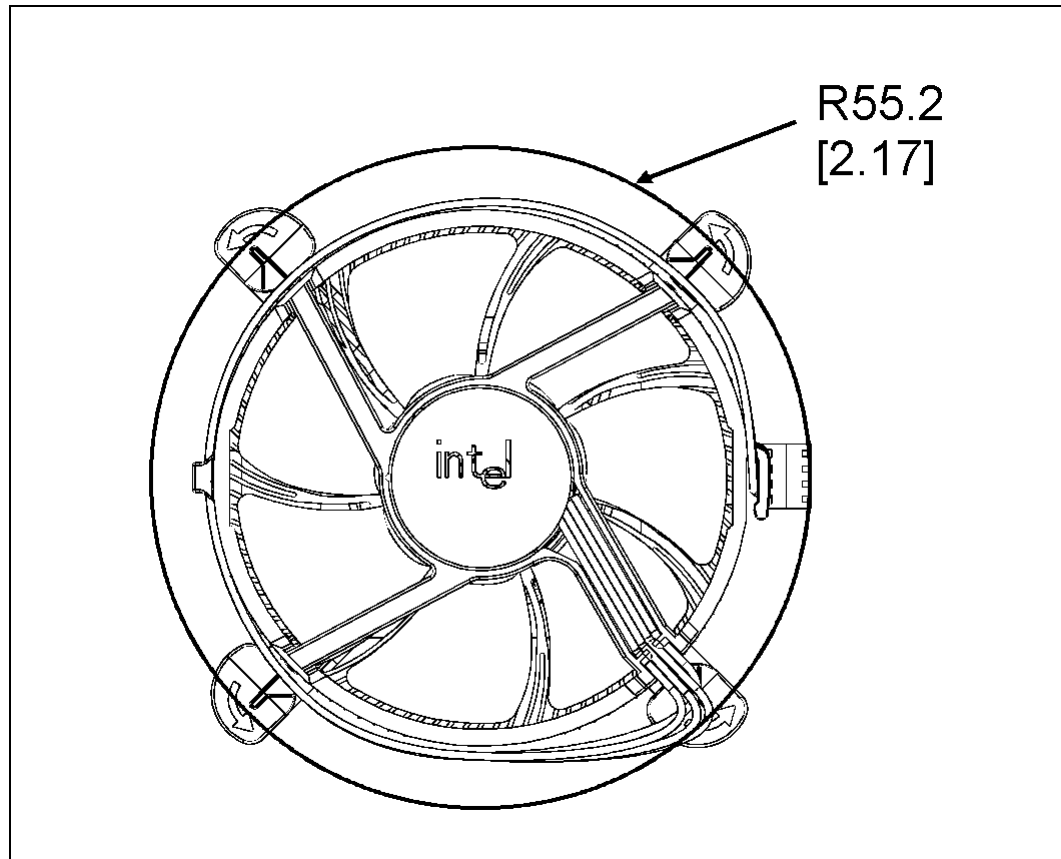
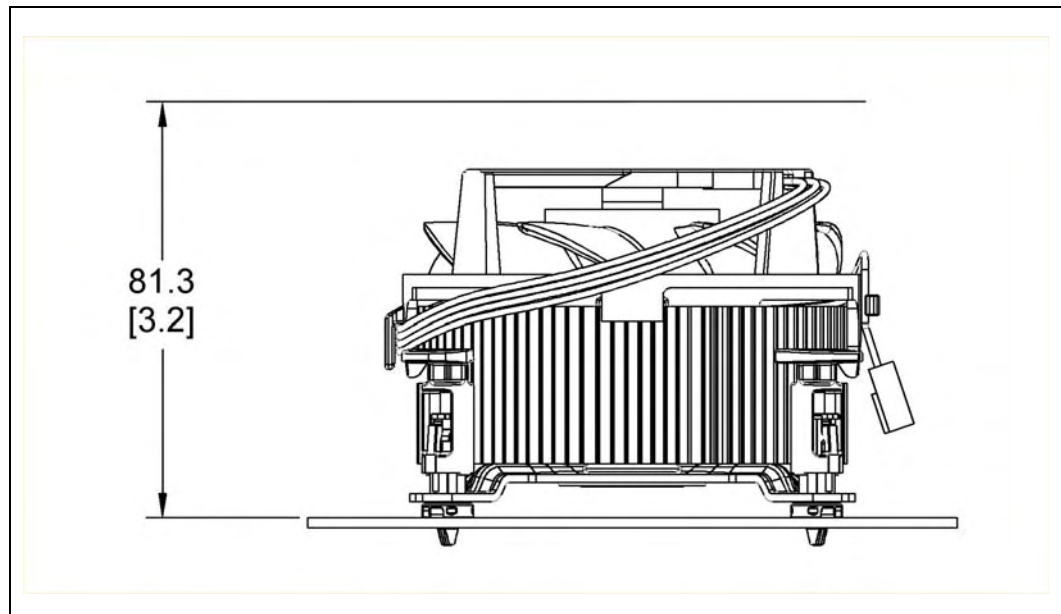


Figure 30. Boxed Processor Fan Heatsink Airspace Keepout Requirements (Side 2 View)



7.3.2 Fan Speed Control Operation (Intel® Pentium® Dual-Core Desktop Processor E2000 Series)

If the boxed processor fan heatsink 4-pin connector is connected to a 3-pin motherboard header it will operate as follows:

The boxed processor fan will operate at different speeds over a short range of internal chassis temperatures. This allows the processor fan to operate at a lower speed and noise level, while internal chassis temperatures are low. If internal chassis temperature increases beyond a lower set point, the fan speed will rise linearly with the internal temperature until the higher set point is reached. At that point, the fan speed is at its maximum. As fan speed increases, so does fan noise levels. Systems should be designed to provide adequate air around the boxed processor fan heatsink that remains cooler than a lower set point. These set points, represented in Figure 31 and Table 35, can vary by a few degrees from fan heatsink to fan heatsink. The internal chassis temperature should be kept below 38 °C. Meeting the processor's temperature specification (see Chapter 5) is the responsibility of the system integrator.

The motherboard must supply a constant +12 V to the processor's power header to ensure proper operation of the variable speed fan for the boxed processor. Refer to Table 35 for the specific requirements.

Figure 31. Boxed Processor Fan Heatsink Set Points

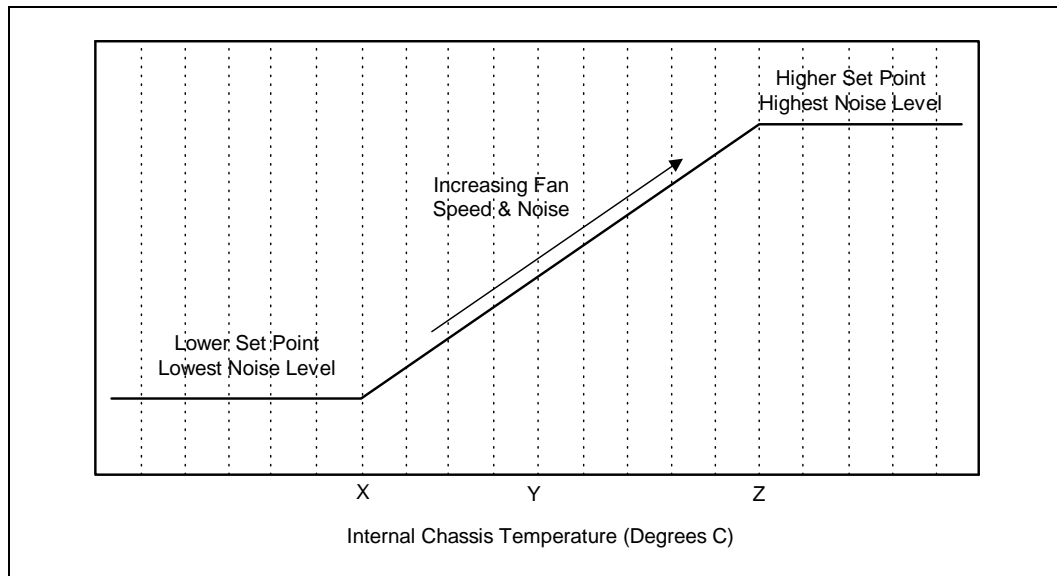



Table 35. Fan Heatsink Power and Signal Specifications

| Boxed Processor Fan Heatsink Set Point (°C) | Boxed Processor Fan Speed | Notes |
|---|--|-------|
| $X \leq 30$ | When the internal chassis temperature is below or equal to this set point, the fan operates at its lowest speed. Recommended maximum internal chassis temperature for nominal operating environment. | 1 |
| $Y = 35$ | When the internal chassis temperature is at this point, the fan operates between its lowest and highest speeds. Recommended maximum internal chassis temperature for worst-case operating environment. | - |
| $Z \geq 38$ | When the internal chassis temperature is above or equal to this set point, the fan operates at its highest speed. | - |

NOTES:

1. Set point variance is approximately ± 1 °C from fan heatsink to fan heatsink.

If the boxed processor fan heatsink 4-pin connector is connected to a 4-pin motherboard header and the motherboard is designed with a fan speed controller with PWM output (CONTROL see [Table 34](#)) and remote thermal diode measurement capability the boxed processor will operate as follows:

As processor power has increased the required thermal solutions have generated increasingly more noise. Intel has added an option to the boxed processor that allows system integrators to have a quieter system in the most common usage.

The 4th wire PWM solution provides better control over chassis acoustics. This is achieved by more accurate measurement of processor die temperature through the processor's temperature diode (T-diode). Fan RPM is modulated through the use of an ASIC located on the motherboard that sends out a PWM control signal to the 4th pin of the connector labeled as CONTROL. The fan speed is based on actual processor temperature instead of internal ambient chassis temperatures.

If the new 4-pin active fan heat sink solution is connected to an older 3-pin baseboard CPU fan header it will default back to a thermistor controlled mode, allowing compatibility with existing 3-pin baseboard designs. Under thermistor controlled mode, the fan RPM is automatically varied based on the Tinlet temperature measured by a thermistor located at the fan inlet.

For more details on specific motherboard requirements for 4-wire based fan speed control see the appropriate Thermal and Mechanical Design Guidelines (see [Section 1.2](#)).







8 *Debug Tools Specifications*

8.1 Logic Analyzer Interface (LAI)

Intel is working with two logic analyzer vendors to provide logic analyzer interfaces (LAIs) for use in debugging systems. Tektronix and Agilent should be contacted to get specific information about their logic analyzer interfaces. The following information is general in nature. Specific information must be obtained from the logic analyzer vendor.

Due to the complexity of systems, the LAI is critical in providing the ability to probe and capture FSB signals. There are two sets of considerations to keep in mind when designing a system that can make use of an LAI: mechanical and electrical.

8.1.1 Mechanical Considerations

The LAI is installed between the processor socket and the processor. The LAI lands plug into the processor socket, while the processor lands plug into a socket on the LAI. Cabling that is part of the LAI egresses the system to allow an electrical connection between the processor and a logic analyzer. The maximum volume occupied by the LAI, known as the keepout volume, as well as the cable egress restrictions, should be obtained from the logic analyzer vendor. System designers must make sure that the keepout volume remains unobstructed inside the system. Note that it is possible that the keepout volume reserved for the LAI may differ from the space normally occupied by the processor's heatsink. If this is the case, the logic analyzer vendor will provide a cooling solution as part of the LAI.

8.1.2 Electrical Considerations

The LAI will also affect the electrical performance of the FSB; therefore, it is critical to obtain electrical load models from each of the logic analyzers to be able to run system level simulations to prove that their tool will work in the system. Contact the logic analyzer vendor for electrical specifications and load models for the LAI solution it provides.

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