Nettop Platform for 2008

System Design White Paper

June 2008

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Revision History

Revision Number	Description	Revision Date
-001	Initial release.	June 2008

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1 Introduction

The basic computing market segment is commonly considered a simplified PC solution at a system price point of $299 USD and below. These computers are part of a new family of computers; called “nettops”, which represent a new generation of low-cost PCs running on Intel processors.

These systems are targeted at users in both mature and emerging market segments whose computing needs and price points require focused and targeted system solutions.

With a small form-factor ideal for young kids and designed to be affordable to first-time users, nettops are configured to run less demanding applications.

This white paper provides a guideline for building a nettop platform for the worldwide sub-entry market segment using the Intel® Desktop Board D945GCLF with the Intel® Atom™ processor 200 series. This product is Intel’s targeted solution for this marketplace.

1.1 Scope

This document consolidates architectural requirements and specifications for delivering a low cost client platform.

This document does NOT:

- Repeat information readily available in standard specifications, but it will reference them.
- Address warranty, distribution costs, tariffs, price, or any other financial or legal terms and conditions.

1.2 Audience

The target audience for this document includes:

- OEMs, platform designers and integrators seeking guidance on low cost platforms.
- Ingredient suppliers for use in low cost platforms.

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2 Platform Vision

Nettops are a simplified version of your everyday desktop, designed to be affordable, energy efficient and have a small form-factor.

A low cost, affordable, purpose build platform for the next billion users.

The low cost platform solution built around the Intel® Desktop Board D945GCLF with the Intel® Atom™ processor 200 series is a simplified PC at sub entry system price points:

- An affordable system for a full PC solution
- Capable of delivering the essential usages for consumers, SMB, educational institutions
- Use standard PC building blocks available in high volume and sustainable quantities
- Small Form Factor Capable

2.1 Platform Capabilities

The Intel Atom™ processor 200 series is purpose-built to deliver necessary performance and experience levels with cost in mind for the new nettop categories, which is a new category for desktop. This category of devices is aimed at content consumption rather than content creation such as, browsing web pages, watching online video streaming videos, etc.

The capabilities enabled by nettops are:

- Basic & Essential Computing
  — Productivity Application, Audio and Entertainment
- Connectivity
  — Email, Internet Browsing
  — Instant Messaging
  — VOIP
- Learning and Education
  — On Line Learning
  — CD Learning
  — Basic Audio, Video
- Ease Of Use
  — Compact, User Friendly with integrated processor
  — Small Form Factor

Table 1 Platform Features

Capabilities	Features
Basic Computing	Supports fundamental computing applications – word processing, spreadsheets, presentation software. Store, manage, and view documents, pictures, and files. Expandability for common peripherals and additional computing needs. Operating system flexibility with Linux*, and Windows* XP.
Connectivity	Supports dial up and broadband connectivity. Scalable for wireless. Communicate via Email and IM for business and personal use. Access information and tour cyberspace with secure browsing. VOIP for low cost phone calls.
Learning and Education	Supports learning initiatives via online, CD, and audio mediums for continued education and early education.
Simple to Use	Platform designed and delivered for key user needs. Easy design and use for first time PC users. No set up required, ready to use within minutes of opening the box. Small size for space efficiency. Simple user interface system easy for navigation and computing. Basic entertainment for music & video enjoyment and entry gaming. Connects to existing TVs.

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3 Platform Overview

3.1 Hardware – Intel® Desktop Board D945GCLF

The key components (Processor, Chipsets, LAN) are soldered down on the motherboard assembly. The Processor and the Chipset reference thermal solutions are pre-assembled along with the motherboard.

Figure 1 shows the principal functional blocks for the platform. The features summary is listed in Table 2. The components location on board are shown in Figure 2. The board dimensions are available in micro-ATX compatible form factor, which is 6.75" x 6.75".

Figure 1 Platform Configuration

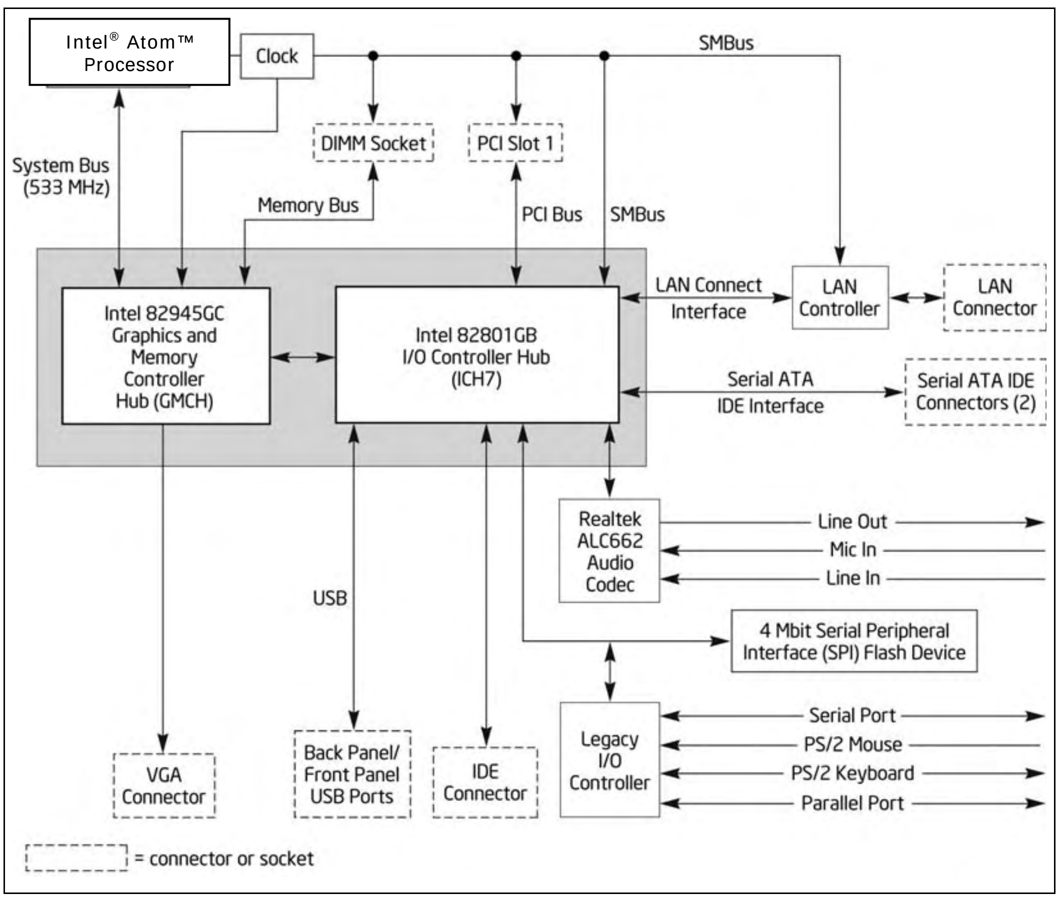

Table 2 Platform Features Summary

Topic	Description
Form Factor	• Micro ATX compatible (6.75 inches X 6.75 inches [171.45 mm X 171.45 mm])
Processor	• Soldered-down Intel® Atom™ processor 230 with 533 MHz system bus
Memory	• One 240-pin DDR2 SDRAM Dual Inline Memory Module (DIMM) socket • Support for DDR2 533 MHz and DDR2 400 MHz DIMMs (DDR 800 and DDR 667 MHz validated to run at 533 MHz only) • Support for up to 2 GB of system memory
Chipset	• Intel® 945GC Chipset, consisting of: • Intel® 82945GC Graphics Memory Controller Hub (GMCH) • Intel® 82801GB I/O Controller Hub (ICH7)
Audio	• 4-channel (2+2) audio subsystem using the Realtek* ALC662 high definition audio codec
Video	• Intel® GMA950 onboard graphics subsystem
Legacy I/O Control	• SMSC LPC47M997 based Legacy I/O controller for hardware management, serial, parallel, and PS/2* ports
Peripheral Interfaces	• Six USB 2.0 ports • Two Serial ATA (SATA) headers • One serial port • One parallel port • One Parallel ATA IDE interface with UDMA 33, ATA-66/100 support • PS/2 keyboard and mouse ports
LAN Support	• 10/100 Mbits/sec LAN subsystem using Realtek RTL8102EL LAN adapter device
BIOS	• Intel® BIOS (resident in the SPI Flash device) • Support for Advanced Configuration and Power Interface (ACPI), Plug and Play, and SMBIOS
Instantly Available PC Technology	• Support for PCI* Local Bus Specification Revision 2.3 • Suspend to RAM support • Wake on PCI, RS-232, front panel, USB ports, and LAN
Expansion Capabilities	• One PCI Conventional bus connector

Topic	Description
Hardware Monitor Subsystem	• Hardware monitoring through the SMSC I/O controller • Voltage sense to detect out of range power supply voltages • Thermal sense to detect out of range thermal values • Two fan headers • One fan sense inputs used to monitor fan activity • Fan speed control

Figure 2 Major components on board

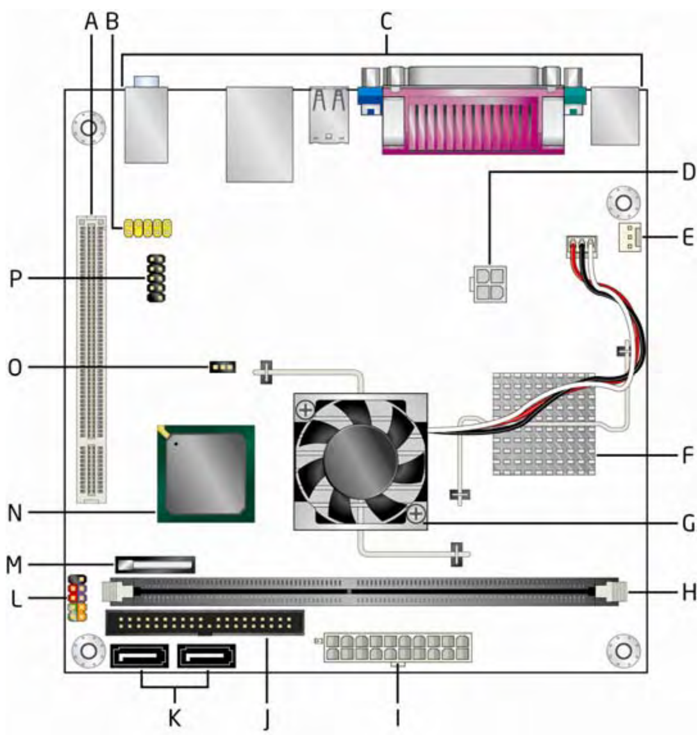

Table 3 Items in Figure 2

Item	Description
A	PCI Conventional bus add-in card connector
B	Front panel audio header Front panel USB headers
C	Back panel connectors
D	+12 V power connector (ATX12V)
E	Chassis fan header
F	Intel Celeron processor
G	Intel 82945GC GMCH
H	DIMM socket

I	Main power connector
J	Parallel ATA IDE connector
K	SATA connectors [2]
L	Front panel I/O header
M	Battery
N	Intel 82801GB I/O Controller Hub (ICH7)
O	BIOS Setup configuration jumper block
P	Front panel USB header

3.2 Firmware

The Serial Peripheral Interface Flash Memory (SPI Flash) includes a 4 MB flash memory device on the motherboard holds the firmware content. The SPI Flash contains the BIOS Setup program, POST, the PCI auto-configuration utility, LAN EEPROM information, and Plug and Play support.

Note: BIOS updates available at: http://downloadcenter.intel.com

3.3 Software

3.3.1 Operating Systems

The platform is validated with the following build of operating systems.

- Microsoft Windows* XP 32/64-bit (Home Edition, Pro Edition)
- Microsoft Windows* Vista* Basic & Starter (32-bit and 64-bit)
- Linux*
  - Mandriva
  - Red Hat
  - Ubuntu
  - Red Flag

Note: *Intel will support on issue fix base on best effort basis.

3.3.2 Drivers

Table 4 Drivers and Software for Devices

Device	Description	Location
Intel® 82945GC Graphics Memory Controller Hub (GMCH) Intel 945GC chipset	Consists of: • Intel® 82945GC Graphics Memory Controller Hub (GMCH) with Direct Media Interface (DMI) interconnect • Intel® 82801GB I/O Controller Hub (ICH7) with DMI interconnect	http://www.intel.com/products/desktop/chipsets/index.htm
USB	Supports: • up to six USB 2.0 ports, • supports UHCI and EHCI • uses UHCI- and EHCI-compatible drivers.	http://downloadcenter.intel.com
Audio Subsystem	Consists of: Intel 82801GB ICH7 Realtek ALC662 audio codec	http://downloadcenter.intel.com
LAN Subsystem	Consists of: • Intel 82801GB ICH7 • Realtek RTL8102EL device for 10/100 Mbits/sec Ethernet LAN connectivity • RJ-45 LAN connector with integrated status LEDs Additional features include: • CSMA/CD protocol engine • LAN connect interface that supports the 82562G • PCI Conventional bus power management • Supports ACPI technology • Supports LAN wake capabilities	http://downloadcenter.intel.com

Note: Drivers updates available at: http://downloadcenter.intel.com

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4 System Configuration

4.1 System Components

Basic system components are listed in Table 5.

Table 5 System Components List

Component	Specification
Motherboard (with soldered down processor)	Intel® Desktop Board D945GCLF • Micro ATX compatible form factor (dimensions: 6.75” x 6.75”) • Supporting Intel® Atom™ processor 200 series with 512K L2, 533 MHz FSB (Soldered down, μ-FCBGA package) • Intel 945GC/ICH7 Chipset • Integrated Graphics via GMA950 • Realtek RTL8102EL 10/100Mb/s or RTL8111DL 1000Mb/s Ethernet LAN PHY • SMSC LPC47M997 SIO with integrated hardware monitoring
Memory	DDR2 DIMM
Storage	NAND flash / Standard hard disk drive (PATA / SATA)
Optical drive	CD / DVD / Combo support
Power supply unit	ATX 12 V / TFX 12 V (refer to Section 4.3 for details)
Chassis	ATX / Micro ATX compatible
Display	CRT / LCD / TV as display (refer to Section 4.2 for details)
Miscellaneous	Full ACPI compliant Energy Star* 2007 compliant

4.2 Display

Display options include:

- CRT
- LCD
- TV as display

CRT-based (cathode ray tube) monitors are a still commonly used with PCs. LCD displays are replacing CRT displays at a high rate. But CRT displays are still expected to be available for 3–5 more years (especially in refurbishing markets). System manufacturers/OEM/ODM need to be aware that the logistical costs for CRT displays is higher than the costs incurred by LCD displays.

LCD displays (liquid crystal) use a thin, flat display technology. It consumes relatively lesser power than CRT displays. There are a variety of related technologies in the LCD space. Current focus is mainly on the TFT (thin film transistor) based color displays.

There is an option to connect the PC to a television. This option may be used for two different reasons:

- Using the TV as a display instead of a monitor
- Using PC media-content-playback features

Using the TV as the primary display may not be a good solution for many users. Depending on the content, the TV display could be unproductive – proceed with caution.

The optional S-video connector in the back panel of the system can be used to connect with TVs supporting this interface (Figure 3, Figure 4). The connector on the platform can support two kinds of TV interfaces, one is S-video by 4-pin s-video cable and the other is composite interface by S-video-to-composite cable (their signal pins use separate pins to deliver better video quality and compatibility).

Figure 3 S-Video Connections

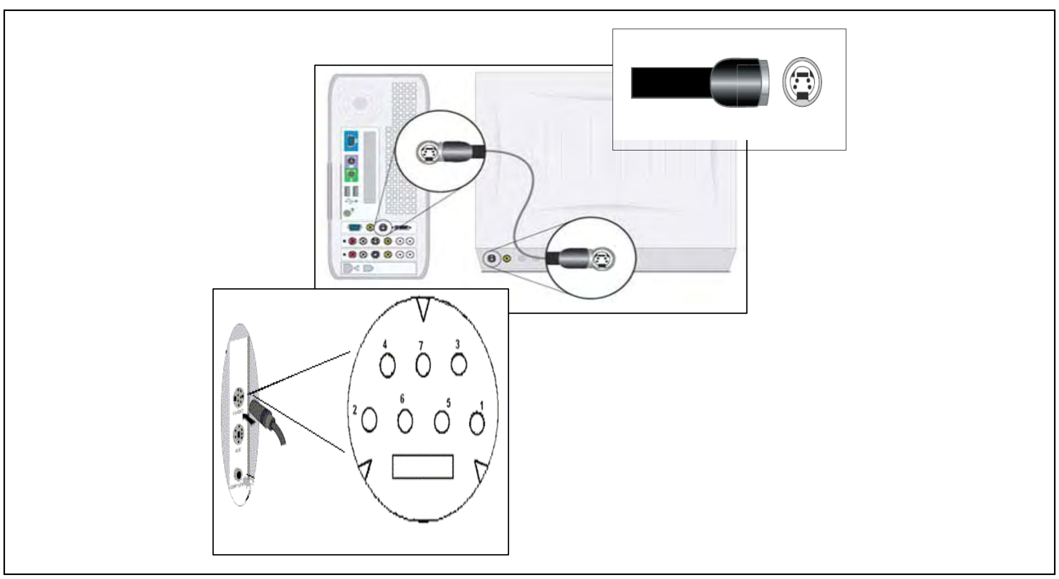
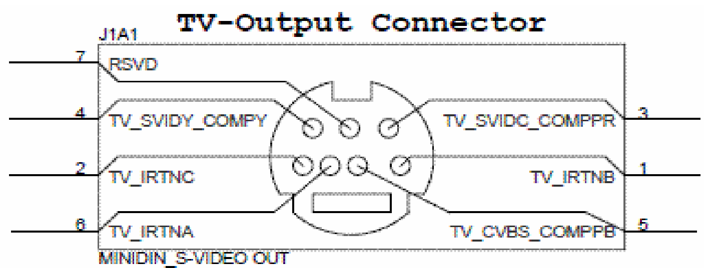


Table 6 Video Specifications

Interface	VGA
Size	15"
Resolution	8x6 (SVGA) or 10x7 (XGA) or 12x10
Technology	CRT (OR) LCD
Color space	Min requirement is to boot Win XP

Figure 4 S-Video Pin Definitions



Analog TV-out Signals

Signal Name	Type	Description
TVDAC_A	O A	**TVDAC Channel A Output:** TVDAC_A supports the following: **Composite:** CVBS signal **Component:** Chrominance (Pb) analog signal
TVDAC_B	O A	**TVDAC Channel B Output:** TVDAC_B supports the following: **S-Video:** Luminance analog signal **Component:** Luminance (Y) analog signal
TVDAC_C	O A	**TVDAC Channel C Output:** TVDAC_C supports the following: **S-Video:** Chrominance analog signal **Component:** Chrominance (Pr) analog signal
TV_IRTNA	O A	**Current Return for TVDAC Channel A:** Connect to ground on board
TV_IRTNB	O A	**Current Return for TVDAC Channel B:** Connect to ground on board
TV_IRTNC	O A	**Current Return for TVDAC Channel C:** Connect to ground on board
TV_REFSET	O A	**TV Resistor set:** TV Reference Current uses an external resistor to set internal reference voltage levels. A 5-kΩ ± 0.5% resistor is required between REFSET and motherboard ground.

4.3 Power Supply

4.3.1 Power Supply Requirement

This platform requires a typical desktop 5 rail output power supply for the whole system. The motherboard is powered from a 20 pin main connector and a 2x2 connector. The common internal power supply can provide a cost effective solution for the platform. The detailed electrical requirement can be found in the Power Supply Design guide for Desktop form factors (www.formfactors.org). For building an ultra small form factor system or Energy Star compliant system, some recommendation is provided in the following section.

Typical Power Distribution

Power supply should meet the minimum power distribution requirement in Table 7.

Table 7 Typical Power Distribution

Output	Minimum Current (A)	Maximum Current (A)	Peak Current (A)[1]
12 VDC	0.2	3	—
5 VDC[2]	0.2	6	—
3.3 VDC[2]	0.1	9	—
-12 VDC	—	0.3	—
5 VSB	—	2	2.5
Total Power	70 W		

NOTES:

1. Peak currents may last up to 17 seconds with not more than one occurrence per minute.
2. Total combined output of 3.3 V and 5 V is ≤ 50 W.

Main Power Connector

This motherboard requires a 20 pin main power connector. A 24 pin main power connector is acceptable. The motherboard designer needs to make sure that not to put any tall components (≦3.5 mm), such as capacitors in the area where the 4 extra pins will be.

Serial ATA* Power Connector

Make sure the power supply has Serial ATA* power connector if the system has Serial ATA devices.

Note: Other electrical and mechanical specifications can be found in the Power Supply Design Guide for Desktop Platform Form Factors (www.formfactors.org)

4.3.2 Common Internal Power Supply

Common internal power supply form factors include ATX12 V, TFX12 V, SFX12 V and Flex ATX form factor. Using a common internal power supply has a comparative lower cost than other power solutions. A system designer should consider the power supply cost together with the system overall size. The mechanical dimension can be found in the Power Supply Design Guide for Desktop Platform Form Factors.

4.3.2.1 Energy Star* Qualified Internal Power Supply

Tier I of the ENERGY STAR* computer specification as documented in *ENERGY STAR* Program Requirements for Computers: Version 4.0* requires that the internal power supplies for compliant computers be at least 80% efficient. The efficiency is specified at 20%, 50% and 100% of the rated output capacity. In addition, the power supply needs to have a power factor of at least 0.9 measured at 100% of the rated output capacity. In order to meet the power factor requirements, internal power supplies will need to incorporate active power factor correction. Active power factor correction consists of wave shaping circuitry on the AC input side of the power supply to improve the power factor. It is unlikely that power supplies with passive power factor correction will be able to satisfy the 0.9 power factor requirement. To meet Energy Star* Version 4.0 internal power supply requirement, the following items need to take consideration:

- **Overall Efficiency Measurements**
  Desktop computer systems typically use internal power supplies with multiple outputs. In many cases, the sum of the output power capability for the individual outputs exceeds the total output capacity of the power supply. For these cases, a method of proportional loading needs to be applied in order to measure or calculate the efficiency of the power supply. This proportional loading method is explained in detail in the *Generalized Internal Power Supply Efficiency Test Protocol* which is available from www.efficientpowersupplies.org.
- **Power Supply Sizing**
  Generally the efficiency of the power supply drops off significantly as the load falls below 20%. If an oversized power supply is used, it will operate in this inefficient range when system operates in idle state. Choose a right size power supply can minimize the power supply loss which allows additional budget for other system components to meet the Energy Star* requirement.
- **5 V Standby (5 VSB) Efficiency**
  5 VSB output is the only output present for the sleep and standby states. In order to meet the sleep and standby targets for ENERGY STAR*, the power supply will need to have good efficiency performance for the 5 VSB output. The Power Supply Design Guide for Desktop Platform Form Factors available at www.formfactors.org has guidelines for 5 VSB efficiency that can be used to guide purchase decisions to ensure good efficiency for this portion of the power supply.

4.3.3 External Adapter and DC-DC Board

Ultra small form factor system can use a DC-DC board and external adapter for the power solution. The system size is greatly reduced by removing part of the AC-DC converter from the system and using an external adapter.

Designing this solution, the following items need to be taken into consideration:

- The DC-DC board should meet the minimum power distribution requirements in Table 7.
- Main Power Connector: A 20 pin main connector is recommended. A 20+4 pin main connector is acceptable.
- Input voltage: The input voltage of the DC-DC board in the market is typically 19 V or 12 V. Comparing these two DC-DC solution, 12 V input DC-DC board usually has no additional regulator for 12 V output. (see Figure 5 and Figure 6) 12 V output of the adaptor passes through the DC-DC board and supply current to the system directly. The advantage of this approach is lower cost due to lack of a 12 V regulator. The potential disadvantage is the 12 V voltage drop on the DC-DC board and higher thermal cost in the adaptor if the system requires large 12 V power. System designer should calculate the power cost together with the adaptor.
- Adaptor Matching: The worst efficiency of the DC-DC should be considered for the adaptor matching. Such as, Total power of DC-DC board is 70 W and its efficiency at full load is ≧ 70%. The adaptor should be at least 70 W / 70% ≧ 100 W to support the DC-DC board power output and power loss.
- Airflow: Some of the DC-DC boards require a certain amount of airflow to support the maximum power. System designers should check the system airflow if the DC-DC board requires this airflow for cooling.
- Cable length: DC-DC board solution is commonly chosen by small form factor or ultra small form factor design. Since the system component density is high, long power cables will increase the system airflow impendence significantly. System designers should optimize the power cable length to reduce the system airflow impendence.

Figure 5   Typical Input Voltage of the DC-DC board in the Market, for example 12 V

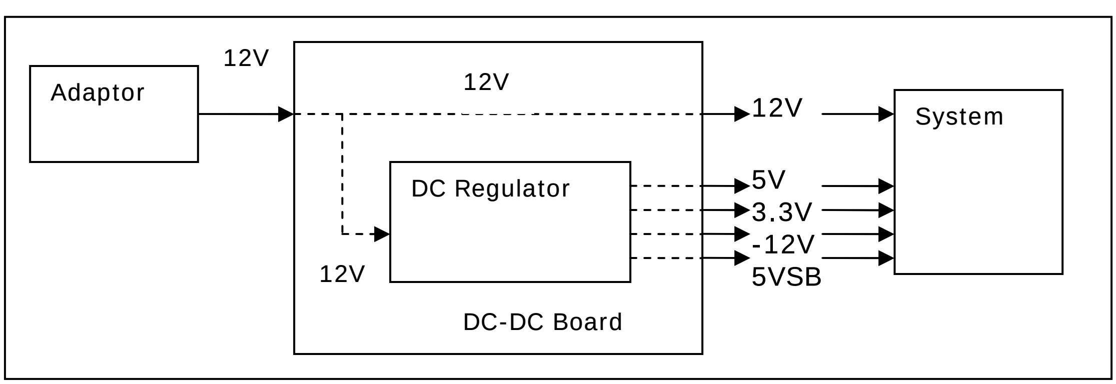
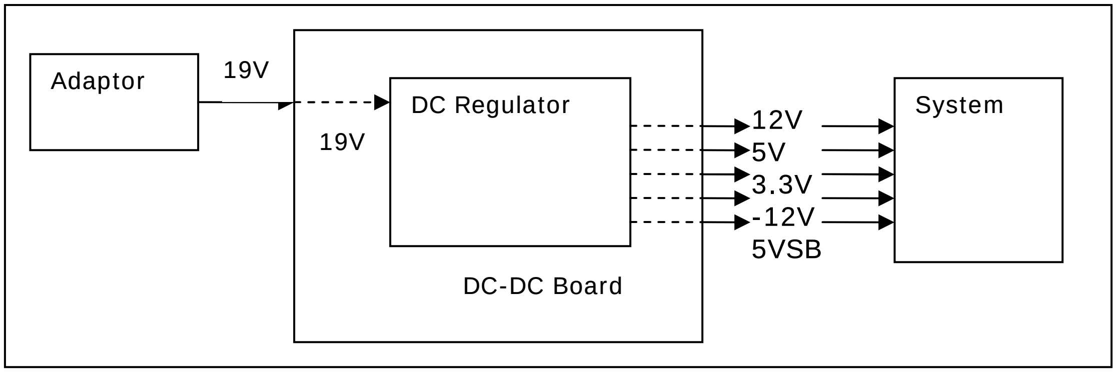


Figure 6 Typical Input Voltage of the DC-DC Board in the Market, for example 19 V



4.3.4 Energy Star* Qualified External Power Supply (Adapter)

Tier I of the ENERGY STAR* computer specification as documented in *ENERGY STAR* Program Requirements for Computers: Version 4.0* requires that the external power supplies for compliant computers be at least 84% average efficiency. Average efficiency is defined as the averaging the efficiencies at 25%, 50%, 75% and 100% of the rated output capacity. In addition, an unplugged external power supply should consume no more than 0.75 W from the wall socket. Details can be found at www.energystar.gov/ia/partners/product_specs/program_reqs/EPS%20Eligibility%20Criteria.pdf.

After November 1, 2008, a new version of *ENERGY STAR* Program Requirements for Single Voltage External Ac-Dc and Ac-Ac Power Supplies* specification will take effect. Both average efficiency and no-load specification become tighter, 87% and 0.5 W respectively. Details can be found at www.energystar.gov/index.cfm?c=revisions.eps_spec. A system designer should consider the version of the Energy Star* compliant power supply when designing an Energy Star* compliant system.

Reference:

Power Supply Design Guide for Desktop Form Factors

ENERGY STAR* Program Requirements for Computers

ENERGY STAR* System Implementation white paper

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5 Improving System Thermal Performance

The heat generated by components within the chassis must be removed to provide an adequate operating environment for the processor and all other components in the system. Moving airflow through the chassis brings in fresh cool air from the external ambient environment and transports the heat generated by the processor and other system components out of the system. Therefore, the number, size and relative position of fans and vents determine the chassis thermal performance, and the resulting ambient temperature around the processor.

To look at thermal design consideration from point of system configuration, it's important to point out that system boundary condition is the most critical and underlining parameters of all. System boundary condition, which is airflow and the ambient condition of the system, is related to heatsink design and component characteristic. It is particularly important to choose a thermally advantaged chassis for the reference thermal solution for Intel® Atom™ processor 200 series on Intel® Desktop Board D945GCLF, for building a nettop system.

5.1 Typical Thermal Solutions

The typical thermal solutions include active, passive and fanless type of solution.

An active thermal solution has a fan (either axial or blower type fan) directly mounted on heatsink as an unified heat removal device. System acoustic (from heatsink fan) and cost are the common trade-offs for an active heatsink.

Passive thermal solution is a thermal solution without fan, which relies on system fan to provide airflow for cooling. System acoustic concern shifts to system fan in this case. The cost is obviously reduced.

Fanless thermal solution is capable of cooling inside a system that does not have any fan, and no moving parts or what so ever. Natural convection is the primary heat transfer mechanism, therefore system ventilation is key factors for good thermal performance of fanless thermal solution.

It is obvious that the thermal performance of a passive or fanless thermal solution is highly dependent on system configuration.

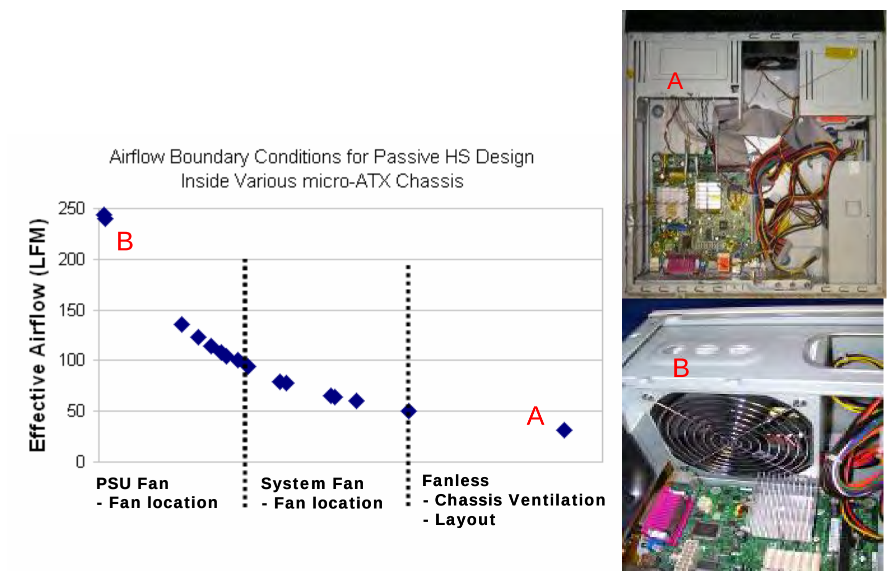
5.2 Boundary Conditions for System Thermal Design

By analyzing airflow condition in µATX chassis, airflow data across multiples different chassis configuration indicates the actual test data and statistic of the effective airflow supplied by the system to processor heatsink.

As shown in Figure 7, high airflow (>200LFM) could be achieved if power supply unit (PSU) with fan is located near processor as shown by chassis B in the Figure 7. The effective airflow varies according to the placement of power supply unit fan and system fan locations in a chassis. The lowest observed airflow in the system is <50 LFM with the fan located far away from the processor and chipset components, as shown in chassis A.

As mentioned previously, system configurations determine boundary condition for passive and fanless system thermal design.

Figure 7 Airflow Boundary Conditions for Passive Heatsink Design in Various Micro ATX Chassis



5.3 Case Studies

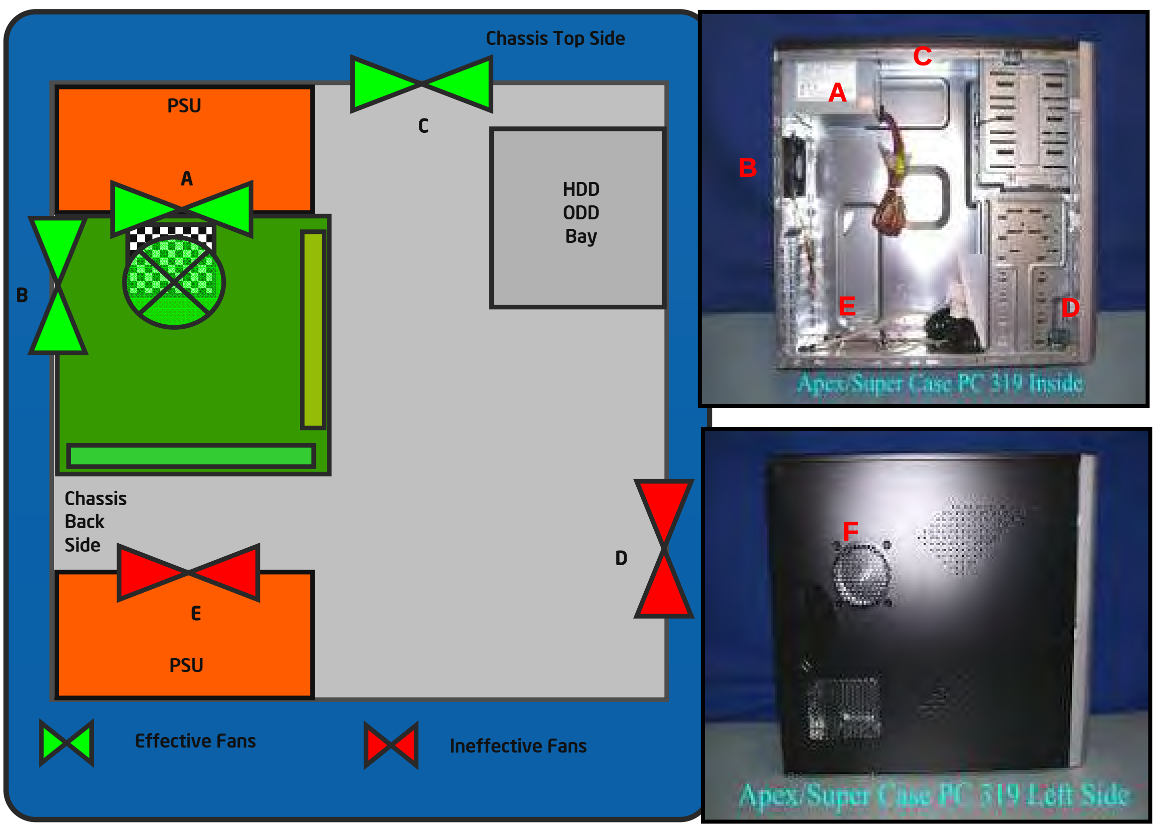
Fan location sensitivity study was conducted using 13L micro-ATX chassis with 3 different configurations, by various fan locations in the chassis.

Schematic in Figure 8 shows a typical internal placement of micro-ATX chassis. Fan could be located at locations A and B, which are the PSU fan and system fan (at back panel) respectively. Some chassis have system fan at location C instead. Alternatively, PSU fan could be placed at bottom region of chassis at location E, and system fan could be located at D & F.

Three scenarios have been studied and giving as examples in this document:

- Case Study #1: Location A, B
- Case Study #2: Location A, C
- Case Study #3: Location D, E, F

Figure 8 Schematic of Typical Micro ATX System Placement



5.3.1 Case Study #1

Case study #1 shows the impact of PSU fan (A) and system fan (B) placements at back panel on the thermal boundary conditions, as shown in Figure 9.

The results of two chassis tested using a same heatsink on processor is shown in Figure 10. Y-axis is normalized specification with 1.0 is value as processor passing thermal requirement.

In chassis #1, system back-panel fan (B) is just good enough to provide boundary condition passing the thermal requirement. If a PSU fan of 80mm is properly aligned with processor heatsink, an improvement of over 50% in airflow boundary condition has been observed over processor heatsink. As a result, a further cost reduction in processor heatsink design with possible smaller and lighter heatsink design can be implemented. Hence, a combination of system & PSU fan will provide enhanced boundary condition.

In chassis #2, test data shows the importance of PSU fan size and its relative location to processor heatsink. A 30mm offset PSU fan (60mm size) will degrade boundary condition by almost 100%. Again, boundary condition could be further enhanced with system fan (B) added.

The two tested chassis configurations in Case Study #1 conclude that a PSU fan aligns with heatsink will provide good airflow (100~130LFM range) to processor heatsink, and meanwhile exhausting hot air away from system. Adding a system fan at back-panel of chassis will further enhance the boundary condition in a chassis.

5.3.2 Case Study #2

Case study #2 in Figure 11 and Figure 12 shows that adding a system fan (C) can further improve airflow conditions in chassis. Comparing chassis#2 (in Figure 10) and chassis #3 (in Figure 12) results, system fan is preferably to be located at the top side of the chassis to provide efficient airflow over processor heatsink.

5.3.3 Case Study #3

Case study#3 is a typical example showing the impact of airflow with inefficient fan locations at (D) and (E). Even if chassis #4 is equipped with an inlet system fan (D) (at front panel) and a PSU fan (E), the result in

Figure 14 shows that it is not providing an effective airflow boundary condition to cool components on motherboard.

Figure 14 shows that the airflow condition provided by fan (D) and fan (E) does not meet thermal requirement. Relocating system fan (D) to location (F) by mounting the fan onto existing side vent of chassis wall can significantly improve airflow condition by around 50% by supplying impingement airflow to processor heatsink.

Figure 9 Case study #1: PSU Fan (A) + System Fan (B)

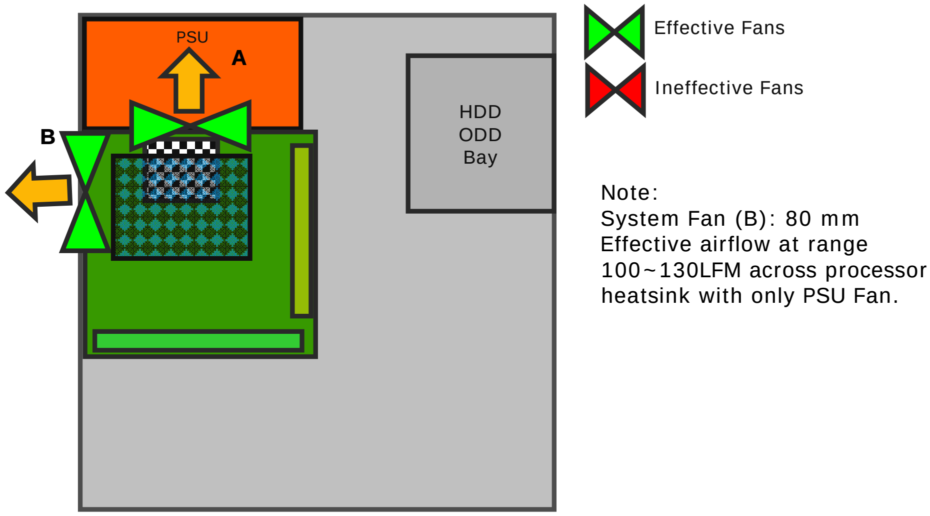
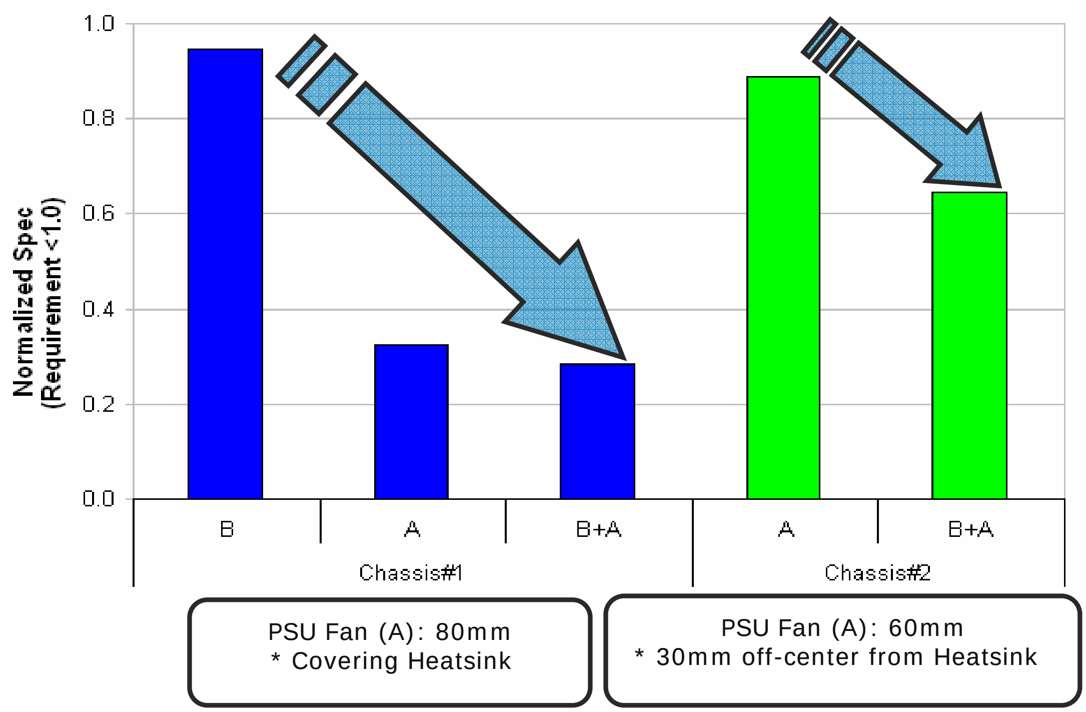


Figure 10 Results of Two Chassis Tested Using Same Heatsink on Processor



NOTE: This figure shows the impact of PSU fan (A) and system fan (B) placements at back panel on the thermal boundary conditions.

Figure 11 Case Study #2: PSU Fan (A) + System Fan (C)

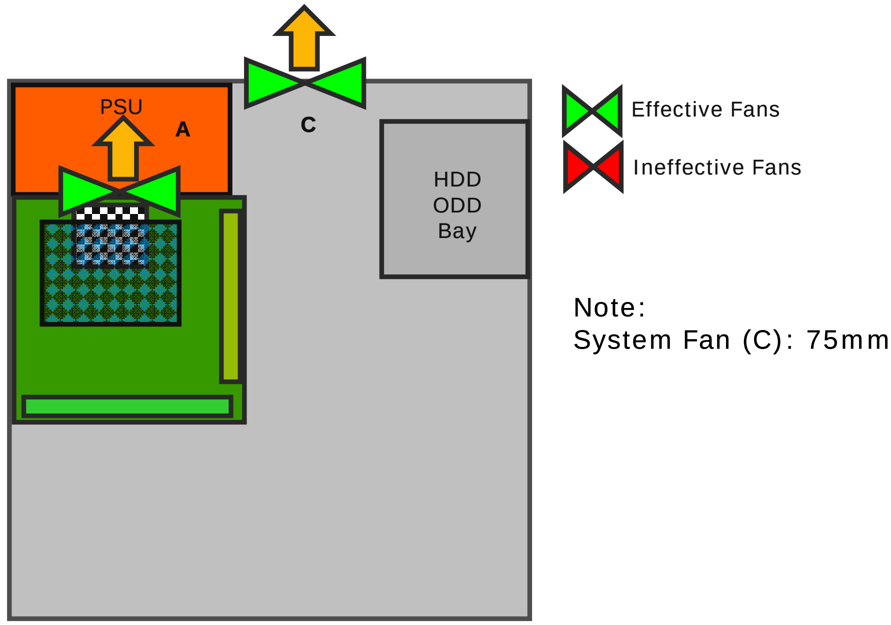
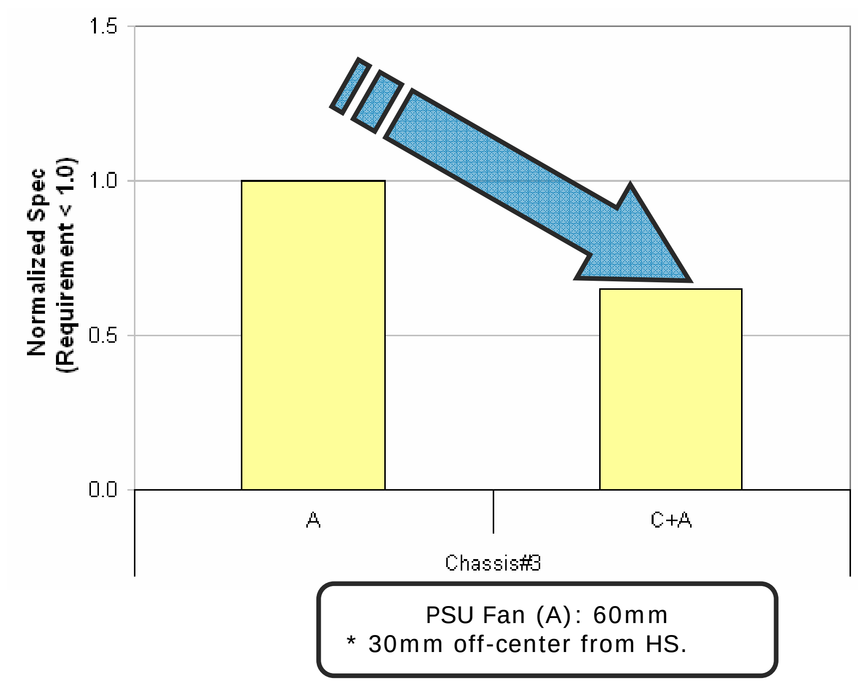


Figure 12 Results Chassis #3 Tested Using Same Heatsink on Processor



NOTE: This figure shows that adding a system fan (C) can also enhance boundary condition.

Figure 13 Case Study #3: System Fan (D) versus System Fan (F)

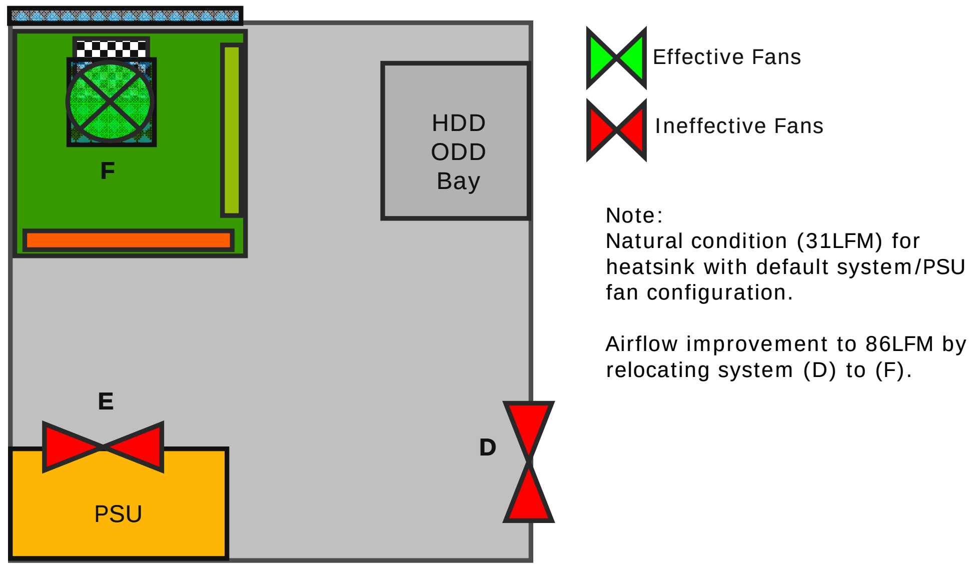
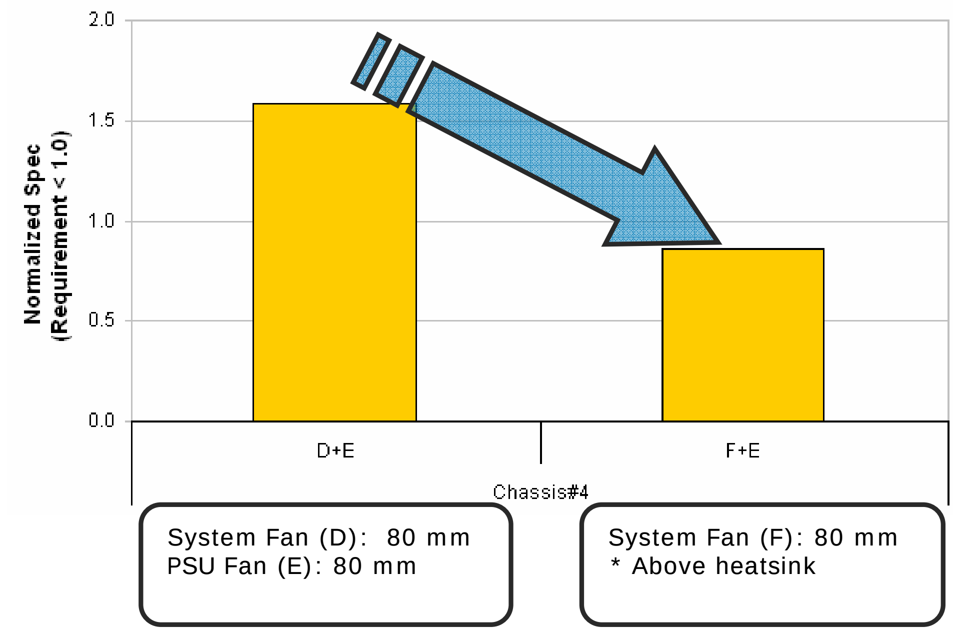


Figure 14 Impact of System Fan Placement on the Airflow over Processor Heatsink



5.4 Summary

The case studies summary in Table 8 shows that in order to enable an effective passive thermal design boundary condition, the placement of power supply unit (PSU) fan and the system fan is critical.

For PSU fan, it's is obvious that placing it closer to processor heatsink is capable to provide excellent airflow. Need to take note that the processor heatsink is placed within coverage of PSU fan. On the other hand, placing a PSU fan at location (E) faraway from motherboard is not preferred.

For system fan, the excellent position is found at (F), which is located on top of processor heatsink. System fan (F) provides impingement airflow to cool processor and the other components on the motherboard. System fan (B) & (C) are able to provide good boundary conditions as well, depending on fan size & location relative to heatsink. System fan (D) is inefficient since it is too far way from the motherboard.

The result shows that PSU fan (A) & System fan (F) are critical for passive design. These two fan locations are capable to provide excellent boundary condition to enable simple, low cost passive heatsink design.

Table 8 Summary of Case Studies

Fans	Location	Sizes (mm)	Rating	Comment
PSU Fan	A	60, 80	Excellent	Heatsink is within PSU fan coverage
	E	80	Poor	Remote PSU fan: insufficient airflow to board
System Fan	F	80	Excellent	Direct air impingement to cool heatsink Relocate system fan to existing side vent Zero cost adder!
	B	80	Good	Performance varies with fan size & location relative to heatsink
	C	75	Good	Performance varies with fan size & location relative to heatsink
	D	80	Poor	Remote system fan: insufficient airflow to board

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6 System Testing

6.1 Validation

Validation of the platform includes component level validation, board level validation and system level validation (in chassis). Extensive effort has been done by Intel on the component and board level with focus on all sub systems. In chassis system validation covers functional and EMI tests of integrated board, chassis, power supply, and peripheral devices. This chapter describes what has been done at the board and system level validation.

6.1.1 Board Level Validation

Board level validation covers the following categories.

6.1.1.1 Processor

- Validation with Intel® Atom™ 230 processor that is soldered to the motherboard.
- BIOS Validation to ensure processor speed, microcode update, Processor ID, etc.
- Board level operating system stress, thermal stress, and EMI environmental verification.
- Compatibility validation of the board with various target operating system and application software.

6.1.1.2 Memory

DDR2 DIMM from various memory vendors have been validated on this platform at the following transfer rate, capacity:

- Transfer Rate: 400 MHz and 533 MHz
- Capacity: 256 MB, 512 MB, and 1 GB.

Memory clock accuracy, signal integrity of the data bus, memory supply regulated voltage stability are the few areas that are validated.

6.1.1.3 Functional, Signal Integrity Validation

Board level validation covers the following functional modules on board with emphasis on signal integrity:

- Processor Voltage Regulator/Controller gate switching integrity, over current protection.
- MCH/ICH/Memory core voltage regulators gate switching and over current protection.
- Memory functional stress test and core voltage stability testing.
- Clock generator, clock source, clock destination phase jitter, rise/fall time signal integrity.
- ICH core voltage stability, GPIO control signal function requirement.
- IDE PATA functional stress and signal integrity testing.
- TV out Video graphics resolution, composite video signal quality verification.
- Audio codec stereo function and audio precision signal integrity.
- SIO, LAN, SPI flash, Fan Control, PCI slot, USB ports rear and front, PS/2 ports, Parallel/Serial Ports, Chassis panel header, BIOS recovery testing.

Subjecting board, peripheral devices, and software to temperature chamber variation and apply supply voltage margining in order to cover all 4 extreme corners of voltage/temperature requirements.

6.1.1.4 Application and Performance Testing

Various software are used for board level compatibility testing and board is subjected to testing of generally accepted benchmark test software such as 3DMark2001 (Pro Build 330), PCMark 2004 Build 120, SysMark 2007.

6.1.2 System Level Testing

6.1.2.1 Thermal Testing

This section describes the system (in-chassis) thermal testing procedures to ensure appropriate chassis is selected to meet thermal requirements for all components inside chassis.

The following preparation is required to perform system thermal testing. Consult the component vendor for latest specification before testing.

Test Preparation

Qty	Items
1	HDD PATA (IDE)
1	DVD ODD PATA (IDE)
1	Memory DDR2 533MHz (512MB)
1	Fluke NetDAQ (data logging system)
-	Type-T thermo couple (TC)
-	Loctite Epoxy (for TC attachment)
-	Software required: WINDOW XP, PCMark05, 3DMark, SysMark 2007, Window Media Player
-	Misc: Mouse / Keyboard

Pass/fail criteria for all components are as follow

Component	Pass/Fail Criteria
Processor	$T_{CASE} \leq 85.2°C$
MCH	$T_{MCH\ CASE} \leq 99°C$
ICH	$T_{ICH\ CASE} \leq 108°C$
HDD	Ambient temperature ≤ 55°C
ODD	Ambient temperature ≤ 45°C
Memory	$T_{Memory\ CASE} \leq 95°C$
PROCESSOR VR	$T_{FET} \leq 120°C$

Thermo couple locations

*All thermo couples are type-T, unless specified.

TC #	Description	Location [Axis]
1	External ambient (TEXT_AMB)	"Far-field" Laboratory ambient. (Outside of system recirculation pattern.)
2a	System intake ambient (TSYS_INLET)	Front panel inlet or system side inlet vent.
3a 3b	PROCESSOR local ambient (TPROCESSOR AMB)	3mm to 8mm [0.1 to 0.3 in] from heatsink.
4	PROCESSOR Tcase (T CASE)	(Type-K) Center point of processor case top surface.

TC #	Description	Location [Axis]
5	MCH Tcase (TMCH CASE)	(Type-K) Center point of MCH case top surface.
6	ICH Case (TICH CASE)	Centered on ICH case top surface.
8	HDD (THDD)	3mm away from component's surface exposed to system interior.
8	ODD (TODD)	3mm away from component's surface exposed to system interior.

T_{CASE} thermo couple 0° attachment metrology

Following is the recommended guideline for proper technique of measuring component case temperature.

1. Mill a 3.3 mm [0.13 in] diameter hole centered on bottom of the heatsink base. The milled hole should be approximately 1.5 mm [0.06 in] deep.
2. Mill a 1.3 mm [0.05 in] wide slot, 0.5 mm [0.02 in] deep, from the centered hole to one edge of the heatsink. The slot should be in the direction parallel to the heatsink fins as illustrated in following figure (top view).
3. Attach thermal interface material (TIM) to the bottom of the heatsink base.
4. Cut out portions of the TIM to make room for the thermocouple wire and bead. The cutouts should match the slot and hole milled into the heatsink base.
5. Attach a 36 gauge or smaller K-type thermocouple bead to the center of the top surface of the die using cement with high thermal conductivity. During this step, make sure no contact is present between the thermocouple cement and the heatsink base because any contact will affect the thermocouple reading. It is critical that the thermocouple bead makes contact with the die. Figure 15 shows modification at bottom side of heatsink for 0° TC attachment.
6. Attach heatsink assembly to the component, and route thermocouple wires out through the milled slot.

Figure 15 0° Angle Attach Methodology (top view, not to scale)

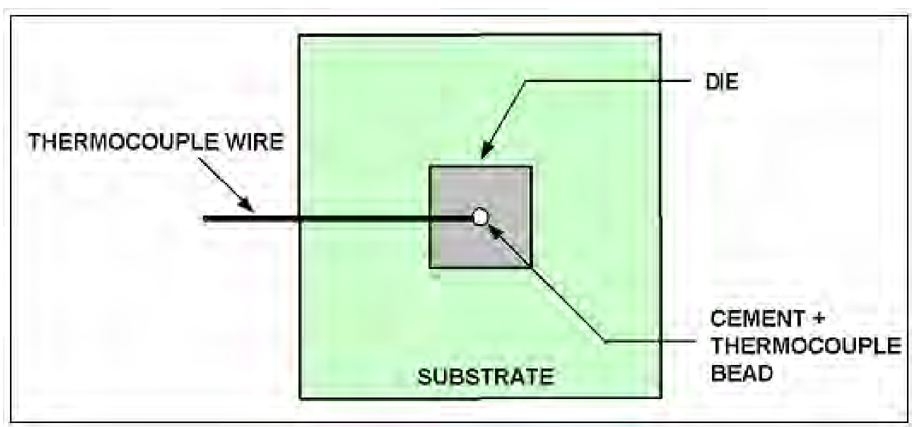
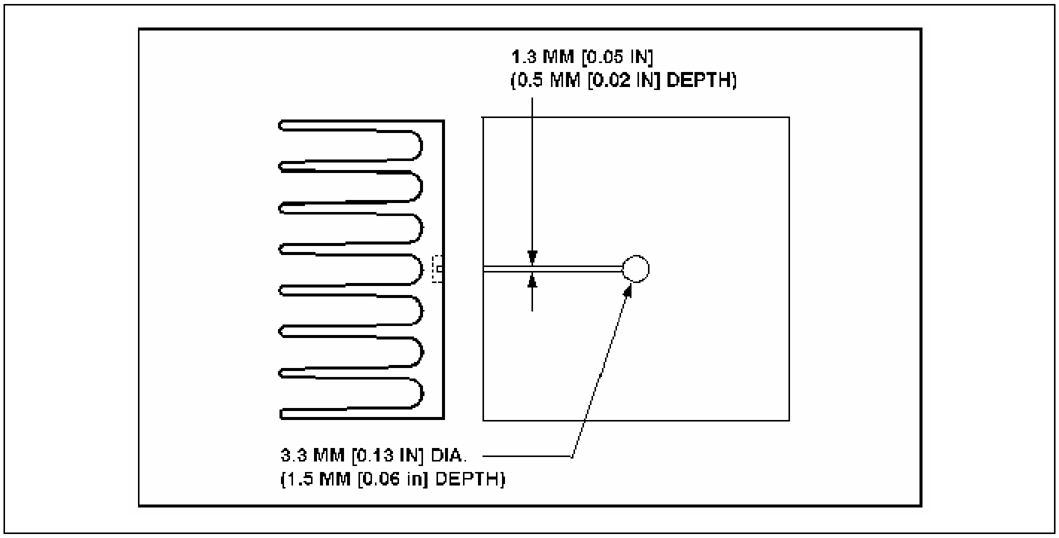


Figure 16 0° Angle Attach Heatsink Modifications (generic heatsink side and bottom view, not to scale)



System Thermal Test Procedures

- Install required software as described in "test preparation".
- Connect all peripheral components (HDD, ODD, memory, PSU, etc…) to complete the system setup.
- Attach all thermocouples as described in "thermo couple locations".
- Ensure all TCs are connected to data logging system.
- Power on system and run test application "DVD playback".
- Start records all temperature readings for 25–30minutes (assume steady state thermal equilibrium).
- Repeat above process with other test applications
  - PCMark
  - SysMark

6.1.2.2 Expected Success Criteria

The expected success criteria for system thermal testing are:

- Case temperatures, T_{CASE} equal to or below specifications
- Sub-component ambient temperatures equal to or below targets

6.1.3 Quality and Reliability

The quality and reliability testing will be done in the HW Platform Configuration described in this document. Sample size: 3 systems for each test.

6.1.4 Required by Regulations

System level regulatory testing includes EMC and Safety testing and certification by a certified Test Laboratory. In addition to EMC and Safety Testing, systems that are being shipped into the European Union and PRC must be RoHS compliant. The motherboard meets the RoHS requirements.

System Level RoHS compliance will be required as well which means that all the components that go into the system, power supply, hard drive, optical disk drive, cables, PCI card must all meet the RoHS requirements in order to certify that the system meets the RoHS requirements.

Board level EMI is done during Intel internal board validation which also includes in-chassis system EMI testing. Selected peripheral devices are added to chassis for EMI testing.

Contact Intel for detailed certification and compliance test results. In general, board satisfies the following:

- Product Safety Compliance
- UL60950 – CSA 60950(USA/Canada)
- EN60950 (Europe)
- IEC60950 (International)
- CB Certificate & Report, IEC60950 (report to include all country national deviations)
- CE - Low Voltage Directive 73/23/EEE (Europe)

The following is a list of EMC regulatory requirements for system level compliance. All components in the system should meet these requirements to ensure system level compliance.

- Product EMC Compliance – Class B Compliance
- FCC /ICES-003 - Emissions (USA/Canada)
- CISPR 22 – Emissions (International)
- EN55022 - Emissions (Europe)
- EN55024 - Immunity (Europe)
- CE – EMC Directive 89/336/EEC (Europe)
- VCCI Emissions (Japan)
- AS/NZS 3548 Emissions (Australia/New Zealand)
- BSMI CNS13438 Emissions (Taiwan)
- RRL MIC Notice No. 1997-41 (EMC) & 1997-42 (EMI) (Korea)

System being shipped into the European Union and PRC are required to meet the RoHS (Reduction of Hazardous Substances) Requirements.

- Product Ecology Requirements
  RoHS
  WEEE (for system shipped to or built in the EU)
- Certifications/ Registrations/ Declarations
- UL Certification (US/Canada)
- CB Certification (International)
- CE Declaration of Conformity (CENELEC Europe)
- FCC/ICES-003 Declaration of Conformity (USA/Canada)
- C-Tick Declaration of Conformity (Australia)
- MED Declaration of Conformity (New Zealand)
- BSMI Declaration (Taiwan)
- RRL Certification (Korea)
- Material Declaration Data Sheet (Europe)

6.1.5 Reliability Testing

System Level Reliability is performed to ensure system functionality after shipping to the end customer. System level testing is performed on a fully assembled system which includes the chassis, power supply, motherboard, hard disk drive, optical disk drive and PCI card if used.

6.1.5.1 System Level Shock

System Level Shock testing consists of repeated drops of the fully configured system on a shock table for a total of 12 drops, 2 on each side.

Pass Criteria:

- No Visible Damage, No Displacement of components, cables or hardware.
- No Chaffing of cables contacting metal edges.
- System must operate normally after shock testing.

Table 9 contains recommended shock parameters for system level shock testing.

Table 9 Shock Parameters

Direction	6 sides	Top, Bottom, Left, Right, Front, Rear
Number of Drops	12 drops	2 drops per side
Acceleration	25 G	Minimum faired acceleration

6.1.5.2 System Level Vibration

System level vibration testing consists of attaching the fully configured system the vibration table and applying vibration for 30minutes on each of the 3 axis X, Y and Z.

Pass Criteria:

- No Visible Damage, No Displacement of components, cables or hardware.
- No Chaffing of cables contacting metal edges.
- System must operate normally after vibration testing.

Table 10 contains recommended vibration parameters for system level vibration testing.

Table 10 Vibration Parameters

Duration	30 minutes / axis	3 Axis X, Y & Z
Frequency (HZ)	Slope (dB/Octave)	PSD (g2/Hz)
5–100	0	0.015
100–137	-6	
137–350	0	.008
350–500	-6	
500		0.0039

NOTES:

1. Frequency — denotes the vibration frequency of the table
2. Slope (dB/Octave) — The slope is the increased amplitude of the vibration as the frequency increases per Octave or the doubling of the frequency
3. PSD (g2/Hz) — PSD is the Power Spectral Density of the vibration and g2 is the acceleration / frequency in Hz. As the frequency goes up the Power Spectral Density or acceleration goes down.

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