Thin Mini-ITX Based PC System Design Guide

All In One, Tiny PC

December 2012

Revision 1.2

Contents

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Revision History

Revision Number	Description	Revision Date
1.2	• USB 3.0 added • eDP section added • General clarifications in Section 2	December 2012

1.1	• Minor updates to align with Compliance Requirements
	  • Section 2.2.1 LVDS
	  • Section 7.4 SATA
	  • Section 2.5 USB
	  • Section 2.6 Front Panel
	  • Section 2.7 Internal Power Input
	  • Section 3 Power Supply
		August 2012

1.0	• Initial release	April 2012

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1 Introduction

1.1 Purpose / Scope

This document outlines possible solutions to creating a system utilizing a Thin Mini-ITX motherboard, as specified in the *Mini-ITX Addendum To The microATX Motherboard Interface Specification Version 1.2*. It will focus on the electrical, mechanical and thermal interfaces between a Sandy Bridge/Ivy Bridge or Cedar Trail based Thin Mini-ITX motherboard, and its enclosure and peripherals

Compliance with the guidance outlined in this document enables chassis and Thin Mini-ITX motherboards that can be interchangeably used between systems. This increases the system design options using a building block approach, while mitigating the need for custom solutions.

Revision 1.2 of this document Design Guide includes changes that are intended to improve the interoperability and system integration experience based on the thin mini ITX motherboard standard. When designing a chassis based on this revision of the design guide, a chassis manufacturer should take into consideration whether to accommodate motherboards in production prior to this document revision. Motherboard designs based on revision 1.0 of this document are generally expected to be compatible with Chassis designs based on later revisions, however issues could include cable length mismatch due to tightening of the connector placement zones in revision 1.1. Refer to the *Channel AIO (Thin Mini-ITX Form Factor) – Compatibility Matrix* for Revision 1.0 based motherboards.

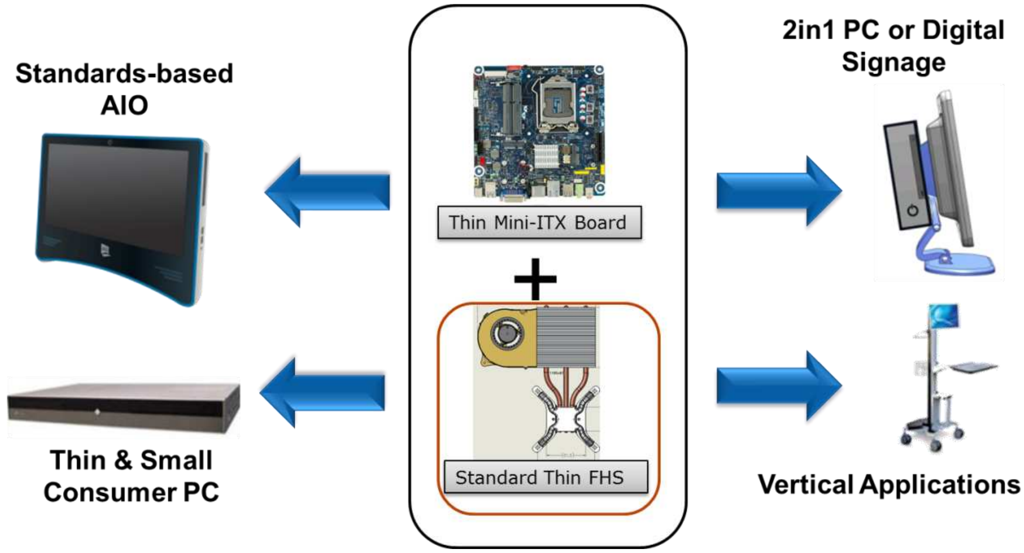
1.2 Overview

Thin Mini-ITX motherboards evolve the standard Mini-ITX form factor in to even smaller system designs. They are especially useful in segments that place a premium on small, slim chassis. Typical usages of such chassis are:

- All In One (AIO) PCs
- Stackable home theater PC to be size compatible with the standard width of AV components such as DVD players and receivers
- VESA mountable Thin PC
- Digital signage PC (Built inside or behind a TV or other display)

In this design guide, particular attention is given to slim, sub-4 liter Tiny PCs, and All In One PCs.

Figure 1-1. Thin Mini-ITX Applications



1.2.1 All In One PCs

The business model for AIO that works for system integrators is when they can buy inter-changeable components and design their own custom system configurations, just like the white box desktop business model.

For this business model to work the following building blocks will be sourced separately:

AIO Enclosure or Chassis Kit (includes flat panel display, AIO metal and plastics of the chassis, power adapter and thermal solution if custom)

Motherboard will ship with low profile IO shield, cables to power the HDD and ODD

Other standard components: CPU, Memory, HDD, ODD

All In One PCs which tightly integrate a flat panel display with PC components have traditionally been based on custom motherboard and chassis designs. Leveraging the common interfaces in this design guide enables a building block approach to AIO systems. Common design features on Thin Mini-ITX based AIO PCs can include the following:

Table 1-1. Common AIO Features in Thin Mini-ITX Based AIO PCs

Feature	Detailed Description – Guide assumption
18.5" or larger, 16:9, thin, low power flat panel	LED backlight, goal < 15mm thickness, LVDS
Thin Mini-ITX Motherboard	Motherboard compliant to the Thin Mini-ITX spec standards in the *Mini-ITX Addendum Version 2.0 To the microATX Motherboard Interface Specification Version 1.2*
Audio speakers	4 Ohm speakers capable of supporting 3W
Qty 1, ODD	Thin profile 5.25" ODD, SATA
3.5 or 2.5" SATA, SSD or HDD	Enclosure may support one or two HDD or SSD
Wireless LAN	Mini-PCIe half card
Bluetooth optional	Assume USB Bluetooth module – with antenna on module or support for discrete antenna
Walkup I/O ports	Options that may be designed in to the chassis include USB, microphone, headphone ports, and SD card reader. No specific configurations are defined in this guide.
Buttons / LEDs	On/off, Power on/off LED, Screen brightness switch

System may be supported by the main Thin Mini-ITX motherboard, daughter boards, and discrete devices.

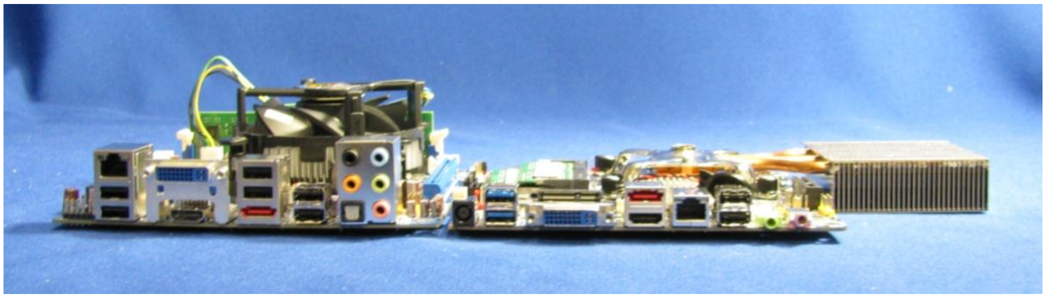
Daughter boards would be required to support walkup I/O, backlight inverter/driver, and front panel interface.

Discrete devices with direct cable attach could include the flat panel, HDD, ODD, camera, touchscreen, IR receiver, IR emitter, right/left speakers, digital microphone, CPU fan, and system fans.

1.2.2 Tiny PCs

The Mini-ITX form factor enabled chassis down to the 4 – 8 liter range. Standard chassis built around Thin Mini-ITX motherboards may shrink to below 4 liters, creating a "Tiny PC" category. Tiny PCs include slimmer designs that make especially good use of the lower height inherent to Thin Mini-ITX motherboards. Figure 1-2 shows a comparison between current mini-ITX vs. Thin Mini-ITX motherboard thickness characteristics.

Figure 1-2. Mini-ITX (left) vs Thin Mini-ITX (right)



1.3 Terminology

Table 1-2. Terms and Descriptions

Term	Description
AIO	All In One
FSC	Fan Speed Control
KIZ	Keep In Zone
KOZ	Keep Out Zone
SFF	8-19 liter chassis (IDC definition)
Tiny PC	Sub-4 liter chassis
Ultra SFF (uSFF)	4-8 liter chassis (IDC definition)

1.4 Reference Documents

Table 1-3. Reference Documents

Document	Document No./Location
Mini-ITX Addendum Version 2.0 To the microATX Motherboard Interface Specification Version 1.2	www.formfactors.org
ATX Specification Version 2.2	www.formfactors.org
Thermally Advantaged Small Chassis (TASC) Design Guide	www.formfactors.org
4-Wire Pulse Width Modulation (PWM) Controlled Fans Specification	www.formfactors.org
ECMA-74 - Measurement of Airborne Noise emitted by Information Technology and Telecommunications Equipment	www.ecma-international.org/publications/standards/Ecma-074.htm
2nd Generation Intel® Core™ Processor and LGA1155 Socket Thermal Mechanical Specifications and Design Guidelines (TMSDG)	324644
VESA eDP	www.displayport.org www.vesa.org
VESA standard mounting	www.vesa.org/Standards/summary/2006_2.htm
Standard Panel Working Group, Rev 3.5	www.spwg.org/specifications.htm
PC form factors web site	www.formfactors.org/developer/specs
Channel AIO (Thin Mini-ITX Form Factor) – Compatibility Matrix	www.intel.com/go/AIO
Wi-Fi Multi-Band Antenna Integration for Intel® Processor-based Desktops and All-in-One Systems	491058

Document numbers and locations are subject to revision and may change.

2 Thin Mini-ITX Internal Electrical Interfaces

2.1 Common Connector List

A high level goal of this document is to enable interchangeability of chassis with motherboards from different suppliers. A common set of minimum interface connectors between the motherboard and chassis is required to achieve a true building block model for system integrators. The below table outlines these standardized connectors.

Table 2-1. Internal Motherboard Connectors

Internal Connectors
LVDS
Flat Panel Display Brightness
Front Panel Audio
Internal Stereo Speakers
Digital Microphone (Optional)
SATA
Internal USB
Front Flat Panel
Fans
Consumer Infrared Receiver (Optional)

It is expected that a group of motherboard connectors will exit the system via the Thin Mini-ITX I/O aperture per industry standards. An example set of external I/O that could be found on a Thin Mini-ITX motherboard is:

- DC Input
- USB 2.0
- USB 3.0
- RJ-45 LAN
- HDMI (in/out)
- eSATA

- DVI-I
- Audio (A/D Line In/Out)

All connector types referenced with a specific manufacturer and model may be substituted with equivalent, compatible designs. No use of a specific manufacturer is implied.

Refer to Chapter 5 for recommended internal motherboard header locations and size considerations.

2.2 Flat Panel Display

Depending on flat panel size, display resolutions, and cost, the flat panel interface connectivity will vary. For most typical panel resolutions up to and including 1920x1200 a connector that supports the best flat panel performance for LVDS is defined. The LVDS Flat Panel must be designed for operation at 5V. The system integrator can then use cabling to adapt the motherboard to any flat panel from basic single-channel LVDS to dual-channel LVDS at up to 24bpp. The Thin Mini-ITX board supports the internal display connectors outlined in the section. The display signal cables must ship as part of the chassis kit.

For flat panel resolutions greater than 1920x1200, eDP is defined. eDP is not a required interface as of this document revision, however shall the board vendor wish to provide eDP support as a value-add it must be implemented per the requirements listed in Section 2.2.2. Please consult with Intel for implementation guidance.

Note that supported graphics resolutions vary between Sandy Bridge/Ivy Bridge, and Cedar Trail SKUs. Consult the latest processor specifications for supported resolutions.

2.2.1 LVDS

An internal 40-pin connector for flat panel display and backlight connectivity is required. Design must support up to the maximum resolution and color depth allowed by the graphics processor.

40-pin LVDS connector: 1x40, 1A rating per pin, white (reference part number: ACES* 88341-40 or equivalent)

Mating plug reference part numbers: (ACES 88441-40, Starconn* 107F40, or equivalent)

Figure 2-1. 40-pin LVDS Header

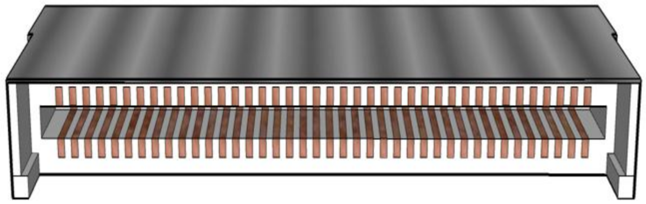


Table 2-2. 40-pin LVDS Header Pin-Out

Pin	Signal Name	Pin	Signal
1	ODD_Lane3_P	21	N/C
2	ODD_Lane3_N	22	EDID_3.3V
3	ODD_Lane2_P	23	LCD_GND
4	ODD_Lane2_N	24	LCD_GND
5	ODD_Lane1_P	25	LCD_GND
6	ODD_Lane1_N	26	ODD_CLK_P
7	ODD_Lane0_P	27	ODD_CLK_N
8	ODD_Lane0_N	28	BKLT_GND
9	EVEN_Lane3_P	29	BKLT_GND
10	EVEN_Lane3_N	30	BKLT_GND
11	EVEN_Lane2_P	31	EDID_CLK
12	EVEN_Lane2_N	32	BKLT_ENABLE
13	EVEN_Lane1_P	33	BKLT_PWM_DIM
14	EVEN_Lane1_N	34	EVEN_CLK_P
15	EVEN_Lane0_P	35	EVEN_CLK_N
16	EVEN_Lane0_N	36	BKLT_PWR
17	EDID_GND	37	BKLT_PWR
18	LCD_VCC	38	BKLT_PWR
19	LCD_VCC	39	N/C

Pin	Signal Name	Pin	Signal
20	LCD_VCC	40	EDID_DATA

Note: Motherboard Requirements for Flat Panel Display:

Flat panel display support must be implemented using the defined LVDS interface for screen resolutions up to and including 1920x1200.

LVDS implementation must support single-channel and dual-channel interface widths, 18-bpp and 24-bpp color depths, VESA and JEIDA color mappings, and configurable display timings. Board must have a mechanism for choosing between such settings and furthermore apply different EDID (or at a minimum, 18-byte DTD) panel-specific timings to accommodate diverse panel selection from all chassis vendors.

Motherboard must provide mechanism for adjusting inverter/driver board settings, namely: maximum PWM, minimum PWM, frequency and polarity. Intel will maintain a list of panel and inverter/driver board specifications as registered by chassis vendors (to be available separately).

Motherboard must also provide 5V power to flat panel display and 19V power to inverter/driver board, each at up to 3A current rating.

AiO Chassis Requirements for Flat Panel Display:

Flat panel displays with a screen resolution up to (and including) 1920x1200 must be LVDS-based. Chassis vendor is responsible for providing panel-specific datasheet, panel-specific timing information (128-byte EDID data, or at a minimum 18-byte DTD structure) and inverter/driver board datasheet to Intel as early as possible for Intel to confirm (and if necessary, disseminate across board vendors) the necessary display support.

Flat panel display must operate at 5V input voltage. Please also consult with Intel shall the panel input voltage requirement be different than 5V (for market assessment purposes only).

Inverter/driver board must operate at 19V input voltage and be matched to the target panel backlight unit (BLU) specifications so that:

- maximum inverter/driver board current output (when driven at 100% PWM) does not exceed the BLU's current input tolerance,
- and minimum inverter/driver board current output remains within the BLU's specification while still producing a legible screen output.

Failure to ensure matching inverter/driver board-to-panel specifications may result in shortened display life, hardware failure and/or customer dissatisfaction.

2.2.2 eDP (VESA Embedded Display Port™)

For flat panel resolutions greater than 1920x1200, eDP is defined in this section. eDP is not a required interface as of this document revision, however shall the board vendor wish to provide eDP support as a value-add it must be implemented per the requirements listed below. Please consult with Intel for further implementation guidance.

An internal 40-pin eDP panel and backlight connector for four-lane, 2.7Gbps and 1.62Gbps eDP flat panel display support is optional. The design must support up to maximum resolution and color depth allowed by the graphics processor. The design must be Embedded Display Port™ (eDP) v1.1a compliant and support hot-plug detect as well as Direct Drive Monitor (DDM, to allow use of large/AIO panels)

The 40-pin eDP connector must be vertical, single-row shrouded colored black, as shown in the below figure. Connector must support four lanes of eDP traffic, AUX channel, panel logic power as well as backlight power and control signals, compliant with the VESA Embedded Display Port™ (eDP) Standard for 40-pin eDP pin assignment, as defined in the below table.

40-pin eDP connector: 1x40, 1A rating per pin, black (reference part number: ACES 50203-040)

Mating plug reference part number: ACES 88441-40

Figure 2-2. 40-pin eDP MB Header

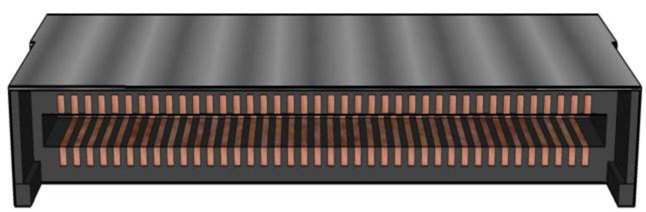


Table 2-3. 40-pin eDP Header Pin-Out

Pin	Signal Name	Pin	Signal
1	NC_Reserved	21	LCD_VCC (3.3V/5V/12V)
2	High-speed_GND	22	LCD_Self_Test-or-NC
3	Lane3_N (DDPD_[3]N)	23	LCD_GND
4	Lane3_P (DDPD_[3]P)	24	LCD_GND
5	High-speed_GND	25	LCD_GND
6	Lane2_N (DDPD_[2]N)	26	LCD_GND
7	Lane2_P (DDPD_[2]P)	27	HPD (DDPD_HPD)
8	High-speed_GND	28	BKLT_GND
9	Lane1_N (DDPD_[1]N)	29	BKLT_GND
10	Lane1_P (DDPD_[1]P)	30	BKLT_GND
11	High-speed_GND	31	BKLT_GND
12	Lane0_N (DDPD_[0]N)	32	BKLT_ENABLE
13	Lane0_P (DDPD_[0]P)	33	BKLT_PWM_DIM
14	High-speed_GND	34	NC_Reserved
15	AUX_CH_P (DDPD_AUXP)	35	NC_Reserved
16	AUX_CH_N (DDPD_AUXN)	36	BKLT_PWR (12V/19V)
17	High-speed_GND	37	BKLT_PWR (12V/19V)
18	LCD_VCC (3.3V/5V/12V)	38	BKLT_PWR (12V/19V)
19	LCD_VCC (3.3V/5V/12V)	39	BKLT_PWR (12V/19V)
20	LCD_VCC (3.3V/5V/12V)	40	NC_Reserved

2.2.3 Flat Panel Display Brightness

The motherboard must provide an additional connector for powering the inverter or driver board. An 8-pin FPD_Brightness connector must be 1x8 shrouded, 2.00mm pitch with 2A rating per pin as shown in the below figure. The connector must also provide backlight enable and control signals, as well as input pins for brightness up/down front panel button control signals. The 8-pin FPD Brightness connector must be validated to support maximum power delivery at 19 Volts, as well as to correctly support backlight enable/control and brightness up/down signals.

- An assortment of LVDS flat panels with CCFL and LED backlights should be used for validating backlight power and control features.
- Backlight brightness must be dynamically controlled via discrete flat panel brightness buttons.

Figure 2-3. PC & Software Brightness Control:

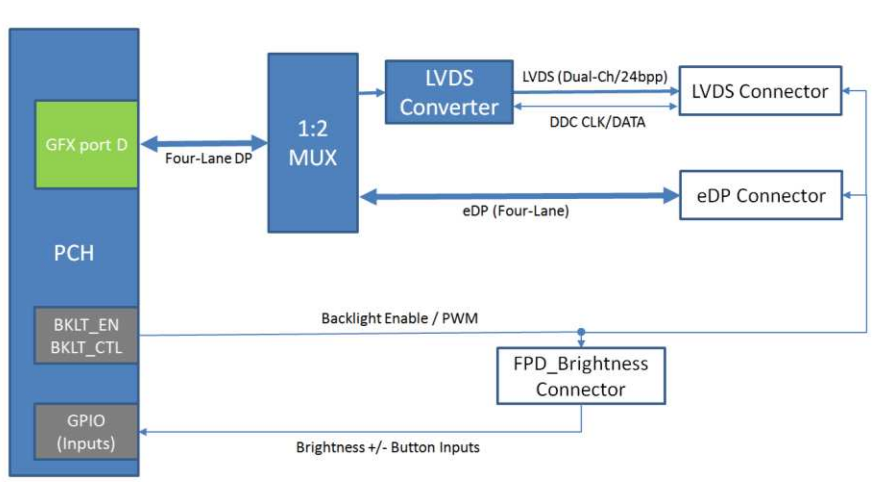


Figure 2-4. FPD Brightness Header

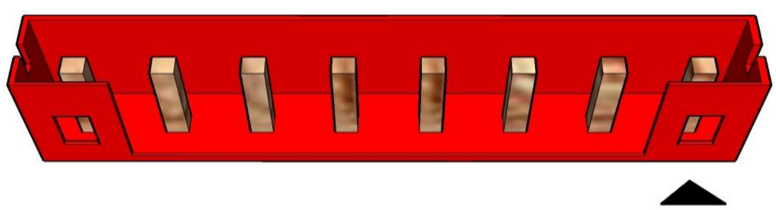


Table 2-4. 8-pin FPD Brightness Header Pin-Out

Pin	Signal Name	Description
1	BKLT_EN	Backlight enable
2	BKLT_PWM	Backlight control
3	BKLT_PWR	Backlight inverter power

Pin	Signal Name	Description
4	BKLT_PWR	Backlight inverter power
5	BKLT_GND/Brightness_GND	Ground (shared)
6	BKLT_GND/Brightness_GND	Ground (shared)
7	Brightness_Up	Flat panel brightness increase
8	Brightness_Down	Flat panel brightness decrease

2.2.4 On Screen Display (OSD)

Windows provides built-in support for controlling as well as tracking the display brightness level within its Power Options control panel. The motherboard BIOS must be designed to have such control panel control as well as the ability to reflect the brightness status of the display. It is recommended that an OSD status utility be available by the motherboard vendor so that a status bar may be shown whenever the brightness increase/decrease buttons are pressed.

2.3 Audio

2.3.1 Front Panel Audio

Front panel audio header: 2x5, 2.54mm pitch, keyed at pin 8

Figure 2-5. Front Panel Audio Header

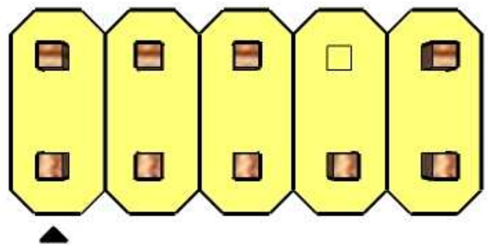


Table 2-5. Passive AC'97 Front Panel Audio Header Pin-Out

Pin	Signal Name	Description
1	MIC	Front panel microphone input signal (biased when supporting stereo microphone)
2	AUD_GND	Ground used by analog audio circuits
3	MIC_BIAS	Microphone power / additional MIC input for stereo microphone support
4	PRESENCE#	Active low signal that signals BIOS that an Intel® HD Audio dongle is connected to the analog header. PRESENCE# = 0 when an Intel® HD Audio dongle is connected.
5	FP_OUT_R	Right channel audio signal to front panel (headphone drive capable)
6	AUD_GND	Ground used by analog audio circuits
7	RESERVED	Reserved
8	KEY	No pin
9	FP_OUT_L	Left channel audio signal to front panel (headphone drive capable)
10	AUD_GND	Ground used by analog audio circuits

Table 2-6. HD Audio Front Panel Audio Header Pin-Out

Pin	Signal Name	Description
1	PORT 1L	Analog Port 1 - Left channel (Microphone)

Pin	Signal Name	Description
2	GND	Ground
3	PORT 1R	Analog Port 1 - Right channel (Microphone)
4	PRESENCE#	Active low signal that signals BIOS that an Intel® HD Audio dongle is connected to the analog header. PRESENCE# = 0 when an Intel® HD Audio dongle is connected.
5	PORT 2R	Analog Port 2 - Right channel (Headphone)
6	SENSE1 RETURN	Jack detection return for front panel (JACK1)
7	SENSE SEND	Jack detection sense line from the Intel® HD Audio CODEC jack detection resistor network
8	KEY	No pin
9	PORT 2L	Analog Port 2 - Left channel (Headphone)
10	SENSE2 RETURN	Jack detection return for front panel (JACK2)

2.3.2 Internal Stereo Speakers

The R/L (4 ohm) speakers must support 3W and be connected to a R/L audio header on the motherboard. If subwoofer support is required, then the low pass filtering and amplification would be with the amp speaker.

Internal stereo speakers header: 1x4, 2.00mm pitch (part number reference: JS*-1125-04, or equivalent)

Mating plug reference part number: JWT* A2001H02-4P, or equivalent

Figure 2-6. Internal Stereo Speakers Header

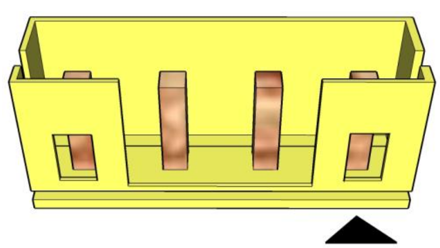


Table 2-7. Internal Stereo Speakers Header Pin-Out

Pin	Signal Name	Description
1	Front_L-	Analog front left (differential negative)
2	Front_L+	Analog front left (differential positive)
3	Front_R+	Analog front right (differential positive)
4	Front_R-	Analog front right (differential negative)

2.3.3 Digital Microphone

A digital microphone (DMIC) can be supported through the below pinout and header.

DMIC MB Header: 1x5, 2.54mm pitch, keyed at pin 5. The header and the mating DMIC cable connector shall be yellow.

Figure 2-7. DMIC MB Header

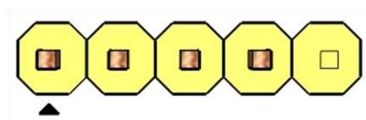


Table 2-8. DMIC Header Pin-Out

Pin	Signal Name
1	+3.3V
2	DMIC_DATA
3	GND
4	DMIC_CLK
5	Key (no pin)

2.4 SATA

To support maximum flexibility in the system features it is recommended that the connectivity between storage devices and motherboard is via SATA data/power cables and not via direct drive to motherboard connections. The motherboard will be responsible to provide industry standard 7 pin data and 15 pin male power connections. It is up to the chassis vendor to define the feature set and decide if they want to support 3.5" and/or 2.5" drives and to provide the appropriate power connection and quantity to support both HDDs and ODD. The motherboard must support at least 0.5A from +12V rail, 1.25A from +5V rail, and 0.25A from +3.3V rail, per SATA data port (i.e. twice as much for a 2-port board), all of which must be provided from the board's DC-to-DC circuit and accounted for in the board's total power budget.

2.5 Internal USB

Typical internal USB devices are webcam, card reader, touch panel, etc. Single and dual USB headers are defined below.

USB 2.0 headers and mating cable connectors shall be black.

2.5.1 Front Panel Dual USB 2.0 Header

Front panel dual USB 2.0 header shall be 2x5, 2.54mm pitch, keyed at pin 9.

Figure 2-8. 2x5 USB 2.0 Header (Keyed at Pin 9)

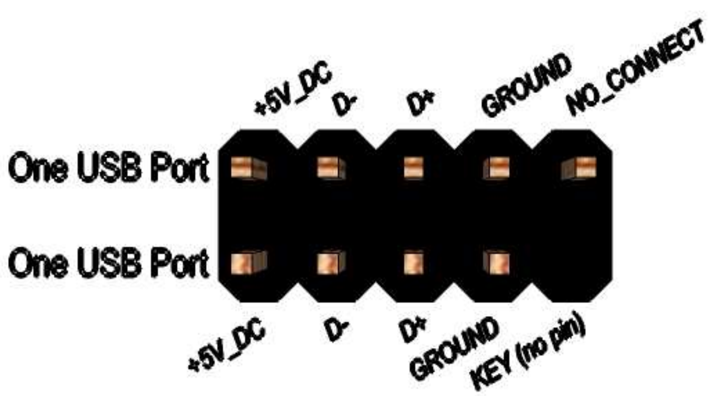


Table 2-9. 2x5 USB 2.0 Header (Keyed at Pin 9) Pin-Out

Pin	Signal	Pin	Signal
1	+5V DC	2	+5V DC
3	Data (negative)	4	Data (negative)
5	Data (positive)	6	Data (positive)

Pin	Signal	Pin	Signal
7	Ground	8	Ground
9	Key (no pin)	10	No Connect

2.5.2 Internal Dual USB 2.0 Header

Internal dual USB 2.0 header shall be 2x5, 2.54mm pitch, keyed at pins 9 and 10.

Figure 2-9. 2x5 USB 2.0 Header (Keyed at Pins 9 and 10)

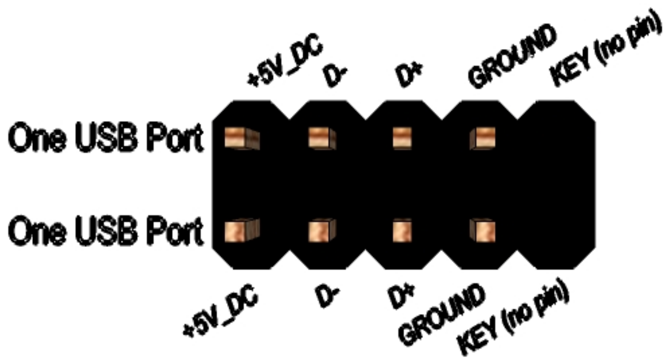


Table 2-10. 2x5 USB 2.0 Header (Keyed at Pins 9 and 10) Pin-Out

Pin	Signal	Pin	Signal
1	+5V DC	2	+5V DC
3	Data (negative)	4	Data (negative)
5	Data (positive)	6	Data (positive)
7	Ground	8	Ground
9	Key (no pin)	10	Key (no pin)

2.5.3 Internal Single USB 2.0 Header

Internal single USB header shall be 1x5, 2.54mm pitch, keyed at pin 5.

Figure 2-10. 1x5 USB 2.0 Header

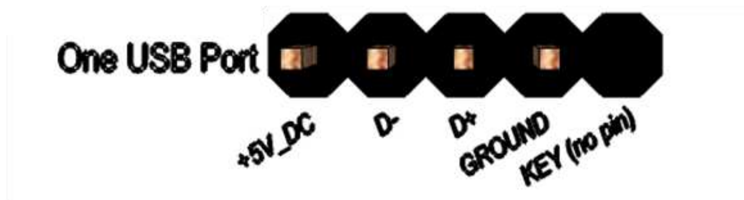


Table 2-11. 1x5 USB 2.0 Header Pin-Out

Pin	Signal
1	+5V DC
2	Data (negative)
3	Data (positive)
4	Ground
5	Key (no pin)

2.5.4 Internal USB 3.0 Header

Internal USB 3.0 header shall be 2x10, 2.54mm pitch, keyed at pin 20. Color should be Pantone 300 blue.

Figure 2-11. 2x10 USB 3.0 Header

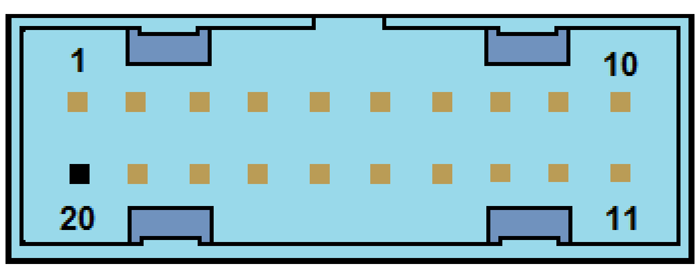


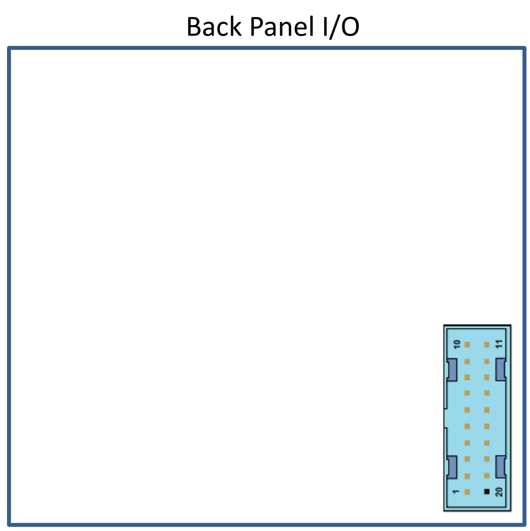
Table 2-12. 2x10 USB 3.0 Header Pin-Out

Pin	Signal	Description
1	Vbus	Power
2	IntA_P1_SSRX-	USB3 ICC Port1 SuperSpeed Rx-
3	IntA_P1_SSRX+	USB3 ICC Port1 SuperSpeed Rx+
4	GND	Ground
5	IntA_P1_SSTX-	USB3 ICC Port1 SuperSpeed Tx-
6	IntA_P1_SSTX+	USB3 ICC Port1 SuperSpeed Tx+
7	GND	Ground
8	IntA_P1_D-	USB3 ICC Port1 D- (USB2 Signal D-)
9	IntA_P1_D+	USB3 ICC Port1 D- (USB2 Signal D+)
10	ID	Over Current Protection
11	IntA_P2_D+	USB3 ICC Port2 D+ (USB2 Signal D+)
12	IntA_P2_D-	USB3 ICC Port2 D- (USB2 Signal D-)
13	GND	Ground
14	IntA_P2_SSTX+	USB3 ICC Port2 SuperSpeed Tx+
15	IntA_P2_SSTX-	USB3 ICC Port2 SuperSpeed Tx-
16	GND	Ground
17	IntA_P2_SSRX+	USB3 ICC Port2 SuperSpeed Rx+
18	IntA_P2_SSRX-	USB3 ICC Port2 SuperSpeed Rx-
19	Vbus	Power
20	Key	Not Connected

2.5.4.1 Internal USB 3.0 Header Orientation

Typical internal USB 3.0 cable connectors exceed the 20mm Thin Mini-ITX component height limitation. In order to facilitate a common design of lower profile right angle connectors suitable for AIO applications, the orientation of the internal USB 3.0 header must be standardized. In addition to the zone location requirement specified in Section 5.2, the orientation of internal USB 3.0 connectors must be as indicated in Figure 2-12 below.

Figure 2-12. USB 3.0 Header Orientation



2.6 Front Panel (Buttons, LEDs)

Front panel features (excluding panel brightness) are supported via a standard desktop board style header, as shown in the following figure, direct to switches and LEDs as appropriate. For an AIO system, it is expected that the front panel supports a very basic set of functions easily accessible to the user to turn the system on/off, provide visibility to an LED that indicates power state, and provide visibility to an LED that indicates storage activity. Through the separate motherboard header, the system front panel must also provide a control to be used for adjusting panel brightness (as detailed in section 2.2.2

Figure 2-13. Front Panel Main Header

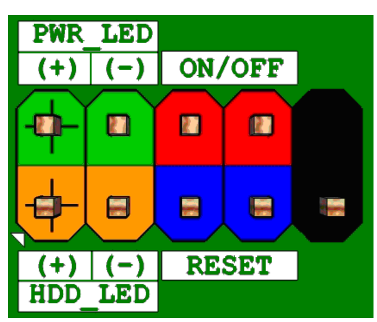


Table 2-13. Front Panel Main Header Pin-Out

Pin	Signal Name	Description
1	HDD_POWER_LED	Pull-up resistor to +5V
2	POWER_LED_MAIN	[Out] Front panel LED (main color)
3	HDD_LED#	[Out] Hard disk activity LED
4	POWER_LED_ALT	[Out] Front panel LED (alt color)
5	GROUND	Ground
6	POWER_SWITCH#	[In] Power switch
7	RESET_SWITCH#	[In] Reset switch
8	GROUND	Ground
9	+5V_DC	Power
10	KEY	No pin

2.7 Internal Power Input

19V internal power input connector: 1x2 shrouded with latch, 9[A] minimum current rating (part number reference: Molex* 5566-2, or equivalent)

Mating plug reference part number: Molex 5557-02R, or equivalent

See chapter 4 for additional information on power.

Figure 2-14. Internal Power Header

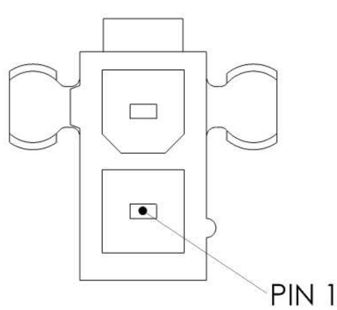


Table 2-14. Internal Power Header Pin-Out

Pin	Signal
1	Ground
2	Vin: +19V DC

2.8 Fans

Chassis that have only one fan must have the fan plugged into the CPU specific header on the motherboard. For systems that have two fans, the CPU cooling fan is to be plugged into the CPU fan header, and the second fan is to be plugged into the system fan header.

Motherboards should support both CPU and System fan headers so they may be used in systems that require two blowers/fans. Atom based boards only need to support a single fan header.

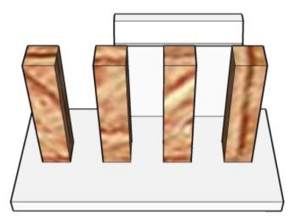
4-pin/wire fans and headers shall follow the *4-Wire Pulse Width Modulation (PWM) Controlled Fans Specification*.

2.8.1 CPU Fan

Boards must implement a 4-pin fan header for a CPU heatsink 4-wire fan. CPU fan header must be colored white.

CPU fan header: 2A continuous current draw

Figure 2-15. 4-Pin CPU Fan Header



2.8.2 System Fan

A PWM controlled, 4-pin/wire system fan design must be implemented on boards/chassis used in All-In-One PC’s. Tiny PC’s are to implement a 3-pin/wire system fan design that is linearly/voltage controlled. In either situation, the system fan header on the motherboard and the mating connector of the fan must be a color other than white to separate it from the CPU fan header.

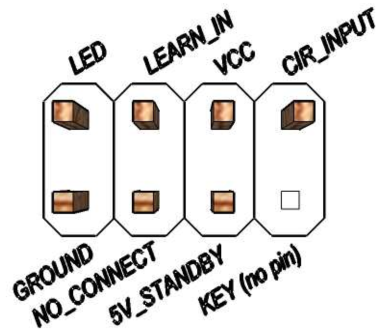
The motherboard ODM is responsible for providing a mechanism to enable the end user to specify the applicable implementation. The motherboard design must default to a 3-pin/wire implementation

System fan header: 1.5A continuous current draw

2.9 Consumer Infrared Receiver

A consumer IR receiver is optional. Port header: 2x4, 2.54mm pitch, keyed at pin 7

Figure 2-16. CIR Receiver Header



2.10 Wireless Bluetooth

If Bluetooth is desired, the motherboard could support a USB Bluetooth module, or Bluetooth could be supported with a mini PCIe module that also supports Wi-Fi. If a discrete module is used then it is preferred that the module be implemented via a USB cable to an internal motherboard USB header, so the Bluetooth module can be placed in an appropriate position in the system.

2.11 Monitor Switch

The motherboard must provide a "Monitor Switch" header for connectivity of a chassis button that would turn off the flat panel display's backlight unit. Additional desirable/optional functions for this header may be simultaneously muting built-in speaker audio, switching to alternate video inputs (if available), or other related functionality.

Connector must be 1x2 railed, 2.54mm pitch and colored white.

Figure 2-17. Monitor Switch Header

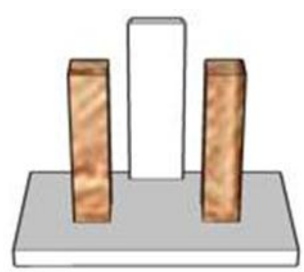


Table 2-15. Monitor Switch Header Pin-Out

Pin	Signal	Description
1	MON_SW	Monitor Switch Signal
2	Vin: +19V DC	Ground

For boards where the requirement is to simply turn the display off/on, a suggested implementation is as follows:

- MON_SW# input signal connects to PCH GPIO3 (pulled-up to +VCC3)
- when the monitor switch button is pressed, PCH receives edge-trigger from MON_SW# input. The system BIOS toggles the state of BKLT_OFF# upon this event.
- BKLT_OFF# output signal is driven out of PCH GPIO6 (pulled-up to +VCC3). This signal wired to gate the BKLT_EN signal from enabling/disabling the inverter/driver board.

Therefore, when the monitor switch button is momentarily pressed, MON_SW# sends a signal to the BIOS which causes the BKLT_OFF# signal to toggle states (default is BKLT_OFF# inactive, for backlight on). BKLT_OFF# output consequently allows the panel's backlight unit to be switched off/on.

3 Power Supply

3.1 External AC Adapter

An external AC adapter is envisioned for operation of a Thin Mini-ITX based AIO system. The output of the adapter is dependent on the overall power of the system as determined from the desired feature set. The external AC adapter output will vary from approximately 100W to an Atom based system to over 200W for a 65W feature rich system design.

AIO systems utilizing 35W, 45W and 65W Sandy Bridge/Ivy Bridge processors would likely use AC adapters with power rating ranging from 120W to 150W, depending on system-level power budget. Cedar Trail based systems would likely use 90W to 120W AC adapters, depending on system-level power budget. AC adapters for SFF chassis that do not use internal flat panel displays may be 20-30W lower in power output.

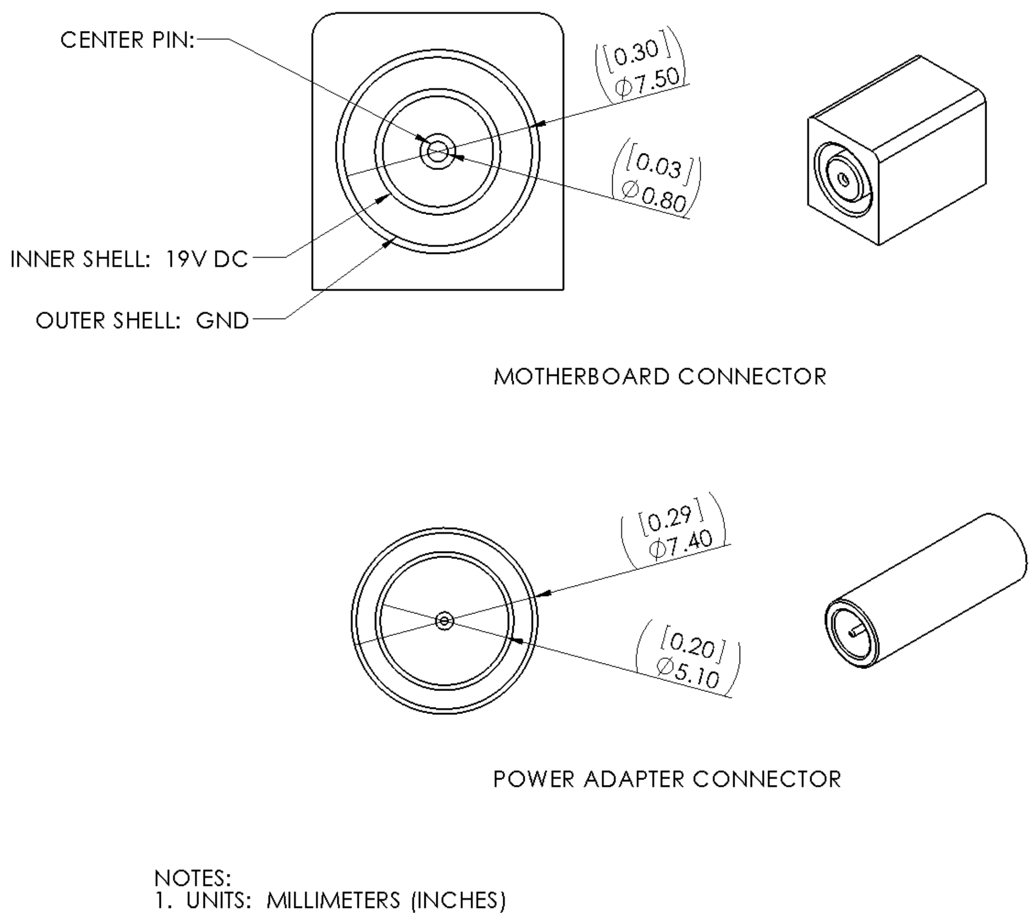
3.2 External Power Connector for Socketed CPU Based Systems

The below image shows reference dimensions for the recommended external 19V DC power connector type to be used for socketed CPU based, as well as Atom CPU based, Thin Mini-ITX systems developed to this Design Guide. Aligning on this connector type helps simplify component sourcing and selection for integrators.

PS_ID (Power Supply ID) is not supported as a feature on the center pin of the motherboard header and power adapter connector. If the center pin of the motherboard header has a trace routed to it, then ESD (electrostatic discharge) protection must be included on it.

Recommended power jack type: Singatron 2DC1003-000211F (or equivalent)*

Figure 3-1. External Power Connector for Socketed CPU Based Systems



4 Thermals & Acoustics

4.1 General Thermal-Acoustics Considerations

A thermal designer must choose inlet and outlet venting locations, CPU thermal solution installation location and orientation, and system fan location and orientation to provide adequately cool air to critical system components. The primary components for consideration are the CPU, voltage regulator components, SO-DIMM memory and the PCH. An enclosure that is much thinner than traditional Mini-ITX chassis poses an increased challenge for SO-DIMM and voltage regulator cooling.

It is essential for these low profile chassis that abundant inlet and exhaust venting is provided to help reduce heat buildup in the system. Thicker blowers push more airflow at a given rotational speed, but it is important to be aware that placing an airflow obstruction too close to the blower inlet plane can significantly reduce airflow and cause the fan noise to increase dramatically.

CPU utilization is lower than TDP (Thermal Design Power) levels when system dynamic memory utilization is highest. Because the CPU fan speed would not be expected to be at its maximum value under these conditions, the inlet vents and system fan (if present) should be positioned to ensure adequate inlet air is drawn through the chassis to cool the memory SO-DIMMs at the lower blower speeds. The chassis designer may want to provide features on the chassis side panel to mitigate vent blocking if the system should be placed against a wall, desk or other obstruction. A motherboard that has an air temperature sensor in the region of the memory that is linked to the motherboard’s fan speed control system will help to reduce the risk of memory components becoming excessively hot during low CPU utilization conditions. Additionally, a low CPU fan speed caused by low CPU thermal power dissipation does not imply that the voltage regulator is also operating at a low temperature. Therefore, the CPU fan or system fan should be placed with any required ductwork in a location and direction to ensure the CPU power voltage regulators are supplied moving air during low CPU utilization conditions.

General Recommendations

- Use a system blower with a width greater than 70mm to ensure good airflow coverage across the voltage regulator region around the CPU socket.
- Implement an inlet vent design whose flow area is greater than the total inlet area to the blower.
- Verify the mechanical attach design for both blowers does not induce mechanical vibration resonance (leading to increased acoustic noise) throughout the entire RPM range of the blowers.
- Maximize overall system venting area.
- Position intake and exit vent areas immediately upstream/downstream of the CPU heatsink appropriately to reduce the occurrence of recirculation of hot exhaust air back into the system.

4.1.1 Blowers

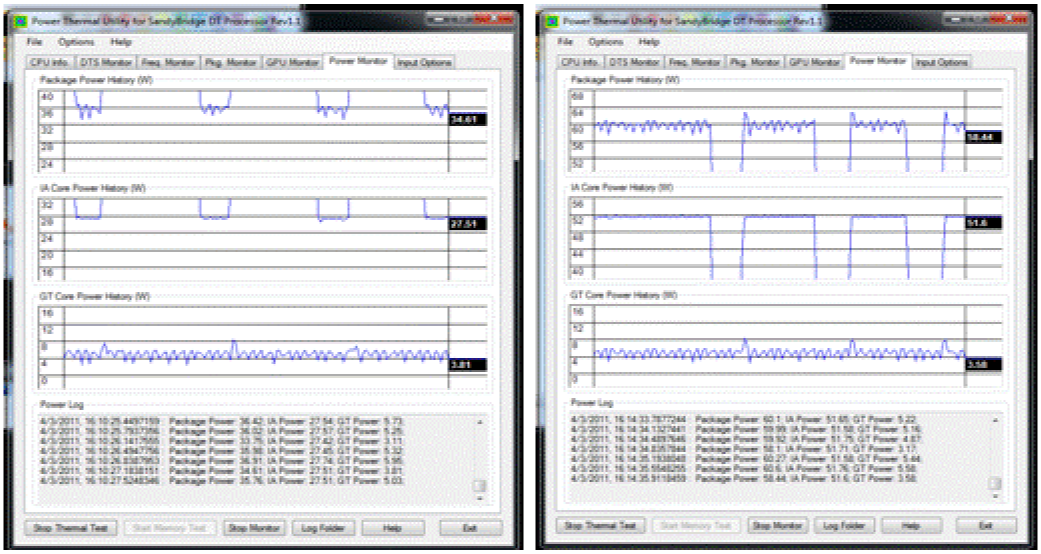
- When using a 4-wire system blower (one that is PWM controlled), use a blower that defaults to maximum speed when no PWM signal is supplied to the blower; for example, when the blower is plugged into the system fan header on the motherboard
- A blower that has both top and bottom side inlets can be leveraged to pull air underneath the motherboard to enhance voltage regulator cooling. Alternatively, the bottom side air inlet could be coupled to a hole in the chassis pan to pull air through the gap between the flat panel display and the chassis component mounting pan to help cool the flat panel display.
- Maximize the flow cross sectional area to the heat exchanger to minimize pressure drop through the heat exchanger, and to minimize internal air temperature rise at the blower exit.
- Larger diameter blowers are more efficient at moving air than smaller diameter blowers.
- Larger diameter blowers tend to spin at lower RPM than smaller diameter blowers. The lower rotation speed results in better sound quality; i.e. lower tonality level.

4.1.2 Fan Speed Control and CPU Throttling

A system integrator should choose a motherboard that provides CPU and System fan speed control that responds to CPU and PCH and motherboard temperature. It is important to understand that there are two mechanisms that can cause CPU throttling. The voltage regulator can have a temperature sensor circuit that is present to detect whether the voltage regulator is operating above its intended maximum temperature limits. The Intel microprocessor is designed to receive a signal from the voltage regulator (VR_HOT#) that will cause the CPU to start reducing its operating frequency to reduce the power output of the voltage regulator in order to reduce the thermal heat dissipation occurring in the voltage regulator. This type of throttling will not be obvious when looking at DTS values of the CPU die. It will be evident when looking at the current processor operating frequency or CPU operating power consumption. The second, and more commonly known, source of CPU throttling is when the CPU die itself exceeds its intended maximum temperature limit. In this case, the DTS values will reach -1 resulting in induced CPU throttling.

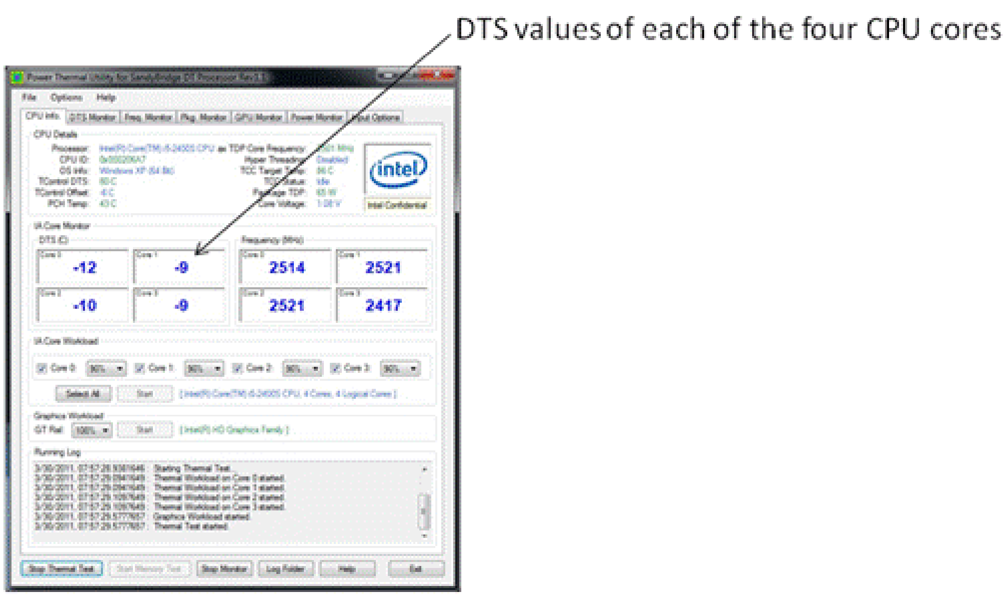
The following figure shows an example of voltage regulator induced throttling. It is evident when looking at the CPU power consumption plot over time. In this example, the voltage regulator is causing its power output to no longer be a constant value of 59W, but to follow a continuous square wave. The power output is cycling between 59W and 35W.

Figure 4-1. Example of Voltage Regulator Induced Throttling



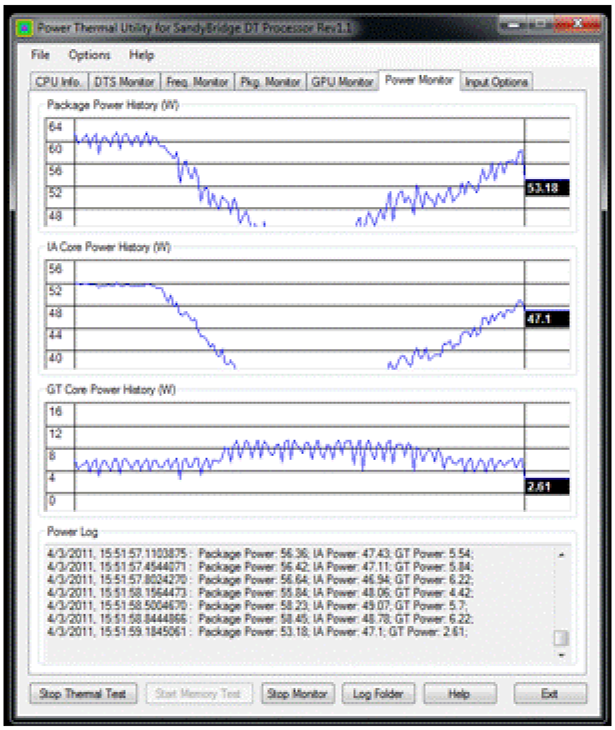
Some voltage regulator designs will bypass a square wave output and will drop the power down to a constant level, such as 35W. In either case, the CPU DTS values will not be near the die's maximum temperature of DTS = -1. This is because the CPU die is not the component that is over temp.

Figure 4-2. Example of a Typical CPU DTS Readout When Not Throttling



When the CPU die itself reaches its maximum allowable temperature to meet reliability requirements the CPU will throttle. Under these conditions the CPU power consumption will be gradually lowered until the temperature reaches acceptable levels. The following figure is an example where the CPU power consumption is gradually reduced and then subsequently increased by adjusting the CPU fan speed. This is the more commonly known CPU throttling behavior.

Figure 4-3. CPU Die Temperature Induced Throttling



Motherboard ODM General Design Recommendations

- Place a motherboard temperature sensor in the vicinity to the VR temperature limit sensor. Set the temperature limit to an appropriate value close to the VR limit to minimize system fan speed.
- Link the system fan to also primarily respond to SO-DIMM temperature. (This also provides an indirect way to react to PCH air temperature.)
- Link the CPU fan to the CPU temperature.
- Design the voltage regulator for zero or minimal air flow.
- Maximize copper flooding in the voltage regulator region to spread out the heat load as much as possible

4.1.3 Vent Free Area Ratio

Free area ratio (FAR) is defined as the total vent open area, divided by the vent area. It is recommended that this vent have an effective open area of at least 53%. This will maximize the effectiveness of the vent and should still contain EMI effectively. Higher FAR's will improve airflow into the chassis but are at the expense of aesthetics, safety, and increased EMI emissions. Lower open area percentages will degrade thermal performance but may still be effective depending on the entire system design. These are design choices the chassis designer must understand.

4.1.4 Dust Considerations

Depending on the geographic region the system is used in, dust accumulation can pose a challenge as it can block fan inlets and degrade heat sink performance. For these concerns, removable screens that may be cleaned by the user are the simplest option. While there is associated air flow impedance by adding a screen, it is generally the best option for dust prevention.

4.2 Environmental and Skin Temperature Limit Recommendations

The table below summarizes the recommended environmental and skin temperature limits that should be assumed for system design.

Table 4-1. Environmental and Skin Temperature Limit Recommendations

Condition	Value
Maximum operating room temperature outside the system	35°C
High touch surface temperature limit	45°C
Low touch surface temperature limit	50°C
Exhaust air temperature limit	70°C

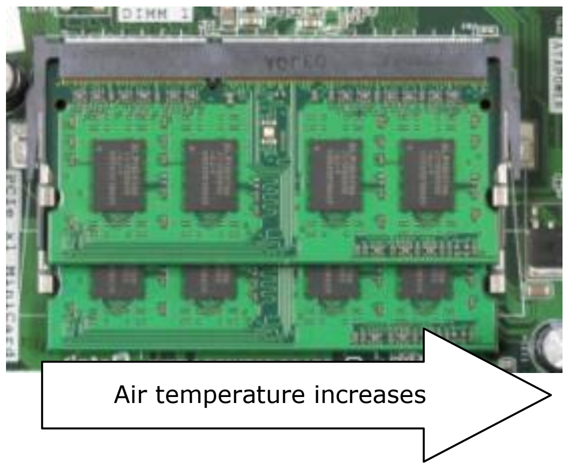
High touch surfaces can be described as surfaces of the system which contact the user's skin for prolonged periods while operational, such as the touch screen. Low touch surfaces can be described as surfaces of the system which the user touches only briefly, such as a system's back when accessing I/O connectors. The system skin temperatures are recommended to be at or below the values listed in the table above for all ambient operating temperatures.

4.3 Motherboard Component Cooling

4.3.1 Memory Cooling

Stacked SO-DIMM memory is used in this design guide because this is the only memory configuration that can meet the height limitations for this form factor and also meet board routing constraints. This introduces a cooling challenge that will require careful consideration in how air is pulled through the system from the inlet vents, through the air moving device and then out exit vents. Since multiple memory chips are placed on each SO-DIMM the air temperature that a particular chip experiences can be affected by the overall direction of the airflow over the SD-DIMM module. Maximum (undesirable) chip temperatures occur when the predominant air flow direction is along the long dimension of the SD-DIMM module. Cooling of the DRAM chips improves with an increase in the local velocity. Therefore, any inlet vents near the SO-DIMMs should be sized to produce maximum velocity without producing too much pressure drop.

Figure 4-4. Air Temperature Increase Across Memory



4.3.2 Platform Controller Hub (PCH) Cooling

The location of the PCH may vary from board to board. Therefore, system airflow should be designed to take that variability into account. But it is recommended that motherboard designers follow the same core layout as the Intel reference design to mitigate this effort.

See Intel's Thermal Mechanical Design Guide for the applicable Intel chipset to obtain explicit thermal boundary condition requirements for the PCH.

4.3.3 Voltage Regulator Cooling

- Voltage regular designs can vary from board supplier to board supplier. Therefore, a system designer must avoid having stagnant airflow in the region of the voltage regulator components. The best solution is to provide a system fan directed toward the voltage regulator region.

- A larger number of phases will produce lower component temperatures because the power is divided out among more components. Hence a three phase VR is thermally a much better choice over a two phase VR.

- Strategically placed chassis vents can help to ensure an airflow path goes through the VR region.

4.4 Acoustics

The system acoustic noise level target goal based on a high power usage scenario should not exceed 38 dBA at operator position at 35°C external ambient when the CPU fan speed is running at the required level to meet the CPU's thermal requirement under Thermal Design Power (TDP) conditions. Microphone placement and measurement type must be made as per ECMA-74 standards. The ECMA-74 has a specific reference to All-In-One PC's (Figures C.4c and C.4d in the ECMA Document as shown below). A Tiny PC chassis should be placed according to table top PCs as shown in Figure C.4a of the ECMA-74 document as shown below.

- Use the sitting operator position measurement for an All-In-One system.
- The computer system is placed upon a standard table (See Section A-1 in the ECMA-74 document)
- It is a single microphone sound pressure measurement.
- The microphone is placed 0.5 meter from the front, bottom edge of the flat panel display of an All-In-One PC
- The microphone is placed 0.5 meter from the front edge of the Tiny PC chassis.
- A keyboard is placed 0.25 meter from the microphone.
- The microphone is placed 1.2 meter above the test floor.

Figure 4-5. ECMA-74 Extract – Figure C.4c

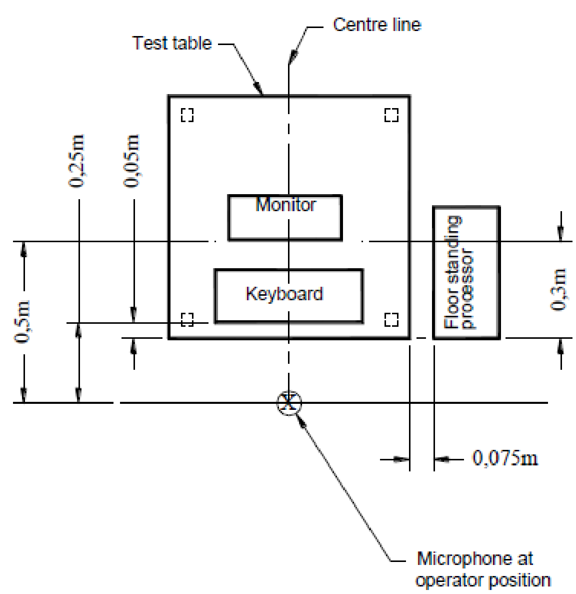


Figure C.4c — Installation for a floor standing system or all-in-one system (at the monitor location)

Figure 4-6. ECMA-74 Extract – Figure C.4d

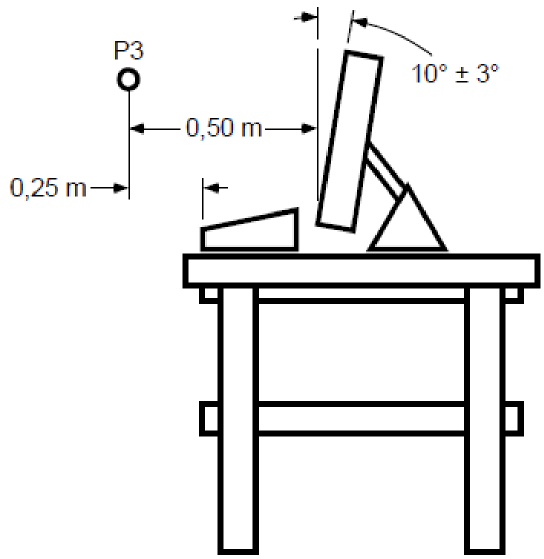


Figure C.4d — Screen angle for all-in-one system

Figure 4-7. ECMA-74 Extract – Figure C.4a

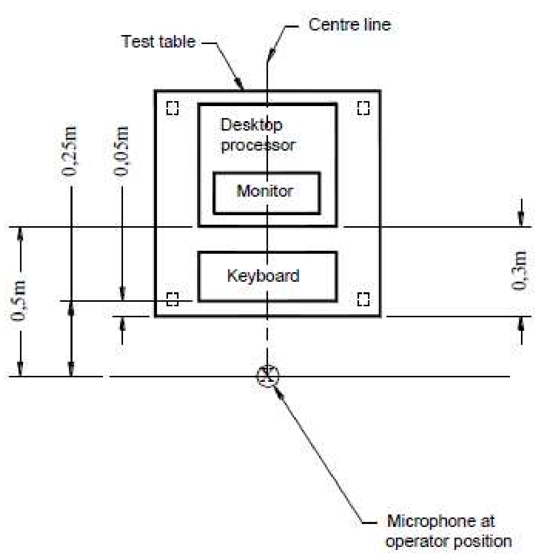


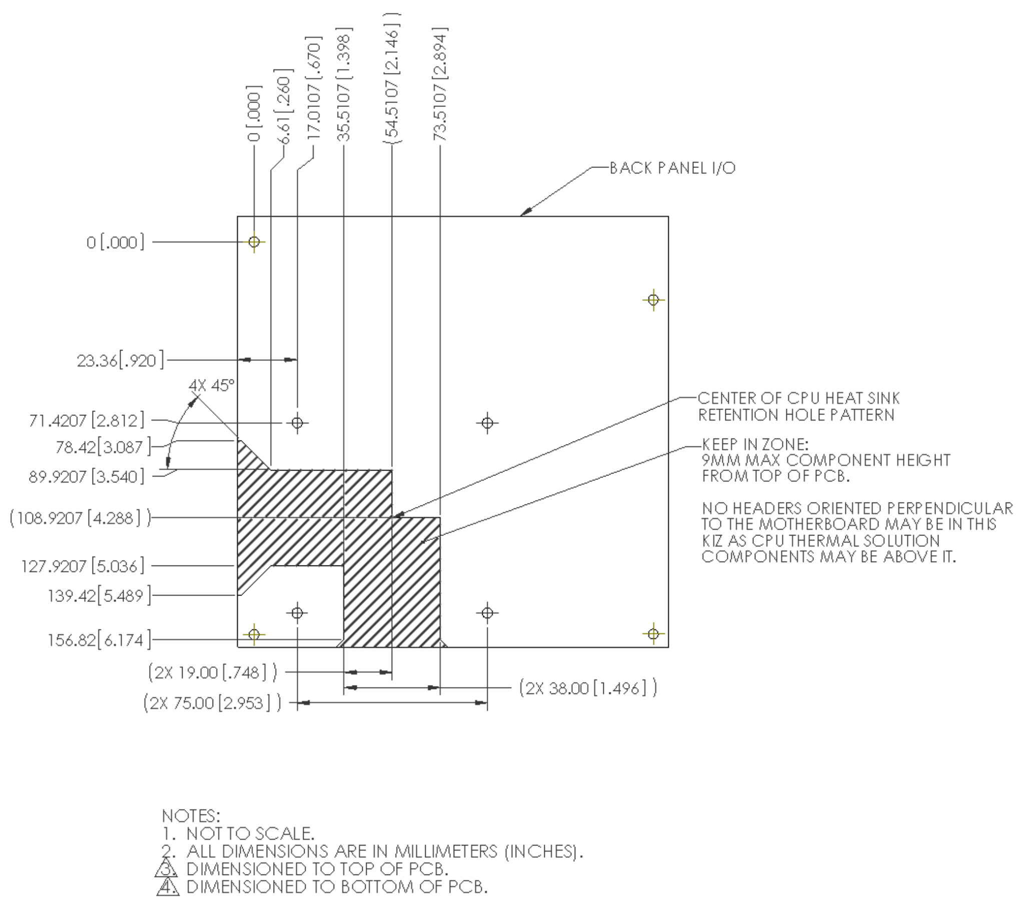
Figure C.4a — Installation for system comprising "flat" table-top equipment

5 Mechanical

5.1 CPU Mechanicals

Figure 5-1 specifies the required location of the CPU heat sink retention hole pattern, based on the standard CPU heat sink retention hole pattern specified in the *[Sandy Bridge/Ivy Bridge] Desktop Processor and LGA1155 Socket Thermal Mechanical Specifications and Design Guidelines (TMSDG)*. Additionally, keep-in zones are added which are intended to support heat pipe routing away from the CPU. CPU keep in zones in this document are in addition to those specified in the TMSDG and the *Mini-ITX Addendum Version 2.0 to the microATX Motherboard Interface Specification Version 1.2*. Supporting these requirements helps ensure compatibility between chassis, motherboards, and standardized Thin Mini-ITX thermal solutions such as Intel's reference thermal solution in Chapter 6. (Note: this does not apply to Atom based boards.)

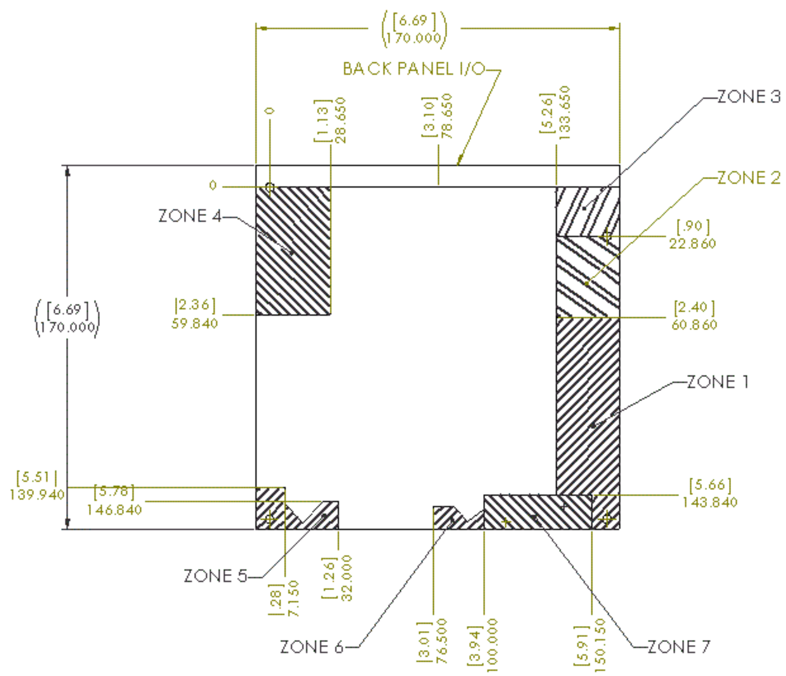
Figure 5-1. CPU Location and Additional Keep In Zones



5.2 Internal Motherboard Header Locations

The header locations in Figure 5-2 are strongly recommended to be supported by the motherboard, chassis, and cables. Supporting these locations allows headers to be in predictable areas so that chassis cables may be optimized for length and routing, and to improve the integration of different combinations of motherboards and chassis with each other.

Figure 5-2. Header Zones



CONNECTOR	ZONE
LVDS	7
PANEL DISPLAY BRIGHTNESS	7
DMIC	4
FRONT PANEL AUDIO	4
INTERNAL SPEAKERS	4
SATA DATA	1 AND 2
SATA POWER	1 AND 2
1x SINGLE-PORT USB	2
INTERNAL DUAL USB	1, 5 AND 6
FRONT PANEL DUAL USB	1, 5 AND 6
FRONT PANEL	1
CPU FAN	1
SYS FAN	1 AND 2
INTERNAL POWER	3
CIR	1
MONITOR SWITCH	1
USB 3.0	1 AND 2

NOTES:
1. UNITS: MILLIMETERS (INCHES)
2. HEADERS SHALL BE LOCATED ENTIRELY WITHIN THE ZONE(S)INDICATED.

5.3 System Cables and Connectors

Motherboards and cabling designed to this design guide shall have motherboard headers, mating cable connectors, and cable routing that when mated and installed fit within the volumetric envelope defined in section 2.4.2 of the Mini-ITX Addendum Version 2.0 To the microATX Motherboard Interface Specification Version 1.2. Keeping within this volumetric will ensure motherboards and cables will work together in chassis that wrap tightly around the Thin Mini-ITX volumetric.

5.3.1 System Cable Kitting

Cables that are an integral part of the chassis must ship with the chassis. These include cables for flat panel displays, user interface buttons, SATA devices, external connectors, web cams, microphone, speakers, system fans, and custom heat sink fans. Chassis that will use the reference thermal solution in this design guide will likely need to supply a system fan/blower to cool the various motherboard components other than the CPU.

Cables that do not directly interface with the chassis, should ship with the motherboard, particularly if they are not commonly available. The cables should be long enough to reach components that are located on the opposite end of a chassis using a 24” screen.

5.4 CPU Thermal Solution and System Fan Mechanical Interface

Standardized, low profile heat pipe based thermal solutions can be designed into Thin Mini-ITX compatible chassis. These solutions include Intel’s HTS1155LP described in Chapter 6, and compatible solutions from other vendors which are designed to the “Specification for Heat Pipe based Thermal Solutions for Thin Mini-ITX Based PCs”.

The motherboard must support the fan requirements referred in Section 0 and the mechanical requirements described in Section 5.1.

Chassis requirements:

- Provide heat exchanger mechanical shock retention feature attach holes and screws at one or more of the locations specified in Figure 5-3, Figure 5-4 or Figure 5-5
- Provide blower mechanical attach features at one or more of the locations specified in Figure 5-3, Figure 5-4 or Figure 5-5.Figure 5-5 shows two different ways a single blower can be implemented with this shown heatsink installation orientation. The blower is offset from the heatsink 2 mm in order to divert some of the cool air over the voltage regulator components.
- The CPU blower attach standoff thread size is M2.5 x 0.45 mm thread pitch.
- A minimum of a 3mm air gap above and below the standard 19mm blower housing is strongly recommended to better support blower performance and system acoustics, as shown in Figure 5-6. Using a smaller gap will severely degrade air intake into the fan and result in a significant increase in system noise.

Figure 5-3. Blower and Heat Exchanger Retention Locations for Two Blower Configuration Option 1

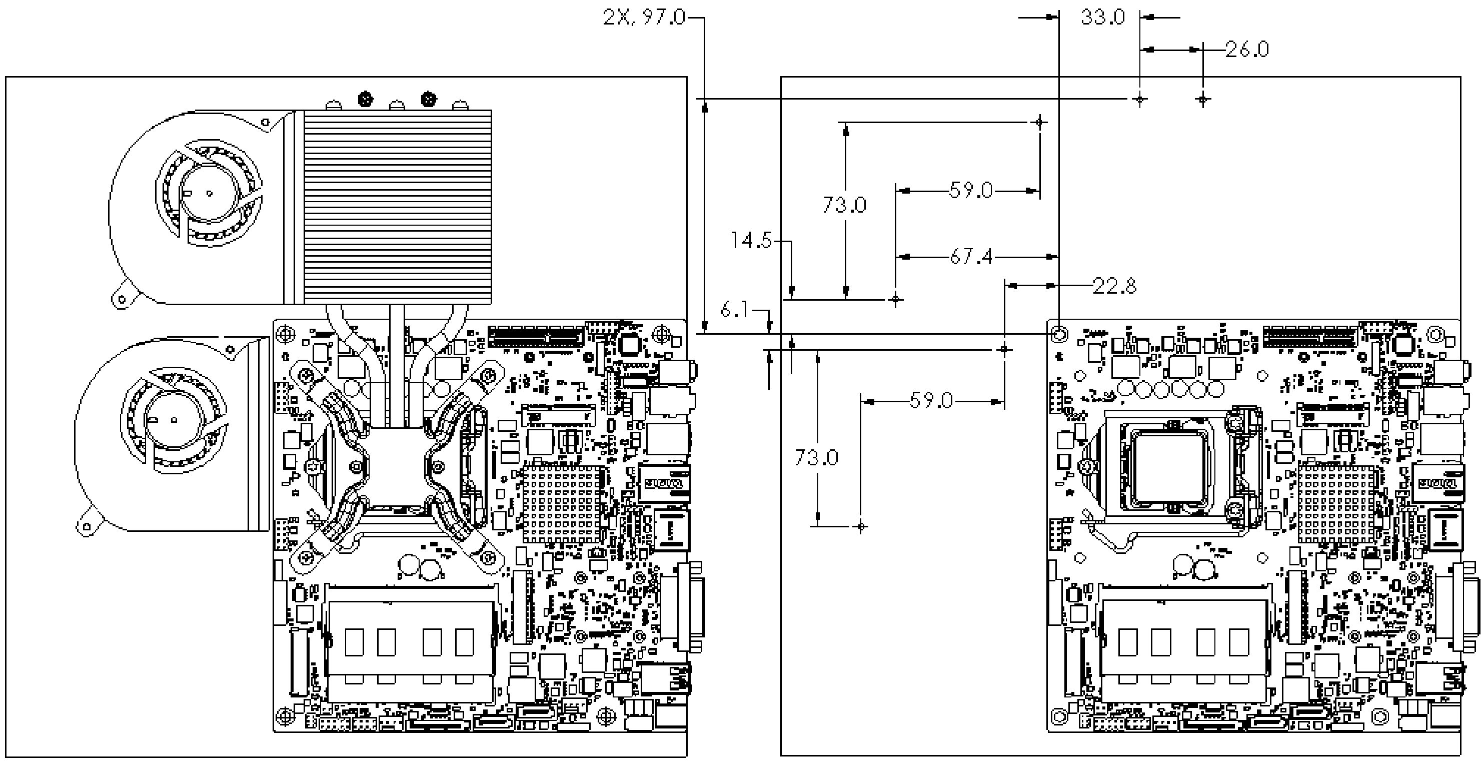


Figure 5-4. Blower and Heat Exchanger Retention Locations for Two Blower Configuration Option 2

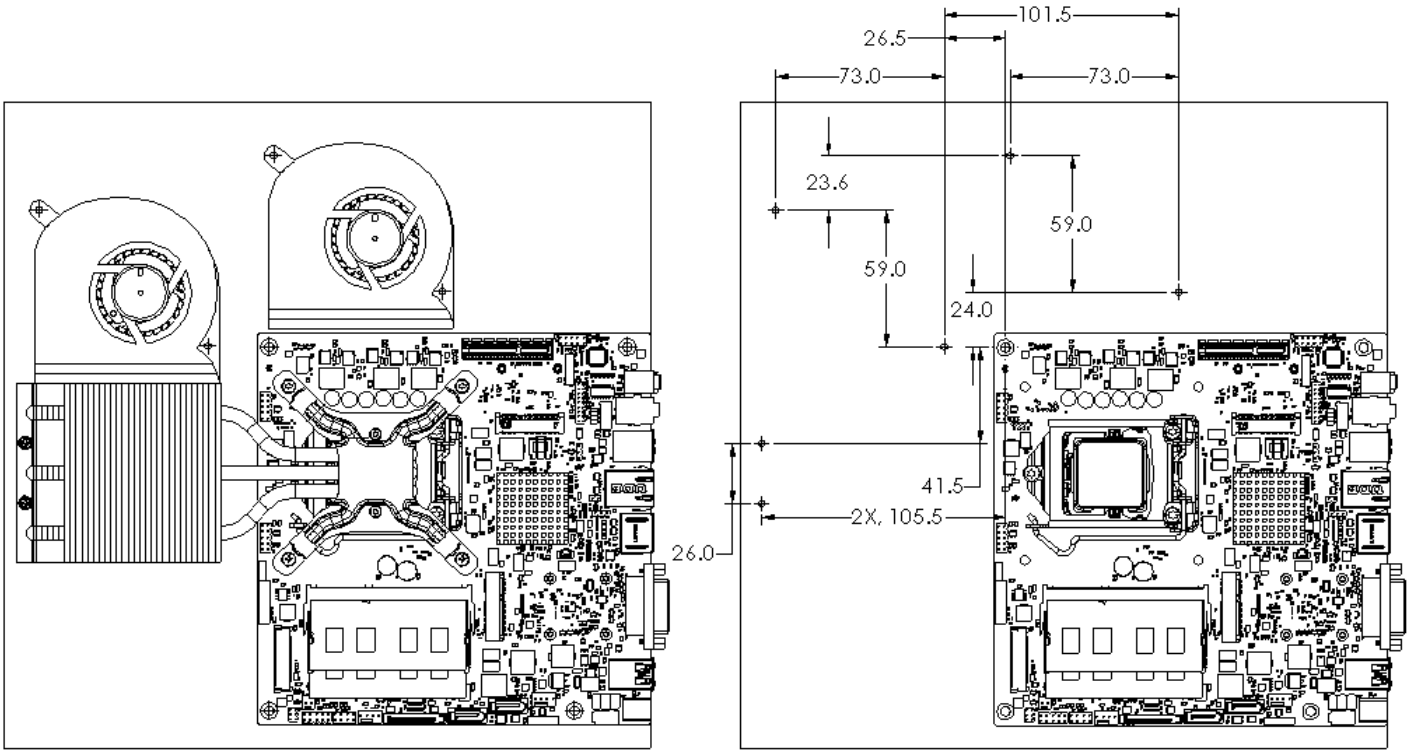


Figure 5-5. Blower and Heat Exchanger Retention Locations for a Single Blower Configuration

(NOTE: two different orientations simultaneously shown)

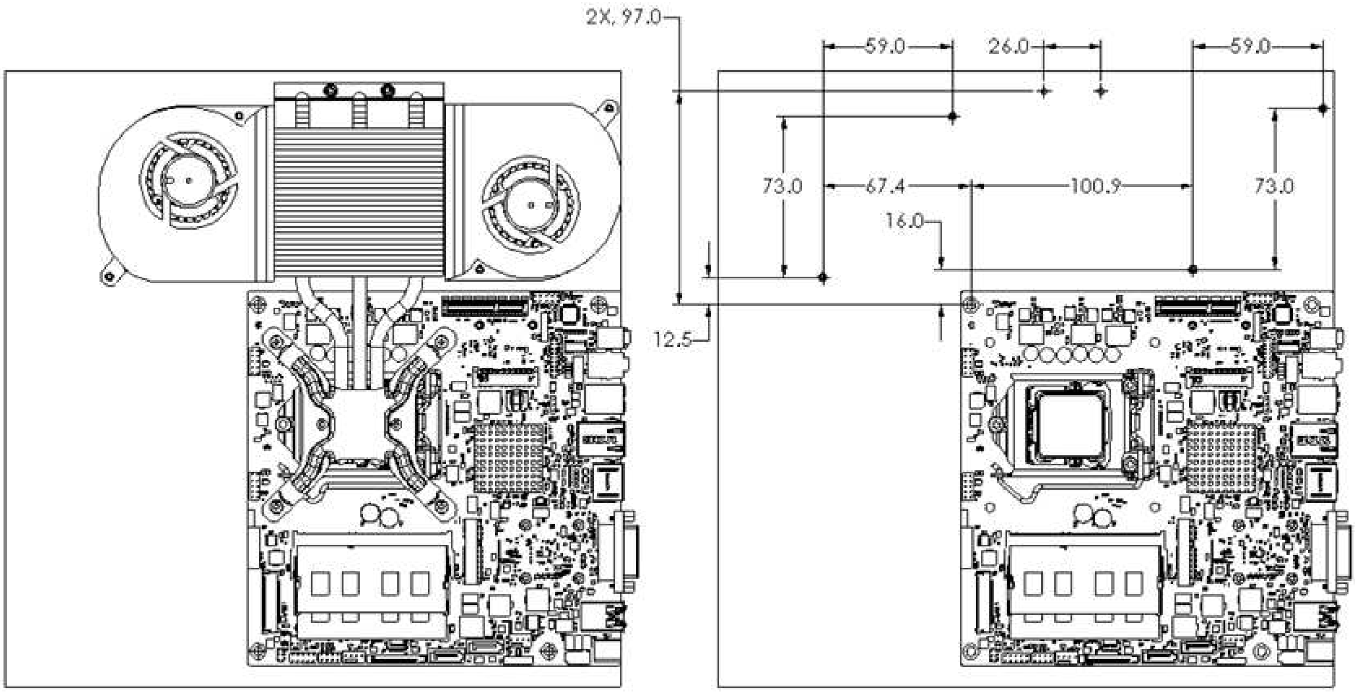
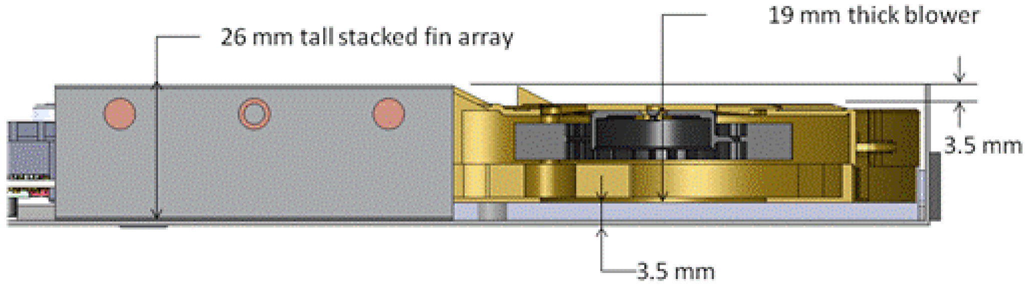


Figure 5-6. Minimum Blower Gap



The free mass of a CPU thermal solution that does not attach directly to the motherboard must be supported by the chassis. As an example, the typical AIO CPU thermal solution consists of a CPU cold plate, heat exchanger and blower. The heat exchanger and blower are typically located outside the boundary of the motherboard footprint. Therefore, the blower and heat exchanger mechanical attach must be designed by the chassis supplier with the targeted thermal solution in mind. The cold plate of the CPU thermal solution must be designed to attach directly to the motherboard via fasteners that ship with the thermal solution.

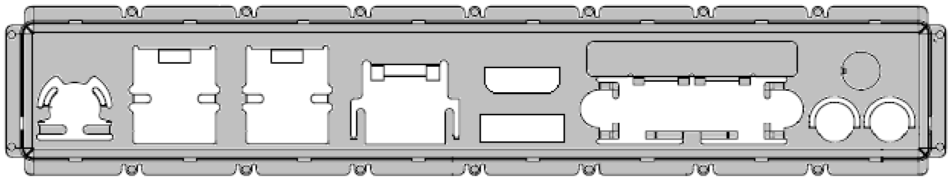
The Low Profile reference thermal solution described in Section 6 is an example of the type of thermal solution targeted for this type of form factor. It consists of a cold plate, heat pipes, and stacked fin array. By design, the stacked fin array will sit onto the chassis bottom pan. The fin stack is suspended beyond the edge of the motherboard by three heat pipes. This type of thermal solution design must be physically constrained in the positive Z direction in the region of the stacked fins of the heatsink so that the heat pipes do not bend during a mechanical shock load in the positive Z direction, i.e. perpendicular to the motherboard plane. Likewise, the heatsink stacked fin section must be physically constrained from movement in the plane of the motherboard during a mechanical shock loading event which occurs in the same plane as the motherboard.

5.5 Thin Mini-ITX I/O Shield

As the specific side I/O ports can vary from motherboard to motherboard, it is recommended that a chassis keep the chassis I/O as an open aperture that is filled by the motherboard’s I/O shield. A chassis could develop plastic molding in this area that is contoured to the industrial design and the specific connector pattern of a motherboard; however, this removes the chassis’ ability to use motherboards with different I/O patterns.

The below figure is an example of a Thin Mini-ITX I/O shield that would ship with a Thin Mini-ITX motherboard.

Figure 5-7. Example Thin Mini-ITX I/O Shield



5.6 Industrial Design, System Layout, and Usability Considerations

Areas to consider in general system design for ease of integration, serviceability, and overall system mechanical performance include:

- Screws are generally better than snaps for retaining external chassis panels that must be removed for system access. When compared to snaps, screws generally allow the panel to be removed / installed easier and with less risk of damaging plastic. Self-tapping screws which are driven in to plastic can work, but are usually only good for a few installation/removal cycles before the plastic becomes overly-deformed and weak. Machine screws driven into a threaded receiver, such as metal studs, are good for numerous installation/removal cycles.
- Captive screws on chassis panels, HDD frames, etc, improve the ease of integration, and reduce the chance of parts being lost.
- Minimize the number of parts which must be removed to gain access to the inside of a system. For example, removing a chassis stand, back panel, and EMI shield to gain access to the motherboard requires many steps. The same can be said if a front bezel, monitor screen, and chassis components must be removed if motherboard access is from the front. The parts may be necessary; however, the steps needed in getting around them should be minimized.
- Provide areas and features within the chassis for bundling up excess cable to reduce system airflow obstruction effects and provide a neater system.

5.6.1 AIO Specific System Mechanicals

- If cables are part of a flat panel display or other part that must be removed to gain access to components in the system, ensure the cables are long enough so that it is not difficult to connect them before reinstalling the flat panel or part.
- Hiding the motherboard I/O connectors and cables behind the flat panel display can result in a cleaner looking AIO system. A combination of cable management and placing the motherboard so that the motherboard I/O ports are recessed from the side of the chassis, can allow the cables to be hidden from view. Most LAN, USB, Audio, and power cables can be hidden if the I/O shield is offset 60mm from the side of the chassis. DVI and HDMI cables may need 80mm. Cable management can be done in different ways, such as a shroud along the side of the chassis which hides the ports, or plastic clips that hold the cables behind the chassis.
- Chassis cables should be identifiable through labeling and proper connector keying for easy match up with the motherboard (color coded where possible)
- Chassis cables should be long enough to reach all of the headers on the motherboard, until motherboard ODM’s bring their boards into compliance to the placement zone recommendations.
- Chassis cables should be long enough to reach headers on any specific intended board(s) that do not comply with the recommended zones shown in Figure 5-2.
- Cable bunch-up areas should be defined with cable guides. Provide zip ties in the box for cable management.
- Minimize the number of screws to open the back panel of the chassis. A maximum of 8 screws is suggested. However, fewer is better.
- An instruction manual should be included in the box which describes steps to open the chassis and install the motherboard and thermal solution
- The same type of screws should be used for back panel/motherboard and thermal solution retention. If not the instruction manual should clearly differentiate the screws and their purpose

A data sheet of the flat panel display or a single page insert with the flat panel display settings should be included in the box so integrators can easily configure motherboard jumpers and BIOS settings.

6 Low Profile Reference Heat Pipe Thermal Solution

The thermal solution described in this chapter supports the thin chassis that are possible with Thin Mini-ITX motherboards. The thermal solution is standardized as are the CPU socket location and keep in zones (see Figure 5-1) so that they may be relied on as interchangeable building block components.

6.1 General Volumetrics / Requirements

- Design chassis for 0.25 inch high motherboard backside standoff height as defined in the *ATX Specification Version 2.2*. This is required to be mechanically compatible with the Thin Mini-ITX reference thermal solution.
- The Intel low profile Thin Mini-ITX thermal solution was designed to function within a chassis whose top and bottom surfaces are in plane with the top and bottom surfaces of the CPU thermal solution heatsink fin array (26mm tall).

6.2 Reference Design CPU Thermal Solution

The Intel reference design in this section has a retail product name of HTS1155LP, and a development project name of DHA-E. It is intended to be installable in more than one orientation on the motherboard and even allow the fan blower to be installed at either end of the heat exchanger. This thermal solution was sized to conform to the maximum height limit constraints defined in the *Mini-ITX Addendum Version 2.0 To the microATX Motherboard Interface Specification Version 1.2*. Contact your Intel technical sales representative for further information on how to obtain detailed design collaterals beyond what is documented below or for component sourcing information.

Figure 6-1. Reference Side and Top View Dimensions for Low Profile Reference Thermal Solution

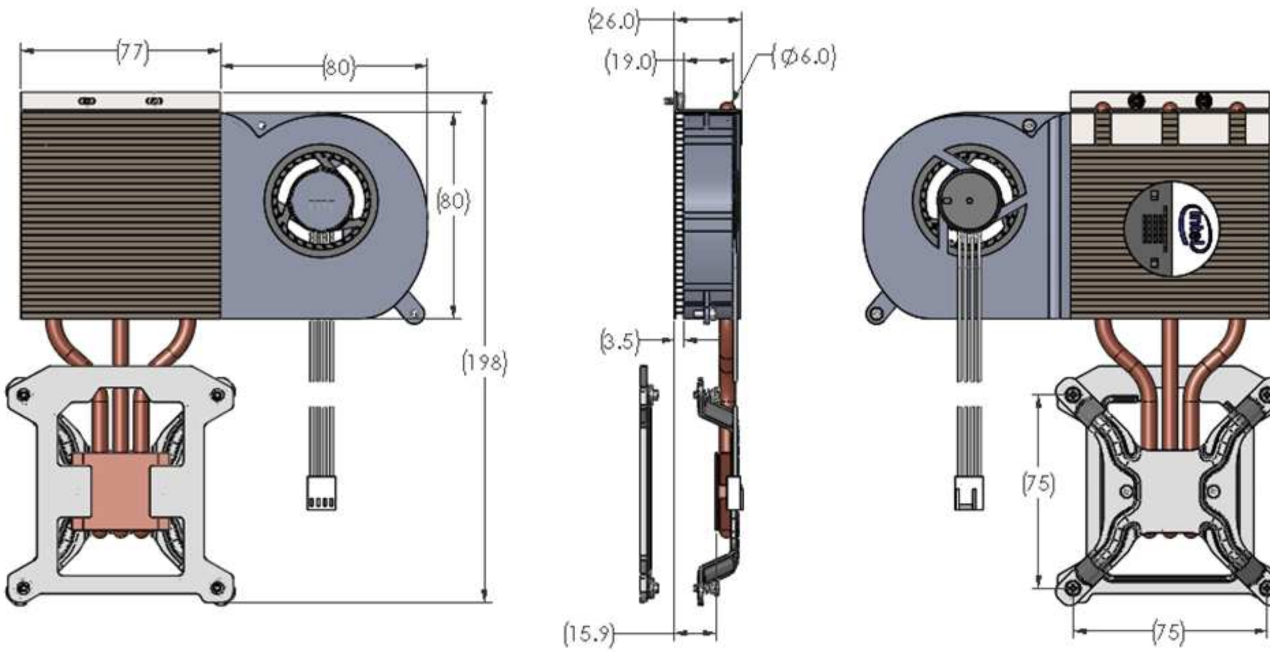
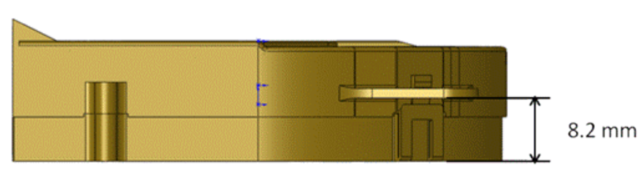


Figure 6-2. Reference Blower Mounting Flange Standoff Height as Measured from the Bottom of the Flange



7 Reference System Layouts

7.1 Thin Mini ITX Based System Design

Intel has identified several general core component (MB and thermal solution) layouts for both All In One and Tiny PC system designs that can meet the thermal requirements. The Intel reference thermal solution described in Section 6 was designed to allow a high degree of flexibility in component layout while maintaining a building block system design approach.

7.1.1 General System Design Considerations

- Utilize a CPU heatsink exit duct to force all of the exiting hot air directly out of the chassis because hot air recirculation will degrade system thermal performance.
- Completely enshroud the CPU blower inlet to isolate it from the internal system air itself to minimize the air inlet temperature to the blower and thus maximize CPU cooling performance and minimize acoustic noise.
- Moving air must be supplied over the voltage regulator power FETs
- Chassis vents should be introduced to ensure VR heated air has an exhaust path out of the chassis because over temp VR's will induce CPU throttling.
- System memory must have high velocity cool air moving over them. (High flow rate is typically not required.)
- Single fan configurations typically require a thermal pad underneath the VR at the bottom side of the motherboard
- Use as much venting as chassis Industrial Design can allow to minimize internal air temperatures.
- The addition of an EMI cage or enclosure around the motherboard will make it more difficult to get good cool airflow over the motherboard components. The introduction of an EMI cage may require a VR thermal pad and/or air flow splitter duct from the system fan to simultaneously supply system fan airflow to the VR components and to the SO-DIMMs.
- The minimization of the air temperature rise from outside the chassis to the CPU blower inlet has a significant benefit to CPU cooling performance. Target limiting chassis temperature rise to at most 7°C.

7.2 Reference Core Components Layouts

These examples are intended for reference and do not cover every detail for a specific complete chassis design. The chassis or system designer is ultimately responsible for defining the locations of other components such and ODD, HDD, etc. as well as venting. Such details are normally driven by the Industrial Design and are at the discretion of the designer.

The following examples are based on a 65W CPU system and the reference thermal solution design described in Chapter 6. No layout guidance is provided for Intel Atom processor based systems because they are fundamentally easier to cool and often require only a single system blower.

Figure 7-1. Core Component Layout – Example A

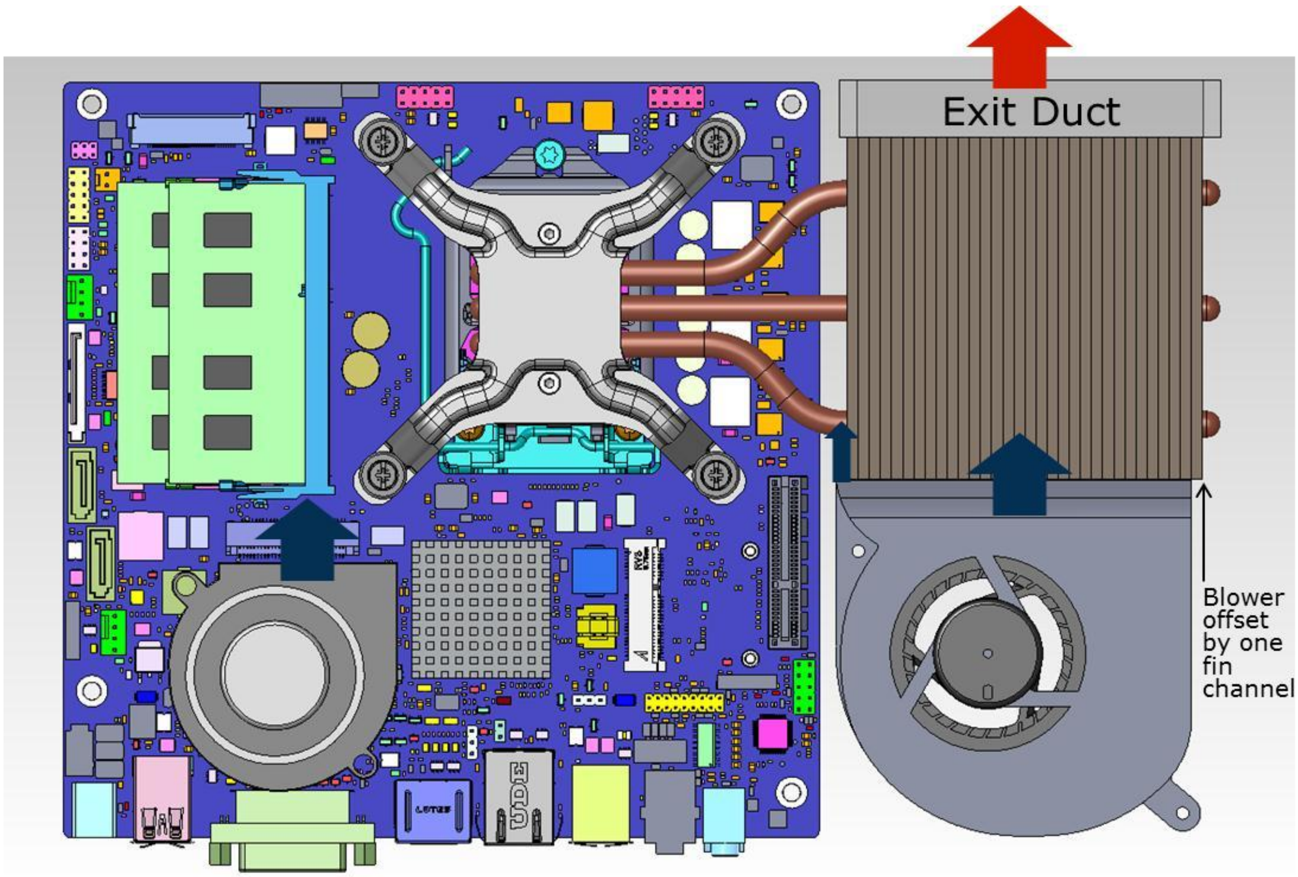


Figure 7-2. Core Component Layout – Example B

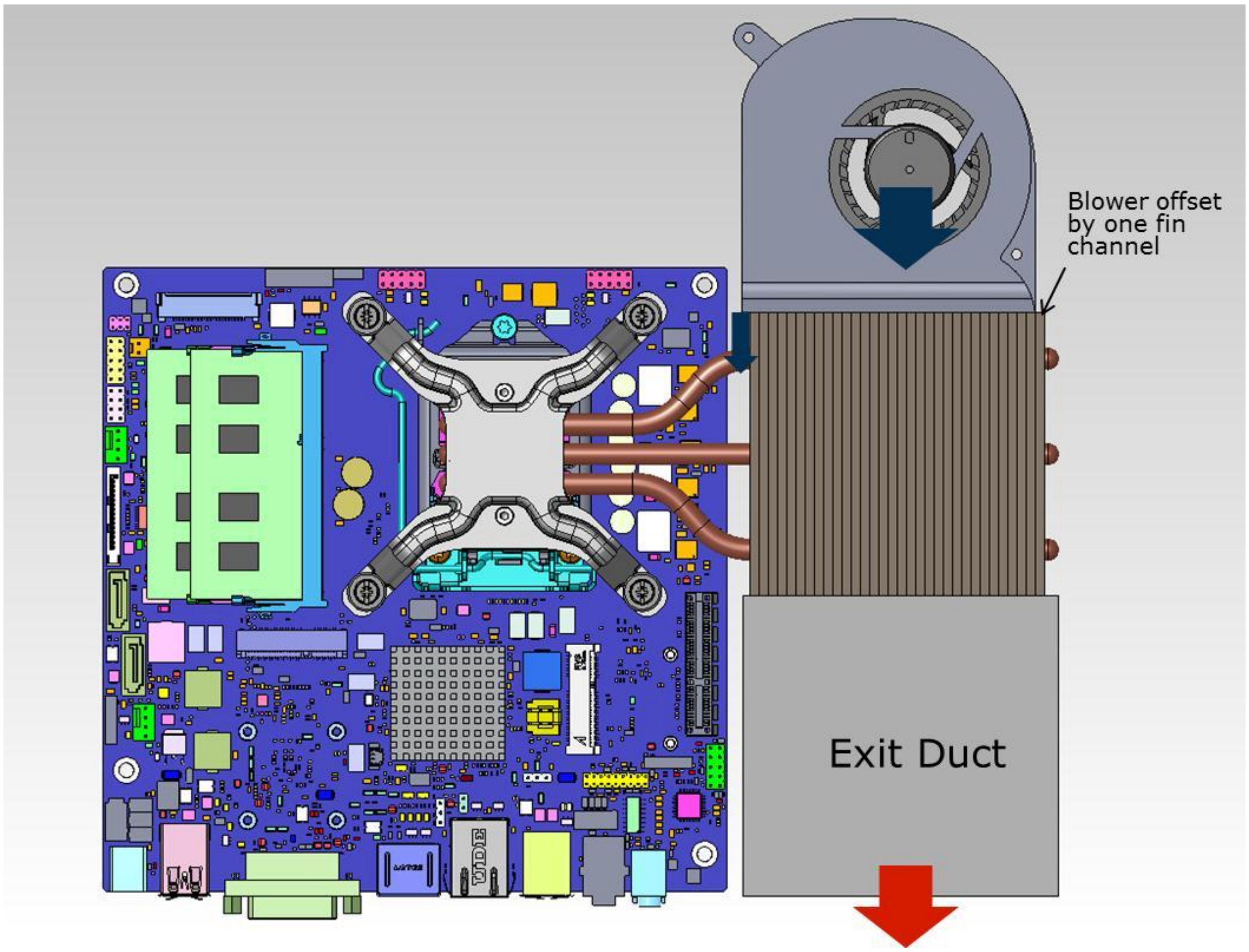


Figure 7-3. Core Component Layout – Example C

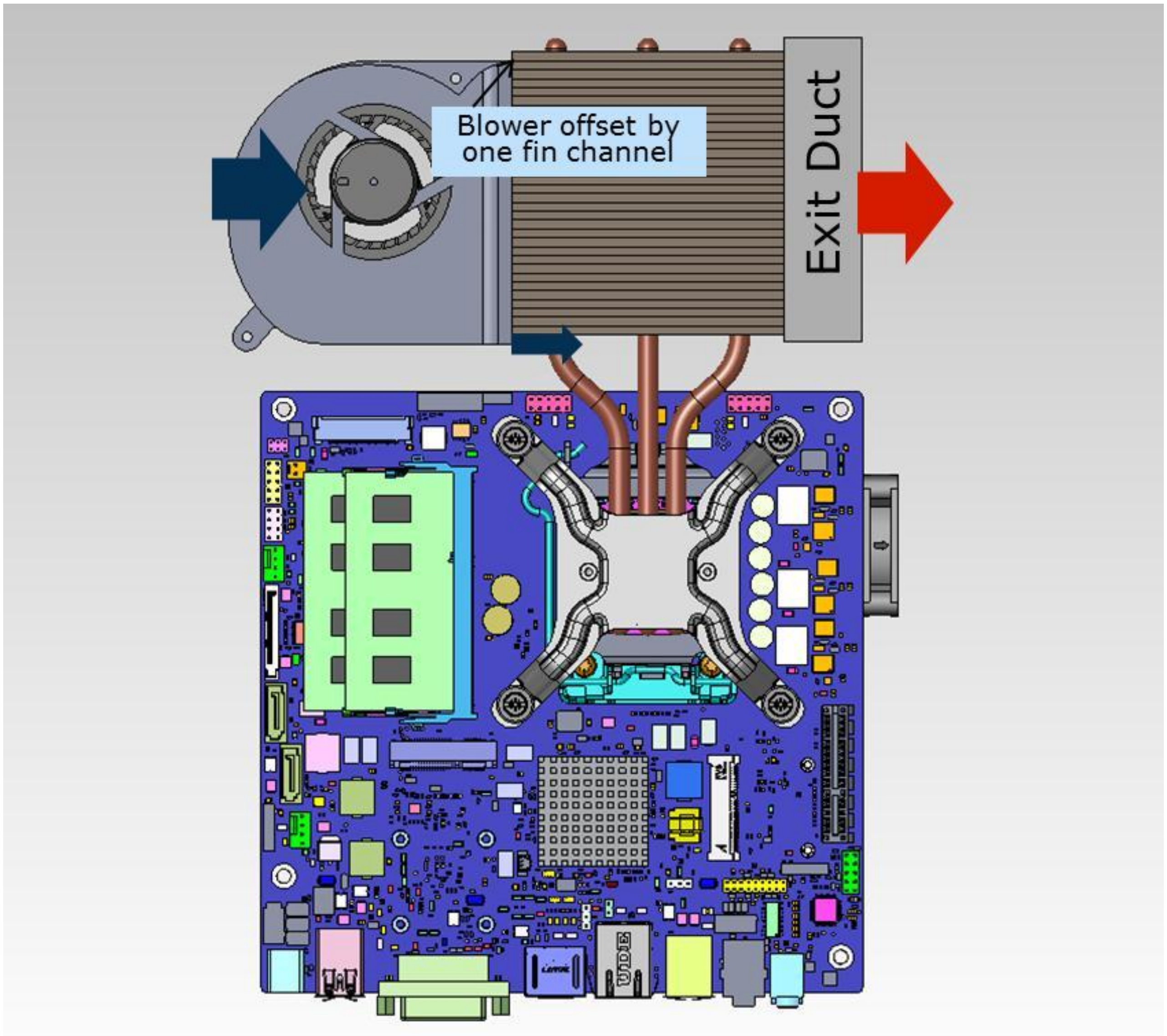


Figure 7-4. Core Component Layout – Example D

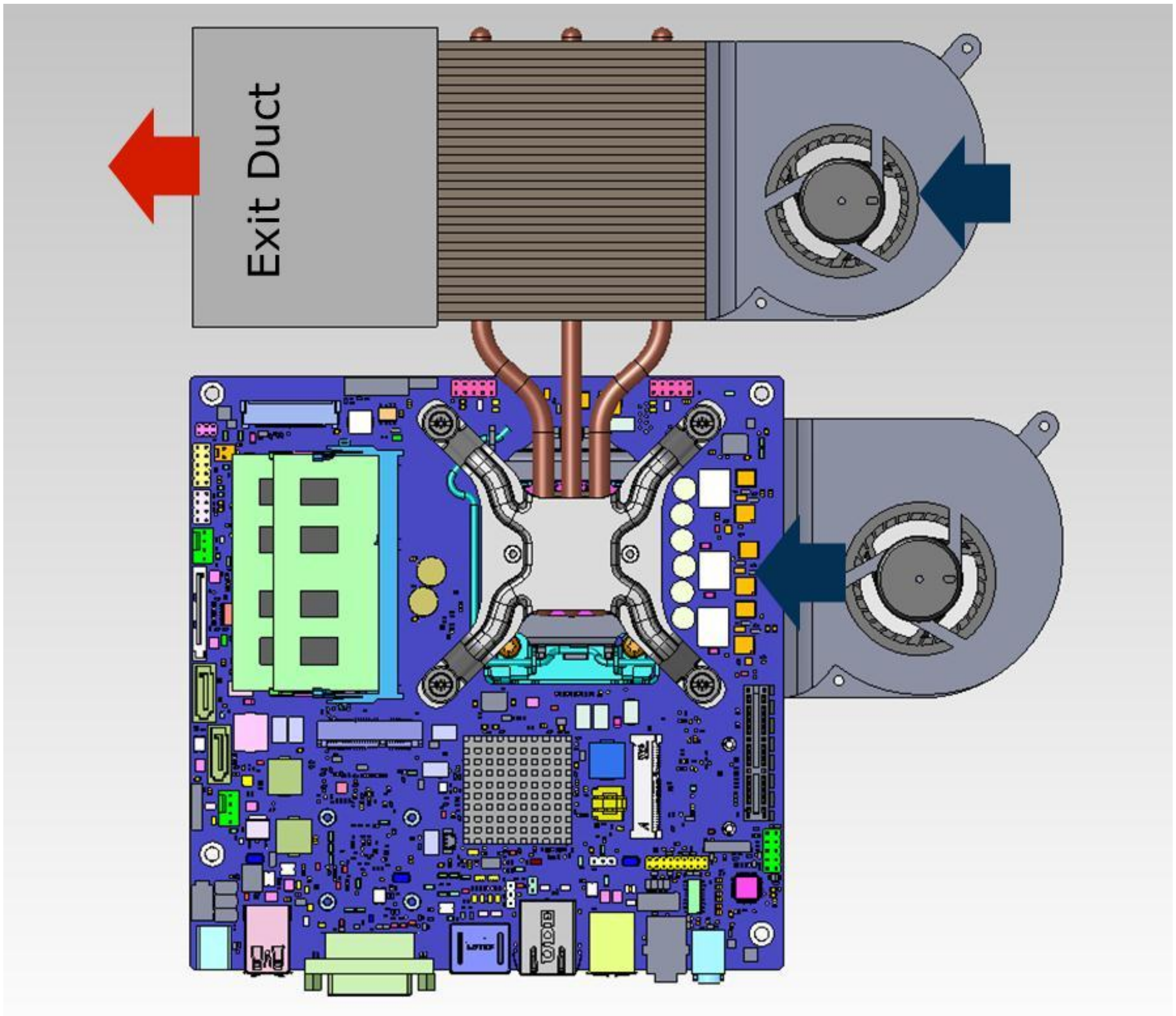


Figure 7-5. Core Component Layout – Example E

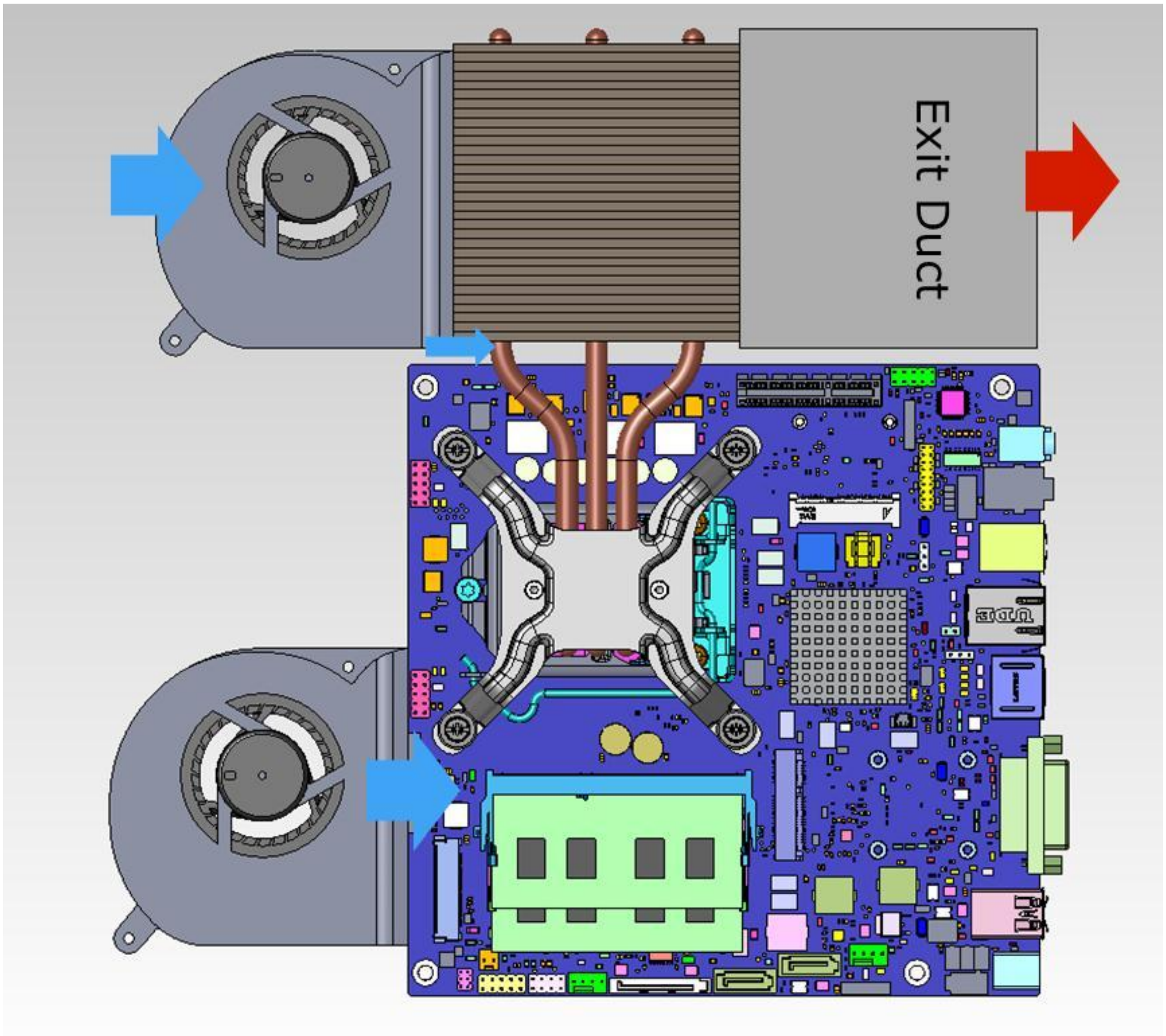


Figure 7-6. Core Component Layout – Example F

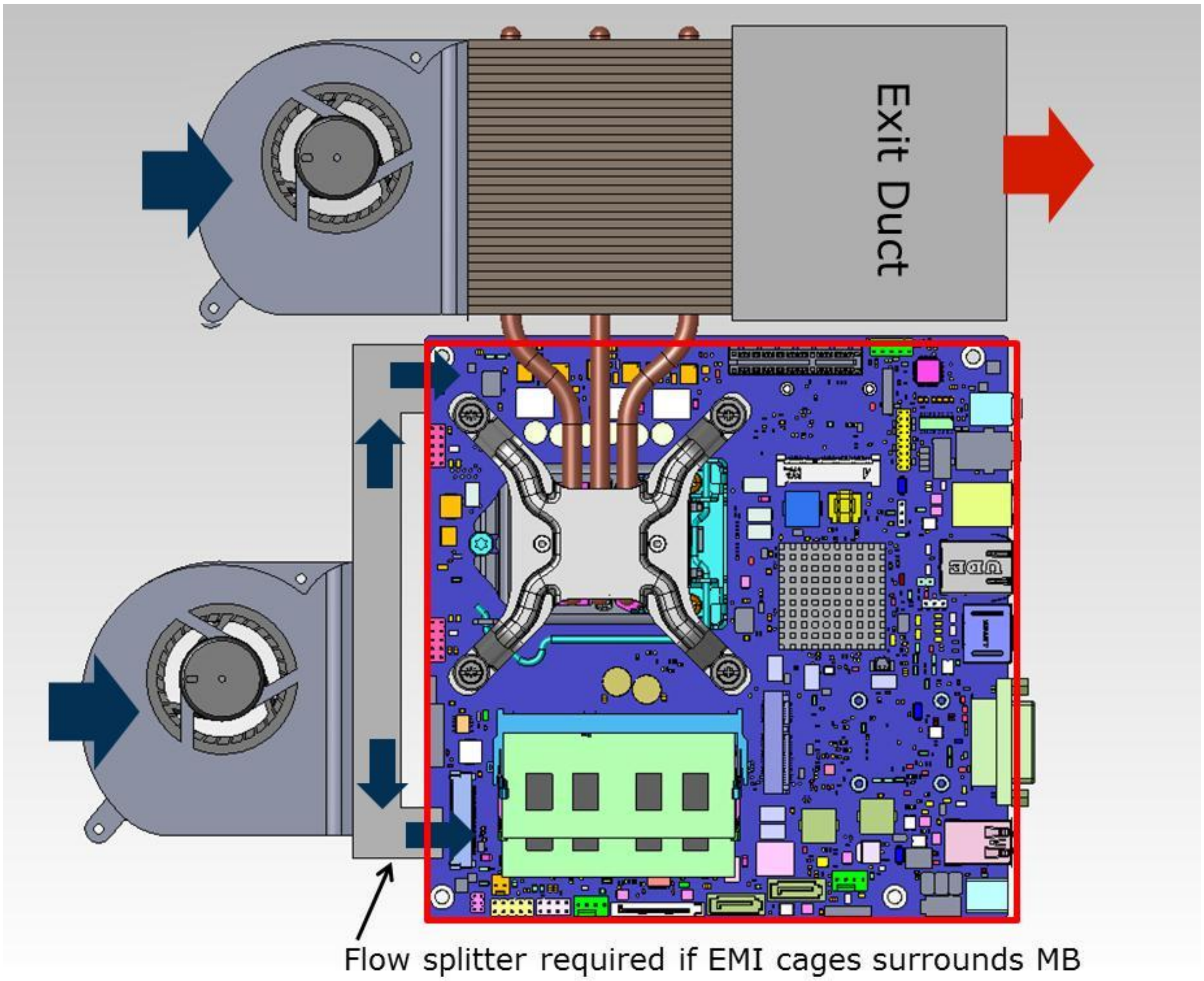


Figure 7-7. Core Component Layout – Example G (Effective Single Blower Option)

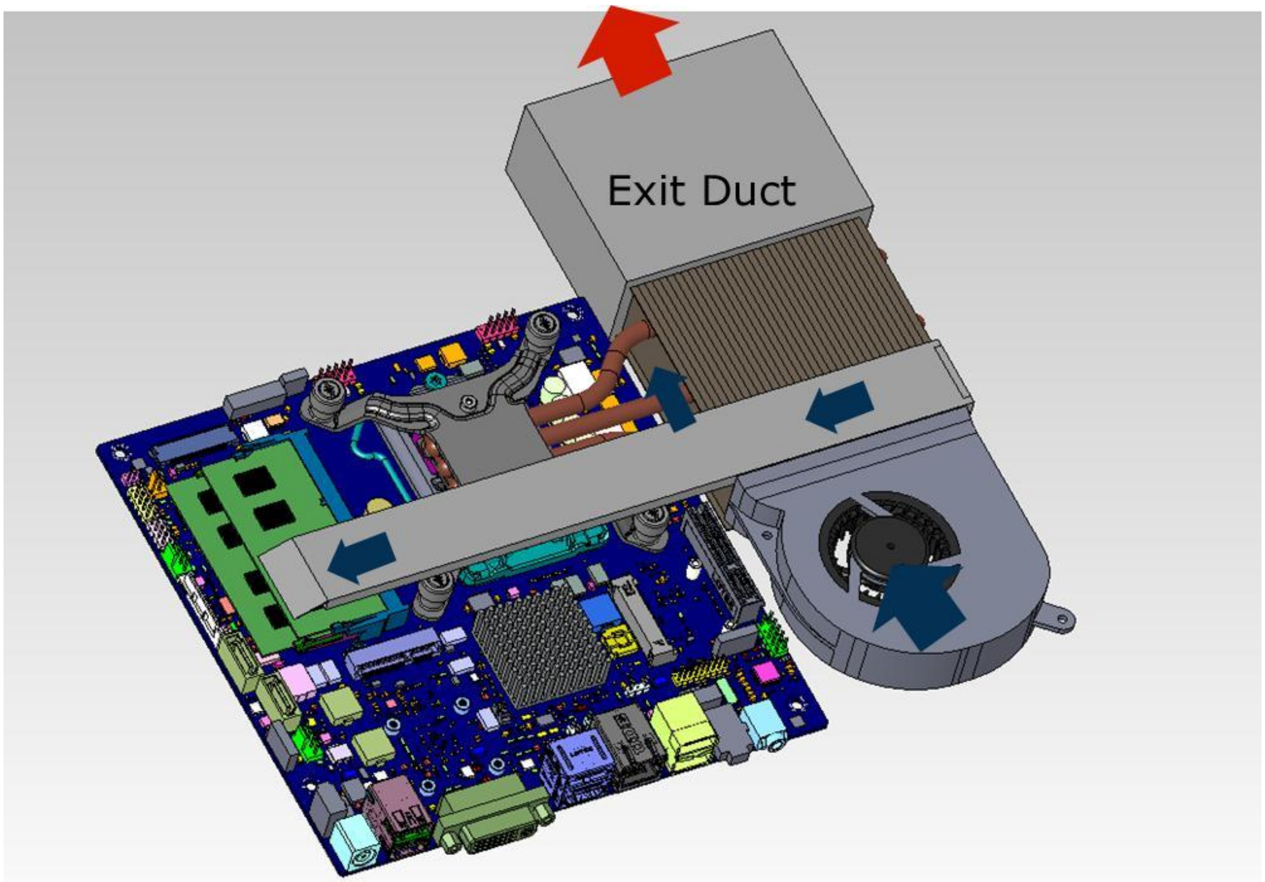


Figure 7-8. Core Component Layout – Example H (Effective Single Blower Option)

Use inlet air transition duct with flow splitting geometry. Most air enters the entire heatsink. Remaining air fills the chassis. (Inlet air shroud not shown.)

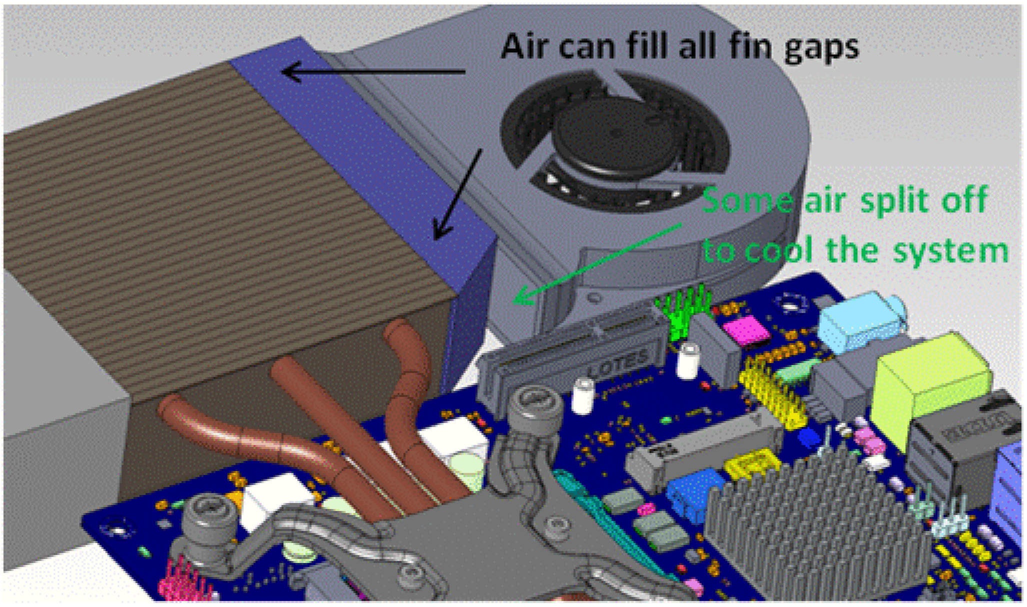
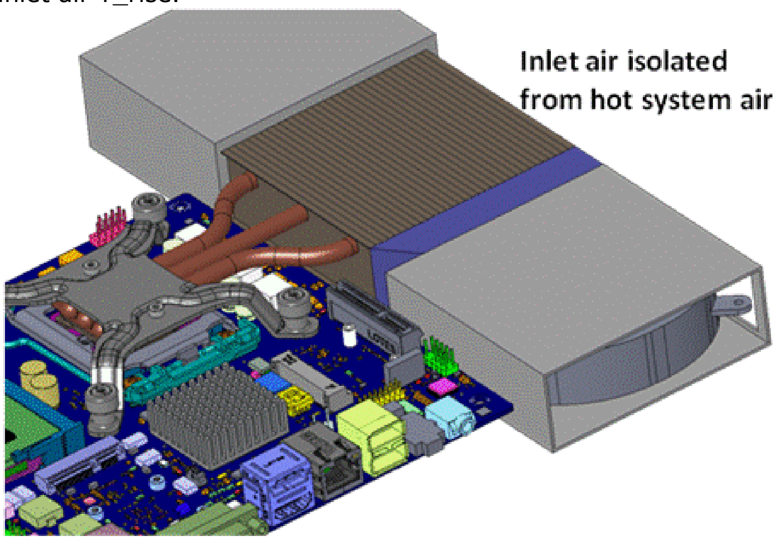


Figure 7-9. Core Component Layout – Example H (Effective Single Blower Option)

Add inlet air shroud to isolate cooling entering air from system air to minimize chassis inlet air T_rise.



7.3 Thermal Test Method

This section describes the thermal test method used by Intel to validate All In One and Tiny PC enclosures based on Thin Mini ITX boards. Intel can provide this testing along with limited design guidance to suppliers. Please contact your local representative for further information.

7.3.1 Components Used for Testing

In order to keep test results standardized and consistent, Intel will use the following components in an LGA processor based system for thermal testing:

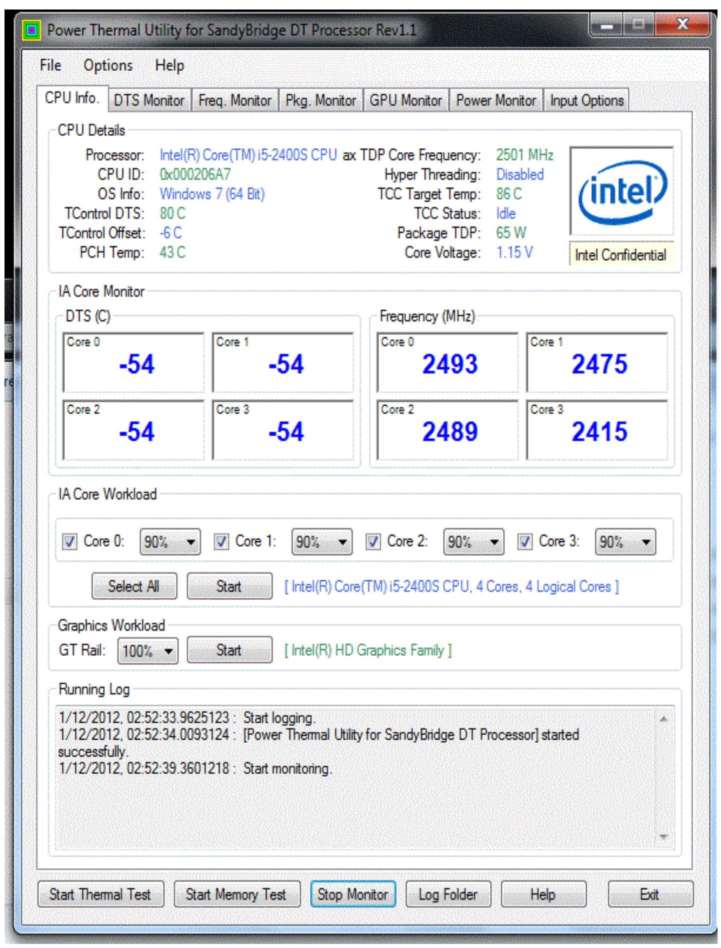
- Environmental test chamber capable of providing still air (no high turbulence) ambient air at 35C as measured “upstream” of the unit under test
- Appropriate equipment for measuring and logging relevant test data.
- Main board for Socketed CPU based systems – Intel DH61AG (Apple Glen)
    - -400 or newer with Revision 31 or newer BIOS
    - CPU – Sandy Bridge operating at 65W under power stress with Tcontrol = 80C
- Mainboard for Atom CPU based systems – DN2800MT (Marshall Town)
    - -800 or newer with Revision 152 or newer BIOS
- SO-DIMM memory – Crucial, 2 x 2GB (4 chips per side)*
    - (CT25664BC1067-M8SFA)*
- O.S. – Win 7, 64 bit for socketed CPU based systems.
- O.S. – Win 7, 32 bit for Atom CPU based systems.
- Thermal Solution – Intel HTS1155LP (for socketed CPU based systems)
- Include (spindle drive) HDD Form Factor applicable to chassis design
- Include optical drive where applicable

7.3.2 Stress Software

Intel uses the Power Thermal Utility software program for the applicable CPU family to thermally stress the system. Two extreme usage cases are considered: CPU stress and memory stress. CPU power dissipation is monitored to check for voltage regulator overheating induced CPU power throttling. CPU DTS values are also monitored to check for CPU die overheating induced CPU throttling. For memory, a DRAM chip on the lower SO-DIMM is monitored to determine if case temperatures remains below 85°C.

- **Desktop SandyBridge Power Thermal Utility Rev 1.1 Settings:**
  - CPU Thermal Stress
    - Run "Thermal Test"
      - The Graphics Workload will be set to a default
      - All four core CPU workloads set to same percentage
  - Memory Thermal Stress Test
    - Run "Memory Test"

Figure 7-10. Power Thermal Utility Example



Cederview Power Thermal Utility Rev 1.2 Settings:

- CPU Thermal Stress
  - Run “Thermal Test”
    - The Graphics Workload will be set to a default
    - All two core CPU workloads will be set to same percentage
- Memory Thermal Stress Test
  - Run 3Dmark06*. Only run the SM2.0 Graphics Test module in continuous loop
    - GT1 – Return to Proxicon
    - GT2 – Firefly Forest

7.3.3 Temperature Measurement Locations

The air temperature entering both sides of the CPU blower and a DRAM chip from the top and bottom side of each bank of SO-DIMM is measured using thermocouples.

Intel’s motherboards have various system component temperature sensors. The highest of the CPU DTS sensor values, the PCH die sensor, memory sensor, Hard Disk Drive sensor, and the voltage regulator board temperature sensor values are recorded during testing.