Thermal Airflow Considerations

SECC2 OLGA HEAT SINK COOLING IN AN ATX CHASSIS

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CONTENTS

1. INTRODUCTION

1.1 Overview

In various chassis the airflow will have different characteristics, these characteristics could have a possible effect on the performance of the Heatsinks used in the cooling of Pentium® III processors. This document will look at the airflow characteristics in one typical chassis and the effect this could have on the capacity of the Single Edge Contact Cartridge 2 (S.E.C.C.2) Organic Land Grid Array (OLGA), Heatsink to cool the processor.

1.2 Background

As the power of motherboards and hardware increases, the requirement for the cooling capacity of any given system is increasing. The demand for quieter systems and stringent EMC regulations is causing an overall reduction in the capabilities of chassis to cope with this increase in thermal output.

The main source of cooling in a typical ATX system is the power supply unit (PSU). The PSU noise output has been reduced to meet noise emission requirements. The fan is the main contributor to this noise and the most effective way of reducing fan noise is to slow down the rotation of the fan blades, this has the effect of reducing airflow, so the PSU's ability to cool the ATX chassis has decreased.

Along with this reduction in PSU cooling power, the chassis have had to be designed to meet EMC emission regulations. The criteria for meeting EMC regulations is that the chassis should ideally be fully enclosed with no gaps. Most chassis are not built fully enclosed but depending on the position and size of the chassis vents, this again can reduce the thermal management of the chassis with reduced airflow through the system.

2. EQUIPMENT UNDER TEST (EUT)

2.1 EUT Configuration

A representative ATX chassis was used for the testing of the S.E.C.C.2 OLGA Heatsinks tested, configured as per Table 2-1.

Supplier	Description	Model/Part Number	Serial Number	Location
N/A	ATX Mini Tower	N/A	N/A	N/A
N/A	ATX PSU	N/A	N/A	Top Rear Chassis
Intel (IQL2794)	SE440BX-2 Motherboard	720938-208	IU5284925186	N/A
Intel	Pentium® III Processor	80525PY500512	48439464-0081	SC242
Micron*	32Mb 100MHz DIMM	MT16LSDT472A 6-10AC3 ES	None	N/A
Teac	Floppy Drive	FD-235HF	3416367	Top 3.5” Bay
Seagate*	H/D 9Gb 1” IDE	ST39140A	AY107107	Bottom 3.5” Bay
Creative Labs*	x2 DVD ROM	DVD2240E	7225PDD06583	Top 5.25” Bay
Intel	i740 8MB AGP Card	N/A	IMRB82510433	AGP Slot
Diamond*	3DII Graphics Card	23150105-005	1680100001435	PCI Slot 3

Full Bios Revision	4S4EB2X0.86A.0009.P03

Table 2-1 System configuration

2.2 Documentation References

2.2.1 Thermal support documentation

Supplier	Reference.
Intel	Application note, AP-586 Pentium® II Processor thermal design guidelines. June 1997
	Pentium® II Processor at 233, 266, 300 & 333MHz. June 1997
	Pentium® II Processor at 350, 400 & 450MHz. August 1998
	Pentium® II Processor specification update February 1999.
	Intel® Pentium® III Processor 450 & 500MHz.

Table 2-2 Support documentation

2.3 Processor setup

Process tested at 500/100MHz CPU/FSB speed.
No secondary fans were fitted in this chassis.
A standard fan was fitted in the PSU. The PSU fan was extracting air from the Chassis.

2.4 Software utilities for stressing the Processor

Hi power stress software was utilized for these tests. The software was designed to run the processor core and the BSRAM L2 cache near to their respective maximum achievable power levels.

3. S.E.C.C.2 OLGA HEATSINK COOLING IN AN ATX CHASSIS

3.1 Setup

Thermocouples or the Maxim 1617 are attached to the specified components (see section 3.4) and the EUT is placed in a Thermal Chamber. During all thermal test runs thermal grease (Thermalcote II, Thermalloy Inc.) or a specified thermal pad was present between the processor and the Heatsink under test.

3.2 Equipment

The accuracy of the type “K” thermocouples used during this testing is +2.5/-0°C.
The accuracy of the Maxim 1617/Thermal diode is +/-3.0°C.

Supplier	Description	Model/Part Number	Serial Number
Thermotron	Thermal Chamber (walk in)	WP-499-THCM2-705	23065
Thermotron	Thermal Chamber	S-8SLE	24207
Cambridge Accusense	Airflow monitor	ATM-24	
Cambridge Accusense	Airflow probe	CAFS-220-5M	
Testo	Testo air volume flow tunnel		
Testo	Testo digital anemometer.	0560.4900	
Testo	Testo probe.	0635.1549	
Maxim	Thermal diode monitor	MAX1617EV	

Table 3-3 Thermal equipment

3.3 EUT

See section 2

3.4 Method

Measurements were taken directly from the $T_{plate}/T_{case}/T_{junc}$ or chassis of the EUT. The T_{junc} measurement is made via the thermal diode in the processor core and the Maxim 1617-evaluation kit, the T_{plate}/T_{case} measurements are made with type “K” thermocouples. The EUT was tested in a thermal chamber for 2 hours at a temperature of 35°C @ 35% Humidity, or until the EUT has reached thermal equilibrium.

KEY:

T_{plate} = Temperature measured at the point of contact between the metal plate on the processor and the heatsink attached.

T_{case} = Temperature measured at the point of contact between the case of the processor core or the case of the component under test and any heatsink attached to the component.

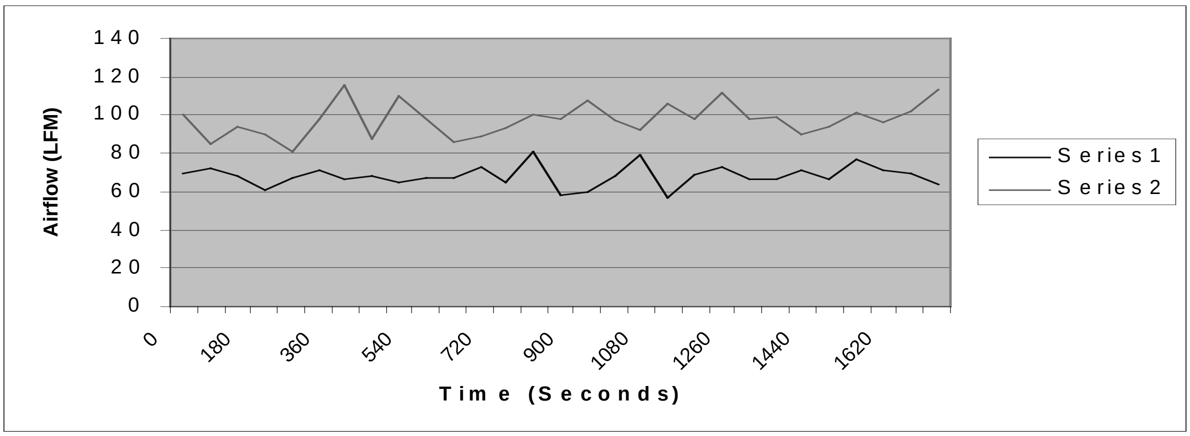
T_{junc} = Temperature measured by a diode built into the processor silicon.

3.5 Test results and Observations

3.5.1 Airflow tests

All airflow measurements are in Linear Feet / Minute (LFM). Please refer to Section 3.5.4 for more information.

3.5.2 Average Airflow for Active Heatsinks

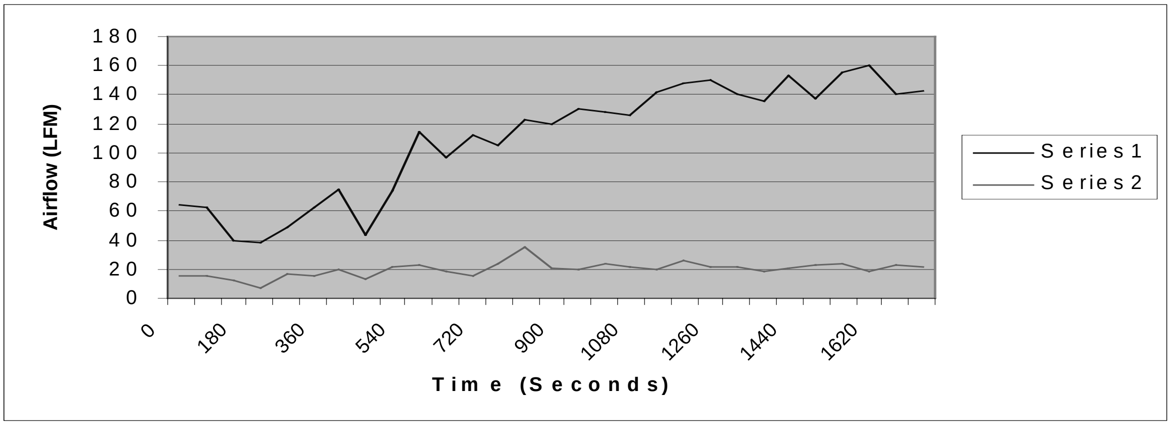


Air Flow Probe	Position in Chassis.	Av. LFM
Series 1	Next to the PSU.	72
Series 2	On the nearest Dimm to the processor ¼" above the Dimm facing the processor.	97

Figure 3-1 Active Heatsinks

3.5.3 Average Airflow for Passive Heatsinks.

Note: Probe 2 for the passive heatsinks was rotated 90° to face the PSU and not the processor.



Air Flow Probe	Position in Chassis.	Av. LFM
Series 1	Next to the PSU.	93
Series 2	On the nearest Dimm to the processor ¼" above the Dimm facing the PSU.	17

Figure 3-2 Passive Heatsinks

3.5.4 Probe positions

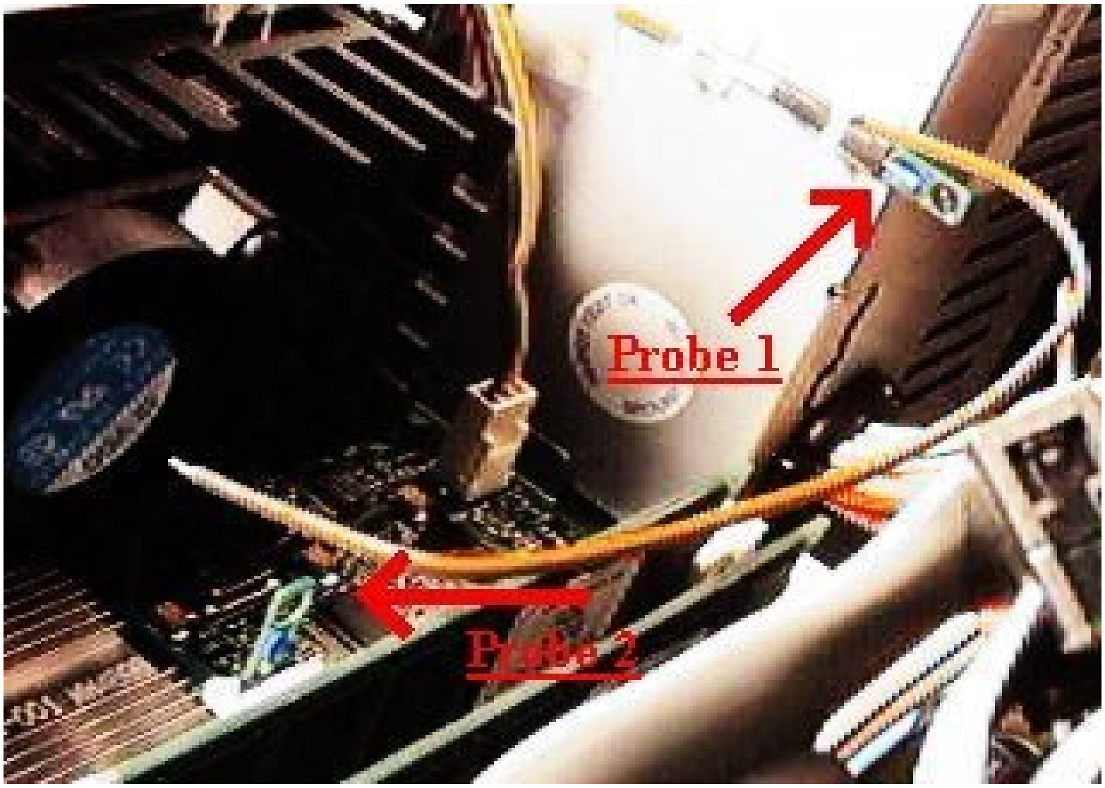


Figure 0-3 Airflow probe positions

Probe 1 = series 1
Probe 2 = series 2

NOTE.

The airflow measured by the probes below 30 LFM can be discounted as the accuracy of the probes is not guaranteed.

3.5.5 Passive Heatsinks.

The airflow shown Figure 3-2, gives a generic idea of the problems faced in cooling a passive Heatsink in an ATX chassis. As is clearly shown the average airflow for the chassis is 55 LFM with the maximum being next to the PSU at 93 LFM, while 10cm away from probe 1 at probe 2 the airflow has dropped to an average of 17 LFM. The design airflow requirement for passive Heatsinks is 200 LFM.

Clearly this is a major short fall. Both of the passive OLGA Heatsinks tested failed both the processor $T_{junction}$ and the L2 cache BSRAM T_{case} specifications by a minimum of 37°C for the $T_{junction}$ and 21°C for the L2 T_{case}.

3.5.6 Active Heatsinks

From the diagrams in Figure 3-1, it can be seen that the average airflow at probe 2 is now 97 LFM, this is generated by the Heatsink mounted fan of the active OLGA Heatsinks. Active Heatsinks are generally designed for use in low airflow chassis, however other considerations need to be taken into account for selecting the correct active OLGA Heatsink / chassis combination.

Six active solutions were tested. Three of these solutions passed both the processor $T_{junction}$ and the L2 cache BSRAM T_{case} specifications. The other three failed the $T_{junction}$ specification but passed the BSRAM T_{case} specification. This paper will look at the $T_{junction}$ and the L2 cache BSRAM T_{case} separately.

Taking the $T_{junction}$ specification first, the maximum temperature requirement is 90°C. Of the 3 solutions that passed one of them was 15°C lower, this solution's Heatsink fan produced the highest airflow at an average of 193 LFM. The other two passing solutions produced $T_{junction}$ temperatures just above the maximum of 90°C but were classed as passes within the logging systems specifications. The average airflow of these solutions was 94 LFM.

$_{junction}$ temperatures were on average 110°C, with their average airflow being 74 LFM. The third failing solution was 37°C over with an airflow of 52 LFM.

Clearly it can be seen from the above the higher the airflow generated by the Heatsink mounted fan the lower the $T_{junction}$ temperature. Caution should be used here as this high airflow Heatsink was not supplied with a thermal pad and therefore thermal grease was used. Thermal grease has a lower thermal resistance than a pre formed pad but would only account for at most 2 to 3°C of the temperature reduction seen. Grease is not a good long term solution for these type of Heatsinks as over a period of time the grease would be pushed out of the processor core to Heatsink junction and could result in a reduced thermal performance.

The L2 cache BSRAM T_{case} specification is 105°C, all six of the active solutions met this specification. The design of these OLGA Heatsinks is such that they make no contact with the processor BSRAMS. Two designs are available one incorporating a “Thermal Chimney” and the other with the standard flat Heatsink back. A “Thermal Chimney” is a raised section on the back of the Heatsink with slots through to the front set above the BSRAM. This acts in the same manner as a normal chimney, in that it will draw the heat generated by the BSRAMS up through the Heatsink as the BSRAM warm up.

From the results of all six Heatsinks no difference was noted between the performance of the “Thermal Chimney” or standard designs. The solution with the 193 LFM airflow, with a “Thermal Chimney”, returned similar results to the solution with 52 LFM with no “Thermal Chimney”, both returned values around 100°C.

3.5.7 Heatsink attachments

Some consideration should be given to the attachment method of the Heatsink design chosen. As some of the solutions tested made contact with surrounding components on the motherboard.

4. SUMMARY

As has been shown, to achieve the required level of airflow over the processor’s passive Heatsink requires the use of additional high airflow fans with the correct use of ducting to direct any airflow over the Heatsink. There are 2 problems with these solutions. The addition of these fans and ducting adds a cost overhead to these (ATX) chassis. Also adding extra fans to a system will increase the perceptible noise output and possibly contravene local environmental regulations.

The testing as carried out has shown there are distinct advantages to using an active Heatsink as opposed to the passive Heatsinks in this ATX chassis. The benefits far out weight the initial additional cost incurred. As active Heatsinks are mounted inside the chassis generally well away from the actual sides, the additional noise output generated by the Heatsink fan is reduced and this could be a consideration depending upon the noise regulations in force. The PSU fan is not required to cool the Heatsink so a wider choice of PSU’s could possibly be available for the chassis manufacturer.

The choice of active Heatsink solution should be matched to the chassis average airflow capability, with careful consideration being given to the airflow generated by the Heatsink fan and the attach method of the Heatsink.