Thermal Airflow Considerations

PPGA370 Heat Sink Cooling In µATX Chassis

May 1997

Order Number: 245025-001

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CONTENTS

1. INTRODUCTION..4

1.1. Overview 4

1.2. Background..4

2. EQUIPMENT UNDER TEST (EUT)………………………………….5

2.1. EUT Configuration. 5

2.2. Documentation References. 6
 2.2.1. Thermal support documentation. 6

2.3. Processor setup. 6

2.4. Software utilities for stressing the EUT. 6

3. PPGA370 HEAT SINK COOLING IN µATX CHASSIS……………...7

3.1. Setup..7

3.2. Equipment..7
 3.2.1. Thermal Equipment..7

3.3. EUT 7

3.4. Method 8

3.5. Test results and Observations..9
 3.5.1. Airflow tests...9
 3.5.2. Passive PPGA370 Heat sinks...10

4. SUMMARY. 12

4.1. Conclusions 12

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 heat sinks used in the cooling of Intel® Celeron™ PPGA370 microprocessors. This document will look at the typical airflow characteristics of some of these chassis and the effect this could have on the capacity of the heat sink to cool the processor.

1.2 Background

As the power of motherboards and hardware increases, for example, a typical 233MHz Pentium® processor was rated at approximately 17 watts, a 366MHz Celeron™ processor is rated at 22 watts, hard disk drives are running faster and hotter, the demands on the cooling capacity of any given system are increasing.

The demand for smaller chassis, microATX (µATX) and power supply (SFX, PS3, ATX) combinations, is reducing the ability of a given chassis (µATX) to cope with these increases in thermal output.

The main source of cooling in a typical µATX system has been the power supply unit (PSU). As the PSU has been reduced in size but still has to maintain and even increase it's load capacity, the electronics have been squeezed into a smaller volume, this has effectively reduced the airflow through the PSU and thereby the airflow in the rest of the µATX chassis.

In parallel to this shrinking of chassis and PSU's, legislation has forced a reduction in overall noise output of these systems, the main contributor to noise in a system is the fan. The most effective way of reducing fan noise is to slow down the rotation of the fan blades. This again has the effect of reducing system airflow and increasing the thermal problems.

2. EQUIPMENT UNDER TEST (EUT)

2.1 EUT Configuration.

Two different but representative µATX chassis were used for a comparison of the PPGA370 heat sinks tested, they were configured as per Table 2-1. Both used ATX PSU’s, as these were the most widely available PSU at the time of testing. As a side issue these PSU’s as they are larger in physical size to the SFX and PS3 PSU’s should be capable of provide more cooling for the system.

Supplier	Description	Model/Part Number	Location
Chassis Z.	Mini Tower ATX Chassis	N/A	N/A
	ATX PSU	N/A	Top Rear of Chassis
Chassis Y.	ATX Mini Tower Chassis	N/A	N/A
	ATX PSU	N/A	Top Rear of Chassis
Intel	BI440ZX Motherboard	721265-102	N/A
Intel	366 MHz Celeron™ Processor	FV524RX366 128 Q921ES	PPGA Socket
Micron*	2 x 32Mb 66 MHz SDRAM DIMM	BE3-0 94V-0	DIMM Slots
Sony*	Floppy Drive	MPF520-E	Floppy Drive Bay
Maxtor*	6.4GB IDE Hard Drive	90680D4	Internal 3½” Drive Bay
Sony*	32X IDE CDROM Drive	CDU701	Top 5¼” Drive Bay
Intel	Express 3D i740 Graphics Card	AA 691879-300	AGP Slot
Diamond*	Monster 3D II 3D Graphics Accelerator	23150109-101	PCI Slot 1

BIOS Rev (non standard to unlock thermal throttles)	4B4IZ0XA.86A.0000.D.9810081357

Table 0-1

The BI440ZX was configured with thermal throttling enabled and unlocked.

2.2 Documentation References

2.2.1. Thermal support documentation.

Supplier	Reference.
Intel	Celeron™ Processor at 266 & 300MHz datasheet. May 1998, P/N 243658-002
	Celeron™ Processor Specification Update June 1998. P/N 243748-003

Table 0-2

2.3 Processor setup.

The systems were tested at 366/66Mhz CPU/FSB speed.

2.4 Software utilities for stressing the EUT.

Note some or all of these utilities may have been used in the testing of this EUT. See section 3.

Kpower

The utility 'KPOWER.EXE' is run in a DOS window under Windows* NT or Windows 95 , this utility increases the power dissipated by the slot 1 processor core to approximately 85% of the specified maximum. If 2 processors are present then Kpower is run twice in 2 DOS windows but only under Windows NT.

Bxpower.

The utility 'BTTS03.EXE' is run in a DOS window under Windows* 95. This utility stresses the BX/ZX chipset. BTTS03 is a utility designed to test the thermal design power for an Intel® 82443BX PCI/AGP Controller.

Ziff Davis* Winbench* 97.

A selection of industry standard PC benchmarks including hard disk and video tests.

3. PPGA370 HEAT SINK COOLING IN μATX CHASSIS

3.1 Setup

Thermocouples and non-intrusive airflow probes were attached to the specified components (see section 3.5) and the EUT was placed in a Thermal Chamber. During all thermal test runs thermal grease or a thermal pad was present between the processor and the heat sink.

3.2 Equipment

3.2.1 Thermal Equipment

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	

Table 0-3

3.3 EUT

See section 2

3.4 Method

Measurements were taken directly from the Tcase of the EUT. The EUT was tested in a thermal chamber for 2 hours at a specified ambient temperature (if a maximum temperature is not specified by the customer the temperature used is 35°C @ 35% Humidity), or until the EUT has reached thermal equilibrium.

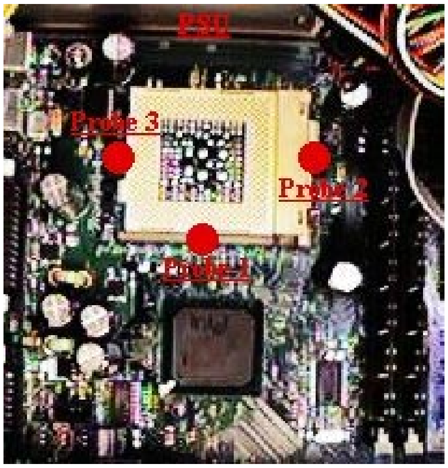
KEY:

Tcase = Temperature measured at the point of contact between the case of the processor
core or the case of the component under test and any heat sink attached to the component.
EUT = Celeron™ processor and active or passive heat sink.
Active heat sink = A heat sink with a fan fitted to the cooling fins.

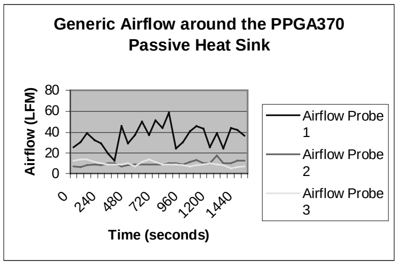
3.5 Test results and Observations

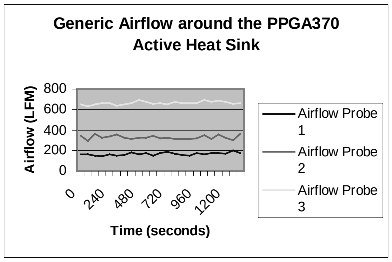
3.5.1 Airflow tests.

For the airflow tests 3 probes were attached to the PPGA370 heat sinks in similar positions.

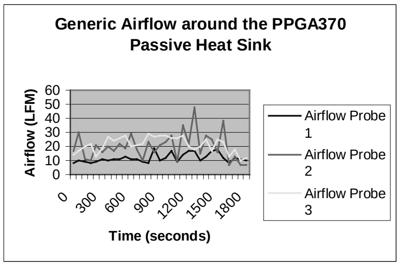


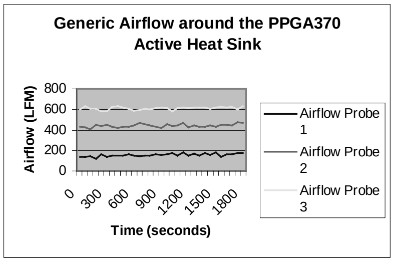
Probe 1 measured the airflow before the heat sink (hs)
Probe 2 measured the airflow entering the hs (or exhausting if the hs was active)
Probe 3 measured the airflow entering or exhausting depending on the position of the PSU and if the hs was active or passive.





Airflow in chassis Y. A. B.





Airflow in chassis Z. C. D.

Charts 0-1

The 2 right hand charts (B. and D.) show the generic airflow for the active heat sinks as used in both chassis. These charts clearly show that the minimum airflow in both instances was around 200 linear feet per minute (LFM). All of the active heat sinks tested gave a similar LFM and none of the PPGA370 active heat sinks allowed the processor Tcase to exceed the maximum set Tcase (85°C) for the Celeron™ processor at 366MHz as tested. Therefore for this paper the active heat sinks will be ignored and testing will be concentrating on the passives.

3.5.2 Passive PPGA370 Heat sinks.

The airflow shown in Charts 3-1 diagrams A and C, give a generic idea of the problems faced in cooling a passive heat sink in µATX chassis. As is clearly shown the average airflow for both systems is about 20 to 30 LFM with a maximum transient peak of 60 LFM. The design airflow requirement for passive heat sinks i s 200 LFM. Clearly this is a major short fall. The rest of this paper will look at methods that could be used to rectify this problem.

Chassis Z

Photo 0-1

Chassis Y

Photo 0-1

The 2 PSU's shown in the above photo's, whilst of similar specification have a completely different layout. Chassis Z PSU has vents facing the peripheral bays and the motherboard, while chassis Y only has vents facing the peripherals. However chassis Y has a low power fan mounted on the rear of the chassis below the PSU. Both chassis have mounting points for fans on the front panel but chassis Z has no provision for a rear panel fan.

The average airflow at the vents on chassis Z PSU was 100 LFM and on chassis Y was 63 LFM. The approximate airflow generated by the low power fan on chassis Y was between 100 and 150 LFM at a point 3 centimeters in front of the rotating blades. As has already been shown the average airflow around the processors is 20 to 30 LFM.

Taking chassis Y first, to increase the airflow over the heat sink, there are a couple of options. The first would be to replace the relatively low airflow fan with a higher output unit. Two fans were considered:

1. PAPST∗ 8412NM
2. Comair∗ ST12K3-030613.

Fan 1 generated 365 LFM. This was measured through a simple Testo wind tunnel, fan 2 measured 460. Some basic assumptions will now be made, as the fan mounting positions for different chassis have differing airflow characteristics, It will be assumed that when in position, the airflow of any fan will be reduced by ½. Therefore, fan 1 will have 182 LFM and fan 2 230 LFM. Another assumption used is that unless the airflow is contained in some form of ducting, at 1 diameter away from the fan the flow will be reduced by ½ again, for fan 1 this gives 91 and for fan 2 115 LFM. Clearly even when using modern high airflow fans they cannot generate the required airflow over the heat sink. The next step would be to direct the flow. This can be achieved by the use of simple ducting, from the fan to the heatsink. This will have the benefit of removing the second assumption above, therefore both fans could provide the required airflow to cool the heat sink. The draw back of ducting is that it directs air to one point in a chassis but reduces the airflow in others, for example around the hard disk bay.

Chassis Z only has a fan mounting point on the front panel. So using all of the above assumptions but also taking into account the use of add-in boards and peripheral cables between the front panel and the processor, it becomes obvious that the airflow at the heat sink would again be inadequate to cool it. Ducting from this fan would be impractical as it (the fan) is too far away from the processor.

However ducting could be applied to the PSU vents nearest the processor this together with either fan 1 or fan 2, could achieve the required airflow over the heatsink.

From the above information it can be seen that in both chassis adequate cooling could be generated by the use of good, high airflow fans in conjunction with correctly placed ducting directing the airflow over the heat sink.

4. SUMMARY

4.1 Conclusions

As has been shown, to achieve the required level of airflow over the processor's heat sink requires the use of additional high airflow fans with the correct use of ducting to direct any airflow over the heat sink.

There are 2 problems with these solutions.

The addition of these fans and ducting adds a cost overhead to the cost of these (µATX) 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 heat sink as opposed to the passive heat sinks in these µATX chassis. The benefits far out weight the initial additional cost incurred. As active heat sinks are mounted inside the chassis generally well away from the actual sides, the additional noise out put is negligible. These active heat sinks can be used in any µATX chassis, regardless of the cooling capacity. The PSU fan is not required to cool the heat sink so a wider choice of PSU's could possibly be available for the chassis manufacturer.

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