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An0046

CPU-1450; Thermal management

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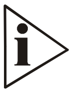
NOTICE

Conventions

The following table lists conventions used throughout this guide.

Icon	Notice Type	Description
	**Information note**	Important features or instructions
	**Warning**	Information to alert you to potential damage to a program, system or device or potential personal injury

Mode of the register:
R/W: Read and write register.
RO : Read only register.
W : Meaning of the register when written.
R : Meaning of the register when read.

Name ranges:
A name followed by a range in brackets, for example Name[0:2], represent a range of logically related entities.

Hex Number:
Hexadecimal numbers are represented with a ‘h’ suffix. (for example 11Ch)

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Chapter 1 CPU-1450 board

The CPU-1450 is a Eurotech PC/104 Plus module based on the 82815 chipset and the Celeron ULV 400Mhz uFBGA package processor. A custom thermal interface has been engineered for this CPU module, allowing a simple mechanical mount for managing thermal transfer.

This application note is intended to describe the thermal interface of the CPU-1450 to allow users to develop a custom solution for thermal management.

Some pratical case studies are included to explain the benefits of adding an external heatsink to the CPU-1450 thermal architecture. This solution allows the user to use the CPU-1450 in higher ambient temperature.

CPU1450 thermal interface

The CPU-1450 thermal interface consists of an aluminum heatsink thermally connected to the hot points of the board. Different types of thermal elastometers are used for the connection to decrease the thermal resistance.

The thermal elastometers have been directly installed to the main chips listed below:

- Intel ® Celeron ULV 400Mhz uFBGA package processor
- Intel ® FW82815 chipset
- Intel ® FW82801 chipset
- Memory
- Clock synthesizer

Heatsink mechanical architecture

Figure 1 shows the mechanical dimensions of the thermal interface. You can see the areas where thermal elastometer "Sarcon" has been placed to increase the thermal transfer.

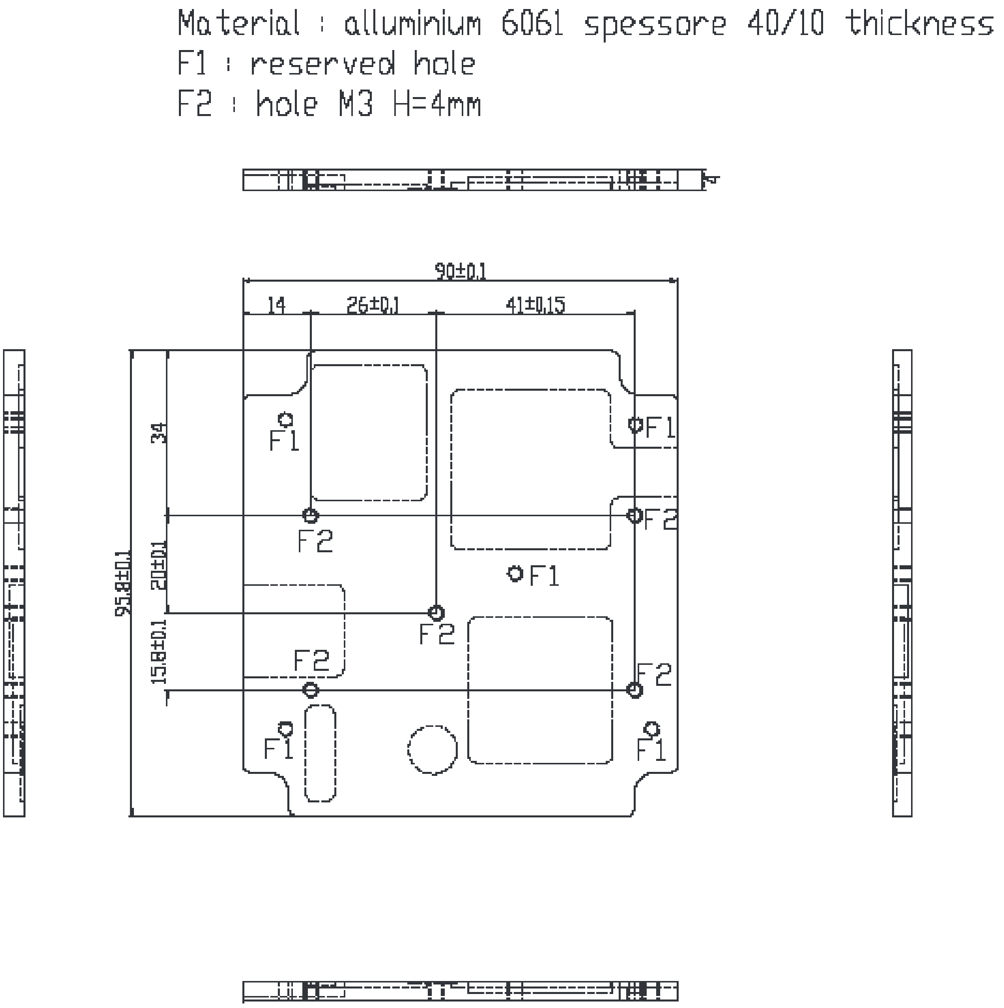

Figure 1. Thermal Interface

The heatsink of the CPU-1450 can be mechanically installed over a dissipative surface using the holes drilled into the heatsink surface (Referring to Figure 1, labeled F2).

The F2 holes are reserved to attach the heatsink to a dissipative layer.

⚠ To prevent damages to the PCB, make certain the length of the bolts do not exceed the thickness of the heatsink. If the bolts are too long, the board may be mechanically damaged and no remedy is available!

Thermal Elastometers

To compensate for different thickness and thermal resistances of the chipsets, different elastometers with different thermal resistances need to be used to match each chip requirement of dissipation.

Table 1 summarizes the characteristics of the Sarcon High heat conductivity gap filler pad materials, which can be correlated with Figure 1.

Ref	Elastometer Material	Dimension	Thickness
A	SARCON GR-M	28x28mm	1.0mm
B	SARCON GR-M	Ref 3D drawing	2.0mm
C	SOFTTHERM 86/200	Ref 3D drawing	2.0mm

Table 1. Main Elastometers characteristics

Sarcon ® Thermal Gap Filler Pads are very conform able high heat conducting gel materials in a versatile sheet form. They easily match and adhere to most all shapes and sizes of components, including protrusions and recessions.
In areas where space between surfaces is uneven or varies or where surface textures are a concern regarding efficient thermal transfer, the supple consistency of the pads is excellent for filling air gaps and uneven surfaces. The following table summarizes the main technical information about Sarcon ® GR-M material:

	Identifier	Test Method	100G-M	200G-M
Thickness	mm	Fujipoly	1.0^±0.2	2.0^±0.3
Thermal Resistance	°Cin²/W	ASTM D5470 Equivalent	.32	.64
Color	Visual	Fujipoly	Dark Reddish Gray	Dark Reddish Gray
Thermal Conductivity	watt/mk	ASTM D5470	6.0	6.0
Volume Resistance	M Ohms · m	ASTM D257	1.3 x 10^6	1.3 x 10^6
Withstand Voltage	kV/mm·AC	ASTM D149	13	13
Specific Gravity	gr/cm³	ASTM D792	3.2	3.2
Hardness	Shore 00	ASTM D2240	< 52	< 52
Elongation	%	ASTM D412	80	80
10% Compression	Kgf/in²	Fujipoly	10.7	8.1
50% Compression	Kgf/in²		87.3	76.8
Sustain 50% Compression	Kgf/in²	Fujipoly	50.6	39.5

Table 2. Sarcon ® GR-M Main characteristics

For detailed information on elastometers characteristics please refer to the Fujipoli website http://www.fujipoly.com .

CPU-1450 3D Model

To allow the best view of the CPU-1450 thermal interface, the “DemoE4202.exe” file is provided in the “Tools” section of the “Download area” for the CPU-1450. It will give the user a different point of view of the board.
This file will launch the eDrawing 2004 application. It allows analyzing the various components of the thermal interface.

To run the application a windows O.S. is required.

The following table shows the description of each “Component” listed in the application.

Component	Ref	Description
E4202-01	--	CPU-1450 PCB and components assembly
1060000080-01	--	CPU-1450 Alluminium 6061 40/10 tickness – Ref Figure 1
GR-M 1mm 20x20-1	A	SARCON GR-M 1 mm
GR-D 2mm 32x32-1	B	SARCON GR-M 2 mm
1592000020-S00-1	--	PCB to Heatsink Spacers
1592000020-S00-2	--	PCB to Heatsink Spacers
1592000020-S00-3	--	PCB to Heatsink Spacers
1592000020-S00-4	--	PCB to Heatsink Spacers
1592000020-S00-5	--	PCB to Heatsink Spacers

Table 3. eDrawings 2004 Legend

Chapter 2 Increasing Thermal Performances

Depending on the thermal requirement (mechanical dimension, maximum operative temperature, etc.), a specific heatsink may be installed over the CPU-1450 thermal interface. For this reason, this document is a good starting point to develop a custom heatsink to be connected to the CPU-1450 thermal interface. This allows the increase of the thermal capability of the system and provides some case studies.

The maximum CPU operative temperature must not exceed 90°C (for safety concerns).

The power consumption of the board is at least 8.5W with Memtest 3.1 running continuously (http://www.memtest86.com/). (Memtest 3.1 makes the processor run at maximum speed.)

Tested Heatsink configuration

We provide several tests on the following configurations:

- Without heatsink – Verifying the maximum operating temperature
- With heatsink 1 – Verifying the maximum operating temperature
- Defining a maximum operative temperature – Selecting the appropriate heatsink 2

This information may be useful for users in determining which thermal approach is best for the custom application.

Test Setup

All previous configurations have been tested on a climatic chamber Model Angelantoni Industrie, series Hygros model 250C setting the working temperature and waiting for regulation of the device with the CPU-1450 always powered and running the memory test Memtest 3.1 for at least two hours measuring at the end the reached temperature.

Board Temperature MAX1618.exe utility

A utility has been developed by Eurotech to verify the temperature of the board; the software, called MAX1618.EXE, is provided in the "Tools" section of the "Download area" for the CPU-1450.

This software allows users to verify the board temperature during a test session.

Chapter 3 Practical results

This chapter is intended to summarize the results obtained measuring the operating temperatures using different methods for thermal dissipation adding different heatsinks models as listed in the previous chapter.

Without a heatsink

This test is useful to show the maximum operative temperature conditions. The CPU-1450 is working without any additional heatsink.
The CPU-1450 has been placed on the climatic chamber running Memtest 3.1, increasing the ambient temperature and measuring the highest temperature of the CPU-1450. The ambient temperature peaked at 68°C, which corresponded to a CPU-1450 temperature of 89°C with a safe margin to prevent damages.

Heatsink 1

We selected a standard heatsink with minimal dimension characteristics, low cost, and easily available on the market. This setup ran the system at the temperature of 70°C.
To increase the temperature transfer between CPU-1450 thermal interface and heatsink we placed a layer of silicone heat transfer compound (HTS silicone heat transfer compound - Electrolube Code HTS35SL).
The mechanical characteristics of this heatsink are illustrated on Figure 2 and Table 4:

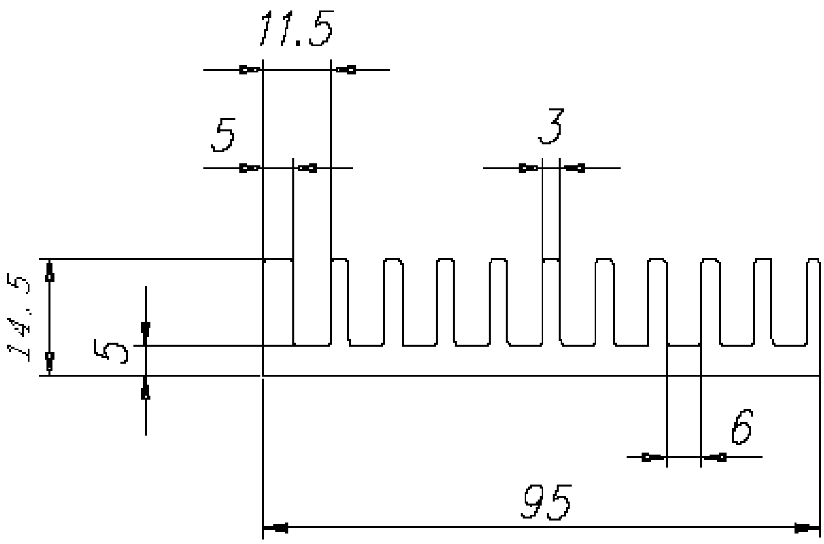

Figure 2. Heatsink 1 mechanical dimension

Length	90mm
Weight	0,810 g
Rt °C/W	~2 °C/W

Table 4. Heatsink 2 characteristics

The system works fine and peaked at 75°C ambient temperature.

Heatsink 2

The approach used in this case was different than the previous two.
We selected a target operative temperature of 80°C and we proceeded looking at a particular heatsink with characteristics that fulfilled the requirements.

The following relation gave us the thermal resistance R_{th} of the heatsink we've to select.

$$R_{th} = \frac{(T_{CPU} - T_{AMB})}{P_w}$$

R_{th}	is the thermal resistance in °C/W	(To be defined)
T_{CPU}	is the maximum CPU-1450 temperature	(From specification = 90°C)
T_{AMB}	is the ambient temperature	(From specification = 80°C)
P_W	is the power dissipated by the CPU-1450	(From specification = 8,5W)

Making the calculation taking a 1°C of safety we obtain:

$$R_{th} = \frac{((90°C - 1°C) - 80°C)}{8,5W} = \frac{(89°C - 80°C)}{8,5W} \approx 1°C/W$$

Looking at a heatsink with the previous requirements we found the following one with the mechanical characteristics illustrated on Figure 3 and Table 1:

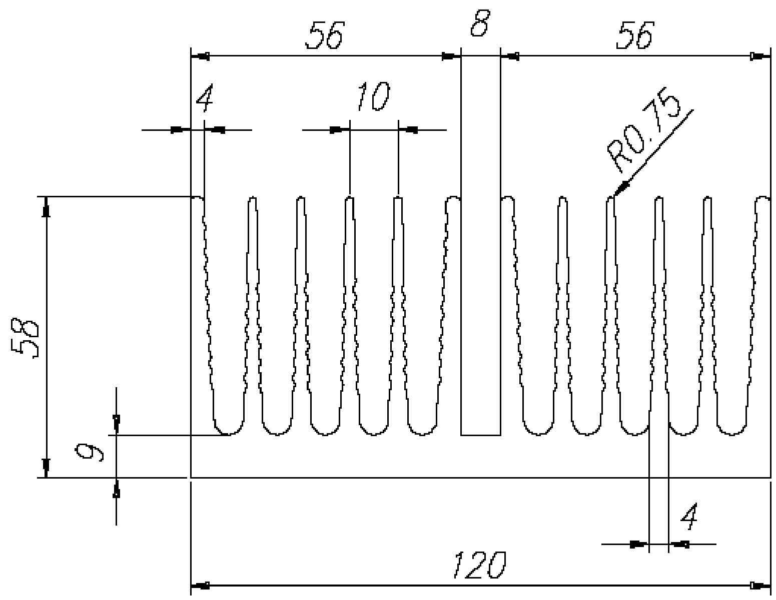

Figure 3. Heatsink 2 mechanical dimension

Length	100mm
Weight	0,810 g
Rt °C/W	0,82 °C/W

Table 1. Heatsink 2 characteristics

To increase the temperature transfer between CPU-1450 thermal interface and heatsink we placed a layer of silicone heat transfer compound (HTS silicone heat transfer compound - Electrolube Code HTS35SL).

Natural Convection

In all previous examples we suppose the system is naturally convected without any fan.
Looking at the heatsink fin spacing those are optimized for natural convection as the relations contained on the following table:

	Fin length, mm (in)			
Flow condition m/s (lfm)	**75** (3.0)	**150** (6.0)	**225** (9.0)	**300** (12.0)
Natural convection	**6.5** (0.25)	**7.5** (0.30)	**10** (0.38)	**13** (0.50)
1.0 (200)	**4.0** (0.15)	**5.0** (0.20)	**6.0** (0.24)	**7.0** (0.27)
2.5 (500)	**2.5** (0.10)	**3.3** (0.13)	**4.0** (0.16)	**5.0** (0.20)
5.0 (1000)	**2.0** (0.08)	**2.5** (0.10)	**3.0** (0.12)	**3.5** (0.14)

Table 5. Fin spacing (in mm/inches) versus flow and fin length

reference Electronics Cooling, http://www.electronics-cooling.com/ .

Related Documents

For more information please refer to the specific CPU user manual. http://www.eurotech.it
MAX1618.EXE CPU-1450 Temperature measurement DOS utility http://www.eurotech.it
Memtest 3.1 http://www.memtest86.com/
How to select a heat sink http://www.aavidthermalloy.com/technical/papers/pdfs/select.pdf
Natural Cooling http://www.electronics-cooling.com/

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