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Solving The Delay Issue In Fan Response To Sudden Component Temp Rise By Using Phase Change Material In Servers

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SOLVING THE DELAY ISSUE IN FAN RESPONSE TO SUDDEN COMPONENT TEMP RISE BY USING PHASE CHANGE MATERIAL IN SERVERS

Abstract

This patent suggest to add a transient thermal solution to the existing steady state solution. The suggested transient thermal solution is a phase change material heat sink (PCM HS) to be added to the existing heat sink (assuming an air-cooled heat sink is already in place). A heat pipe to be utilized to connect the PCM HS to the existing heat sink. The heat pipe should have the capacity to transfer the max amount of heat dissipated by the component. The PCM heatsink contain PCM between its fins, and it is sealed to prevent leakage. When sudden power increase is experienced the heat will be transferred through the heat pipe to the PCM HS to be absorbed by the PCM, causing an instant melting of the PCM and preventing a steep rise in component temperature giving the fans more time to gain control of the temperature.

Introduction

In typical servers, components are cooled by system fans. The system fans speed is driven by ambient and components temperatures. Some components may have a sudden power increase, due to high data processing load, which will result in increasing components temperatures. This temperature rise drives the fans to increase their speed in order to stop the component temperature from rising beyond its max thermal limit. However in many cases the fans experience a delay in response resulting in the components to exceed their thermal limit for a short period of time.

A good example for such situation is some of the thermally challenging CPU's, even though some systems do have thermally sufficient steady state solution to cool the CPU's (for example appropriate heatsink and fan(s)) they might reach throttling point before fans react properly. The delay in fan(s) response might be associated with the following:

1. Frequency temperature is collected. Sensors are set up to scan and report the temperature a fixed time period (for example one second). This time period can be long for some challenging components.
2. Slow reaction of the management firmware that is driving the fans.
3. Mechanical lag of the fans due to the mass of the rotating parts.

If CPU thermal limit is reached, its performance will be reduced, and customers do not want this lost performance, even for a short period, which is addressed by this patent.

Solution:

This patent suggest to add a transient thermal solution to the existing steady state solution. The suggested transient thermal solution is a Phase Change Material Heat Sink (PCMHS) to be added to the existing heat sink (assuming an air-cooled heat sink is already in place). A heat pipe(s) is to be used to connect the PCM HS to the existing heat sink. The heat pipe should be designed in a way to have the capacity to transfer the max amount of heat dissipated by the component. The PCMHS contains PCM between its fins, and it is sealed to prevent PCM leakage. See figure 1

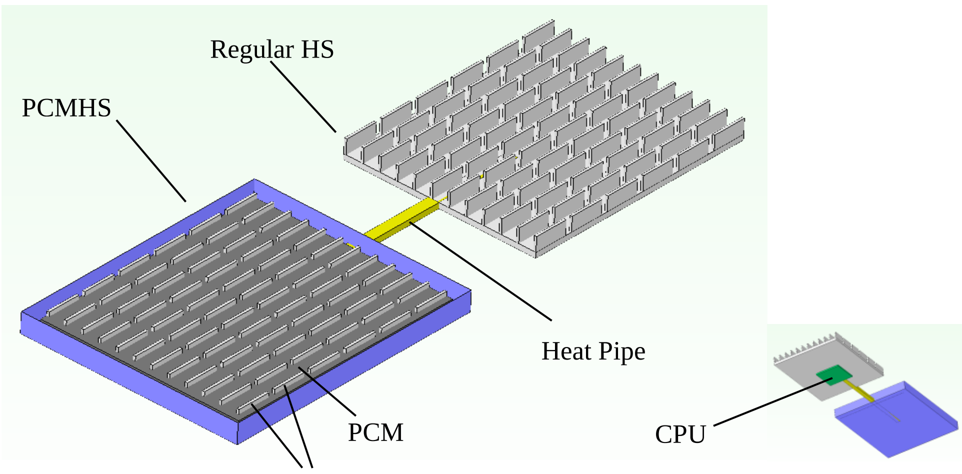


Figure 1. PCMHS is connected to the regular HS via heat pipe

When sudden component power increase is experienced the heat will be transferred through the heat pipe to the PCMHS and absorbed by the PCM, causing an instant melting of the PCM and preventing a steep rise in component temperature giving the fans more time to gain control of the temperature.

The amount of time delay of the temperature rise depends on the amount of PCM in grams, for example a component dissipating 50W, using 10 grams of the PCM65-P [(1)] (which has latent heat of 200 J/g):

Total heat required to melt the PCM is 200 J/g * 10g = 2000 J

Time to melt the PCM = 2000 J / 50W = 40 s

The temperature of the component will rise steeply after all the PCM has melted, therefore the **more grams of PCM is the slower temperature rise**.

The PCM HS fin pitch is to be optimized to have a good contact between the HS and PCM, yet to include the most quantity of the PCM. During PCM selection it should be insured that its melting temperature is lower than the spec temperature of the component. It is not necessary for the PCM HS to be located in the air flow for cooling.

Other Designs that attempt to achieve same result

Other companies have used power sense capability to proactively drive fan speeds.

Experimentation and Data

Several experiments were performed to investigate the effectiveness of the PCM on the CPU temperate rise when sudden power increase is experienced. A thermal test vehicle CPU was used. Two different configurations were tested, in the first configuration the PCMHS was installed directly on the CPU (Fig.2), and in the second configuration a regular (none PCMHS) was installed on the CPU, while two PCM HS's where connected to the regular HS through heat pipes (Fig.3). PCMHS's were stuffed with PCM65. The CPU temperature was collected by thermocouples.

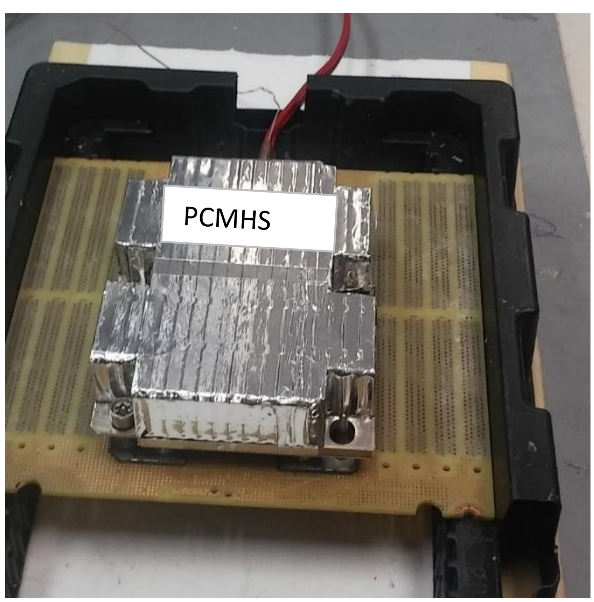


Figure 2 PCMHS installed on the CPU

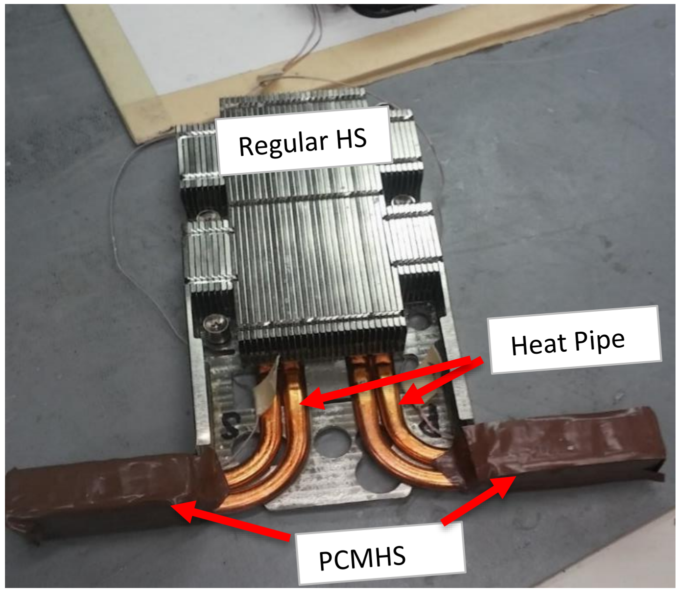
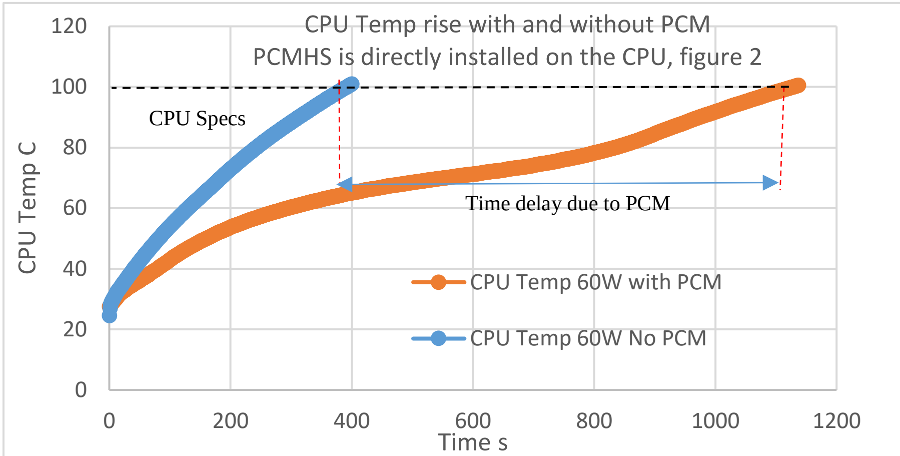


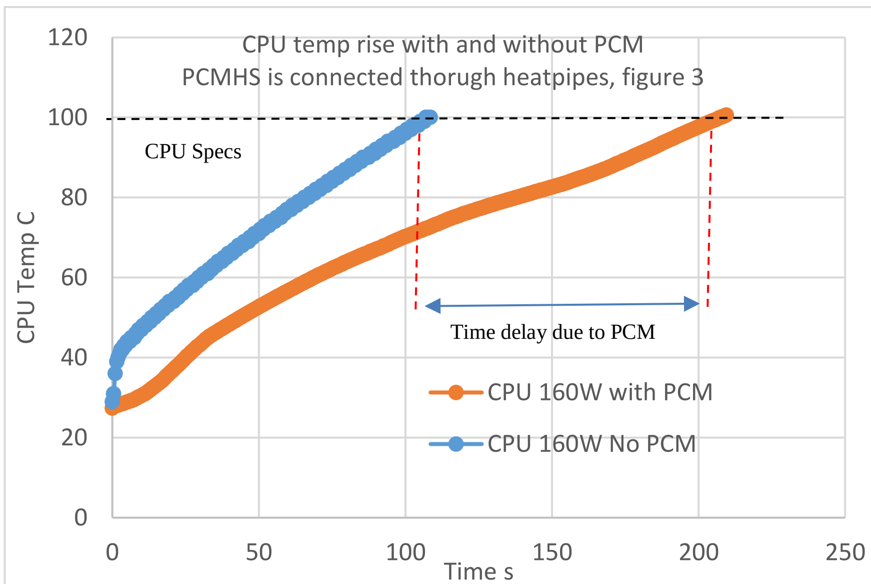
Figure 3 regular HS is installed on the CPU, while 2 PCMHS are connected to the regular HS via heat pipes

Result

The existence of PCM delayed the CPU temperature to reach the spec's when a sudden power increase was applied. See graphs 1, and 2. In real applications this delay in component temp rise will give the fans the time to catch up and control the temperature, thus prevent reduced performance.



Graph 1: CPU temp reaching specs is delayed when using PCM.
PCMHS is installed on the CPU. CPU power is 60W.



Graph 2: CPU temp reaching specs is delayed when using PCM.
PCMHS's are connected to the regular HS via heat pipes. CPU power is 160W.

(1) CM65-P (Hydrotreated Paraffin)- provided by Microtek laboratories, inc

Disclosed by Nabeel Fathi – Hewlett Packard Enterprise.