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# A new CPU cooler design based on an active cooling heatsink combined with heat pipes

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ABSTRACT

The performance of active CPU cooling heatsinks primarily depends on the forced air convection created by computer fans. Boosting the fan speed, however, results in noise, vibration problems, and increased power consumption. The active heatsink, therefore, should be optimized under the constraints of overall volume, cost, and noise level. In this paper, a new CPU cooler is proposed that provides a more efficient heat dissipation capacity from the CPU to a finned heatsink without adding more heat pipes at a low-noise level of a small fan under the confined space constraints of a computer chassis. Computational fluid dynamics simulations were used to search for a proper cooling design. The simulation results were validated with corresponding physical experiments. The proposed CPU cooler has been shown to provide a total thermal resistance of 0.11–0.19 °C/W at a noise level of 21.5–36.3 dBA.



## 1. Introduction

CPU thermal problems have become an issue in computer industries and markets. One popular cooling solution uses aluminum extrusion heatsinks with aluminum or copper plate fins soldered to copper metal bases. Most research and development for obtaining solutions that would meet cooling requirements has concentrated on the use of a computer fan to maximize the heat transfer rate from the heatsink.

The rapid development of silicon technology, the demands for more powerful computing performance, the manipulation of extensive data, and increasing graphic processing capabilities have led to today's highly complex, super-fast CPUs running at beyond 3 GHz. These advances were made possible by the advent of nano-electronics with integrated circuits of nano-meter size that can be routinely fabricated with high precision and manufacturing yield [1]. On the other hand, the typical heatsink technology cannot cool down super-fast CPUs effectively under low-noise conditions. The performance of most of these heatsinks primarily depends on the forced air convection created by computer fans. The higher fan speed causes the noise level to reach high values of over 40 dBA, which has a significant adverse effect on the computer users.

The typically permissible operating temperature of a CPU is below 70 °C. The reliability of the chips then decreases by 10% for every 2 °C above the permissible operating temperature [2]. To maintain the temperature below the permissible limit, an air active CPU cooling system comprised of a fan, finned heatsink, and heat pipe combinations has been commercially used because it can dissipate heat under the reliable operation conditions of CPUs [3–5]. However, the active air cooling heatsinks have encountered some development problems such as those associated with manufacturing costs and limiting the system size to the confined space within a desktop PC chassis because CPU over-clocking and high-end personal computers require new CPU coolers that are able to eliminate 2–3 times as much heat as that eliminated by existing systems under low-noise conditions.

Typically, the total thermal resistance ($R_t$) is used to evaluate the thermal performance of CPU coolers. The CPU junction temperature and ambient temperature are kept constant and are represented as $T_j$ and $T_a$, respectively. The heat dissipation ($Q$) of the CPU to the surrounding air can be expressed as

$$R_t = \frac{T_j - T_a}{Q} \tag{1}$$

Fig. 1 shows the general view of a thermal circuit for CPU coolers. $R_c$ represents the contact resistance between the CPU and

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