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ORIGINAL ARTICLE

CPU cooling using PWM interfaced peltier unit

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Abstract: With the increase in the processing power of the computer, there is an increase in operating temperature. Even though newer processors have the ability to handle high temperatures up to 80 or 100 degree C, CPU intensive applications or games may cause the CPU to go beyond the given safe temperatures and even reach the critical temperature. In order to protect the processor from damaging the manufacturers have built in a mechanism that causes the processor to throttle. Throttling reduces the frequency at which the processor is operating there by reducing the temperature. However throttling hinders the performance of the CPU for a certain period of time until it reaches under the limit of safe operating temperature. There are a lot of CPU air, liquid, coolers available in the market. However the one that do their jobs very well are either very expensive or bulky or require various arrangements to be made. This configuration discusses the integration of thermo-electric cooler with the already present on board PWM controller.

Keywords: *PWM, Throttling, Performance, Thermo-electric, Heat sink, Air cooler,* Temperature

I. INTRODUCTION

In the last recent years, there are huge advancements made in the software and game industry. With multiple CPU core and thread at disposal, software like the automation and design software, etc. are able to project real world scenarios in real time. However, the number of processing core and thread vary from CPU to CPU. As a result these software are generically designed to work on all types of CPU. These software may make full utilization of certain core whereas completely no utilization of the remaining cores. This will lead to increase in the temperature of the core under full utilization and thus leading to the rise in the overall temperature of the package causing the whole system to throttle.

II. NEED FOR THE INTEGRATION OF TEC WITH PWM CONTROLLER

One of the major problems with the thermo-electric cooling is the condensation. Cooling of the processor below the room temperature or the temperature inside the CPU cabinet will lead to the formation of water drop-lets around the peltier unit and the processor. These water drop lets may cause an electric short and damage the components. To avoid this thermo-electric cooler or the peltier unit cannot be directly connected to the +12V supply from the SMPS inside the CPU. As a result there arises a need for an additional circuitry that will control the peltier unit. In such a system there arises a need for the integration of sensors required for the measurement of the cabinet temperature, measurement of the temperature at the junction of processor and the cold side of the peltier unit, a separate processing unit such as the microcontroller to compare the data, and a power amplifier for handling the current requirement of the peltier unit. Another method that has been already implemented is the peltier control unit that interface with the USB ports of the computer and receives the required data and control the peltier unit. Both of the discussed methods are either very bulky to implement or are very expensive in terms of time invested in developing and the overall final cost of the unit.

Hence an alternative to the above two systems would be to use the onboard PWM fan controller. The Onboard PWM signal can be used by the power amplifier to control the peltier unit.

III. ABBREVIATIONS, ACRONYMS AND NOMENCLATURE

ACPI: Advance configuration power interface

CPU: Central processing unit

D: Duty cycle

DTS: Digital temperature sensor

GND: Ground

I-MAX: Maximum rated current

PW: Length of PWM wave in seconds

PWM: Pulse width modulation

PECI: Platform environment control interface

SMPS: Switch mode power supply

T: Time period of wave in seconds

TEC: Thermo-electric cooler

IV. TWEAKING THE ACPI AND THE PWM SIGNAL

ACPI stands for the ADVANCED CONFIGURATION

POWER INTERFACE. It controls the voltages supplied to the processor cores, on board graphics processing unit, PWM fan controller and various other onboard devices. The PWM 4-pin fan controller has the following configuration:

PINS	SIGNAL
1	GND
2	+12V
3	RPM SENSE/READ FAN RPM
4	PWM I/P FOR FAN

Pin configuration table.

The PWM signal can be controlled using various fan speed controlling software on WINDOWS or using the FANCONTROL command line tool on LINUX. The PWM i/p pin has a fixed voltage of +5.25 Volts. The speed of the fan is controlled by switching the fan ON and OFF depending upon the PWM signal. The PWM signal has a frequency ranging between 21kHz to 28kHz typically 25kHz. The speed of the fan depends upon the duty cycle of the signal. [1]

This property of the PWM signal from the controller also makes it available to us for controlling the peltier unit. The signal can be divided into values ranging from 0 to 255. Where 0 represents the 0% duty cycle (that is no signal or gnd) and 255 represents the 100% duty cycle. The duty cycle can be determined from the following formula:

$$\%D = (PW/T) * 100 \quad [2]$$

The signal from the PWM pin has to be adjusted so that at ideal load the heat transfer from the peltier unit does not cause condensation and at high load there is a maximum heat transfer. This can be achieved by manually configuring the PWM pin depending upon the values from the CPU (PECI/DTS) temperature sensor values. On LINUX this can be done using PWMCONFIG. We can tweak the signal by setting the MINPWM, MAXPWM, MINTEMP, MAXTEMP, FCFANS, FCTEMPS, MINSTOP, MINSTART parameters [3].

The configuration of these above mentioned parameters will vary from system to system depending the type and size of cabinet, no. of processor cores, type and size of CPU heat sink, ventilation, etc. leads to confusion because equations do not balance dimensionally. If you must use mixed units, clearly state the units for each quantity that you use in an equation.

V. POWERING THE PELTIER UNIT:

Connecting the peltier unit directly to power supply will lead to uncontrolled cooling. Also excess current supplied or drawn by the peltier unit may damage the peltier unit or the power supply. So it is necessary to control the current supplied to the peltier unit. The onboard PWM controller has an output voltage of +12V (PIN 2) and a maximum current rating of 1A (PIN 2). As the current rating of the onboard PWM controller is very less it is not possible to connect the peltier unit directly to the PWM header.
To supply the current to the peltier unit in a controlled manner, the peltier unit can be connected to a power amplifier. The power amplifier will receive its input signal from the PWM pin (PIN 4) on the header. Even though this is not required another benefit of this is that it will allow us to adjust the amplitude of the input signal which in turn changes the output of the amplifier circuit thus giving us more control over the system.

The power amplifier can be driven by the SMPS and can have a output voltage of +12V however it is important that the peak current output of the power amplifier is less than the maximum current rating of the peltier unit being used (I-MAX).

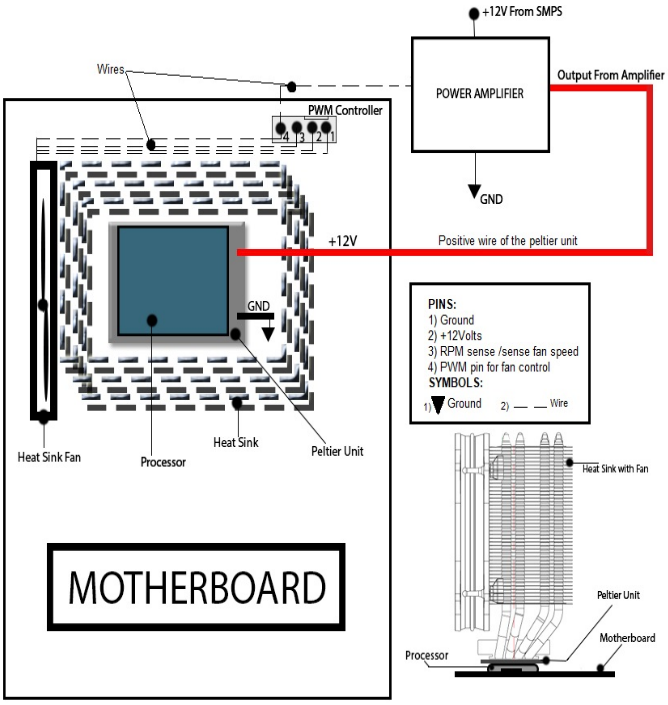
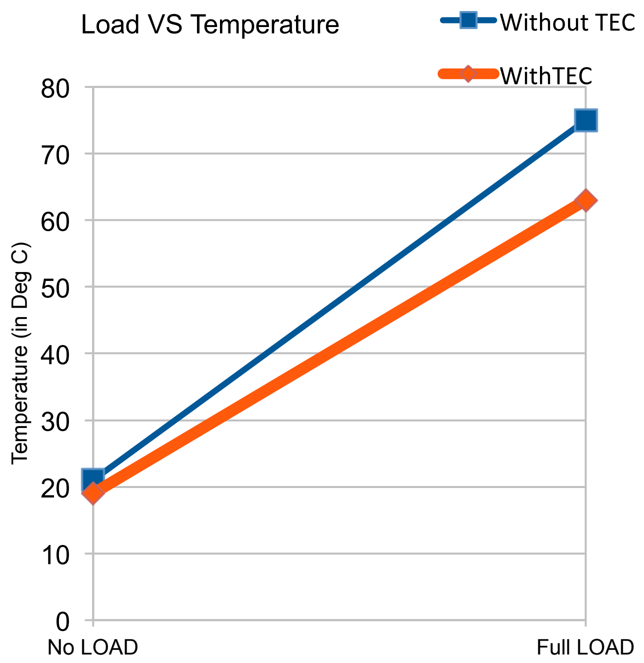


Figure.1 Assembling the Peltier unit.

VI. LIMITATIONS:

- Much better ventilation is required as compared to the liquid cooler or air cooler.
- Power consumption is very high as compared to the liquid cooled or air cooled system.
- Does not take into account the thermal power dissipation of the processor.

VII. RESULTS:



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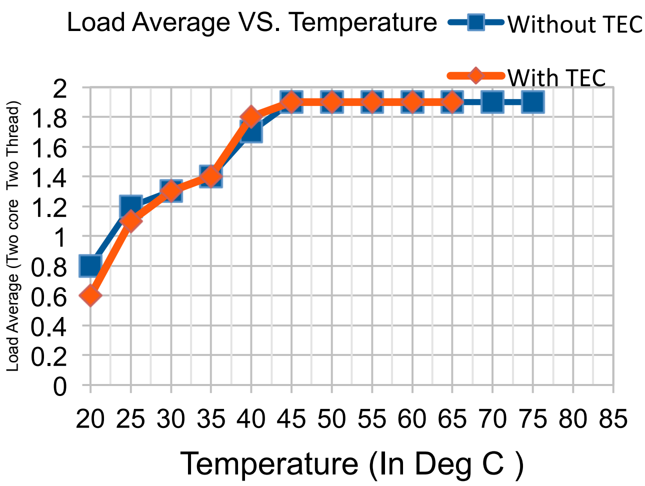
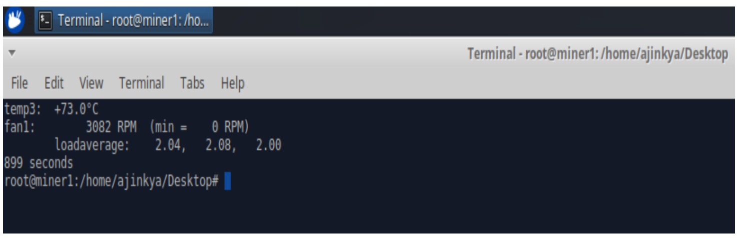
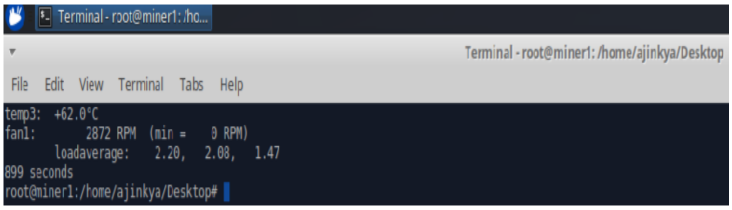


NOTE: Tests were performed on AMD A4 4000 APU and are specific to the system. These results will vary from system to system.

Load Averages and temperatures:



Without Peltier (TEC) Unit:
Figure.2 Load average without peltier unit.



With Peltier (TEC) Unit :
Figure.3 Load average with peltier unit.

VIII. CONCLUSION

Thus from the results we see that there was a drop in the temperature by 11 Deg C, at high load when the peltier unit was not used from the load average for 15 Minutes, we see that the load average was 2.0 i.e. 100%, whereas when peltier unit was used the load average for 15 minutes was dropped to 1.47 i.e. 73%. Thus we can conclude from the results that the CPU throttled for the first test when the peltier unit was not used and that there was a drop in the performance as compared to the second test.

IX. DECLARATION

All author(s) have disclosed no conflicts of interest.

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