Tropical Technology Journal
Volume 18, Issue 1 (2015)
ISSN: 1656-0264

The Performance of Microcontroller-Based Computer Cooling System

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ABSTRACT

Overheating of the computer would damage the integral parts of what makes the computer work. Thus, monitoring the temperature inside the System Unit of a computer is critical task to ensure the performance is not disturbed by excessive room temperature. In the Philippines, it is necessary to incorporate a separate cooling system to maintain computers from getting damaged by heat since these computers were designed in other countries with much lower room temperatures. Hence, this study was conducted to fabricate a prototype design of a microcontroller-based computer cooling system with smart characteristics to cool components inside the System Unit and prevent damage the hardware parts. The device uses AT89C2051 microcontroller and DS18B20 Thermal Sensor. It is also equipped with a seven-segment display to provide monitoring of the System Unit's temperature. The device took temperature reading from the temperature sensors and displayed real time temperatures. It decided to turn on the fan and control its speed of rotation depending on the temperature of the heated components or to keep it off if its temperature is lower than the trigger temperature. It rotates on the following percentages: 25%, 50%, 75% and 100%.

Statistically, the computer with the Microcontroller-based Computer Cooling System has significantly ($p<0.05$) reduced the temperature of the components inside the System unit. It is therefore recommended for use in school computers to prevent from damage and shortening the lifespan of the hardware.

Keywords: temperature, heat, Thermal sensor, System Unit, AT89C2051, DS18B20

INTRODUCTION

Computer nowadays is a necessity to everyone. But, it comprises of electronic components such as a central processing unit, Motherboard and more which produce heat. In addition, most computers being used in our country today are imported from other countries designed to operate at room temperature. However the room temperature and humidity of these countries differ in our country. Thus, overused of computer especially at room temperature may lead to overheating.

Overheating can reduce the lifespan of computer components and peripheral units and can lead to data loss and irreparable damage. Thus, computer system is required to increase cooling and ventilation capabilities to move air through unit, dissipating excess heat and keeping

 ISSN: 1656-0264

the components working within safe operating temperatures. Because if this excess heat is not removed by sufficient cooling it can negatively impact the normal functioning of the central processing unit and can cause circuits and components to become unstable. Furthermore, without a proper cooling system, the PC's electronic components may not be able to function optimally and the integral parts of what makes the computer work could be damaged. Because of this, researchers are now focusing on the different methods to dissipate heat from the computers to ensure that the components remain within their normal operating temperature ranges.

Moss et al. (1996), discussed two processes, air exchange cooling process and forced-air-cooling. In air exchange cooling process, the heated air within a chassis of the computer system may be replaced with cool air outside the chassis of the computer system. While in forced-air-cooling, specific component maybe cooled by directly applying air across the surface of the component. High velocity air immediately applied to the surface of that component raises the convective heat transfer coefficient for the surface of that component, thereby increasing convection cooling with respect to that component. Another method explained by Takemae et al. (1988), and Irving et al. (2004) was associated with sensors. The controlling server chassis cooling fans contain monitoring operating temperatures associated with each of a plurality of temperature sensors which may be coupled with a plurality of respective server processing cards. The operating speed is increased or decrease depending on the operating temperature. It will increase if it exceeds a predetermined maximum operating temperature measured at any one of the sensors it will decrease if the temperature is below the predetermined minimum operating temperature.

Despite of the many methods and designs of cooling system, air cooling with fans is widely used in dissipating heat in computers. But according to Deshmukh et al. (2013), in some cases the overheating was caused due to fan jamming. Also, the cooling fans available nowadays have fixed rotational speed, even the computer doesn't need enough air to cool it down, it will still rotate fully, and hence more electricity is consumed. Moreover, most cooling systems nowadays utilizing thermal sensor incorporated only within the motherboard of the system unit.

Thus, it was the objective of this study to fabricate a low-cost Microcontroller-based Computer Cooling System. Each hardware that generate heat within the system will be installed with fan with different speeds of rotation depending on the temperature reflected on the sensor to lessen the electricity consumption and can effectively provide optimal temperature for operation at room temperature.

MATERIALS AND METHODS

Materials and Equipment Needed:

For the device construction the materials and equipment needed are as follows, 1 piece AT89C2051 Microcontroller, 1 piece 74LS247 Decoder, 1 piece 11.0593 MHz Crystal, 2 pieces 7-Segment Display, 5 pieces Electrolytic Capacitor, 5 pieces Ceramic Capacitor, 20 pieces Resistors

 ISSN: 1656-0264

(1/4 watts, assorted), 2 pieces Transistors, 1 cut Printed Circuit Board (5”x 5”), 1 roll Soldering Lead, 2 rolls Masking Tape, 1 bottle Ferric Chloride, 1 piece DS18B20 Thermal Sensor, 10 meters Solid Wire # 22, 2 pieces Generic Fan, 1 pack photo paper, 2 pcs. Soldering Iron, and 2 pieces Cutter. These materials were purchased from the local electronic store.

For the device testing, the equipment needed are as follows 2 sets of Personal Computer and its specifications (A10, MSI A88XM-E35, 2 pieces 4GB DDR3-1333 – Kingston, WD Blue 1TB SATA/64MB, Cougar CMX 700W, Sapphire R7-240 1024MB 128 bit DDR5 Boost Full, HEC Cougar 5SS7 Spike), and 5 units Digital Thermometer TPM-10 (HUI-26047). These equipment were purchased in the local computer shop.

Procedure:

Establishment of the Computer’s baseline temperature data.

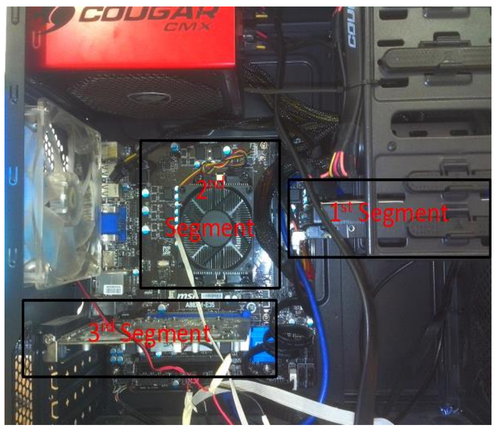

Figure 1. The different heat Segment inside the System Unit

Digital thermometers were strategically placed near the components of the System Unit that generates heat, specifically Hard Disk, Processor, and Video Card, as shown in Figure 1. One thermometer is placed outside the chassis of the System Unit to measure the room temperature.

Unstressed

The computer was turned on twenty-four (24) hours for six (6) consecutive days. Temperature, both internal and external, on each segment was monitored and recorded. The internal temperature data were taken from the BIOS (motherboard of the System Unit) while the external data were taken from the installed digital thermometer. The recording of data was done from 8:00 A.M. to 8:00 P.M. The computer in this test is in active mode the whole time but no major data processes was being done.

Stressed

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The computer was turned on twenty-four (24) hours for six (6) consecutive days. A software "StressMyPC 2.66" was turned on. This software is a Freeware downloaded from http://www.softwareok.com/?seite=faq-StressMyPC&faq=0. This is used to simulate heavy data processing on the three components of the System Unit. The temperature, both internal and external, on each segment was monitored and recorded every hour from 8:00 A.M. to 8:00 P.M. The computer in this test is active and does heavy data processing the whole time.

Device Assembly and Programming

Device Assembly

The schematic diagram, shown in Figure 2, was simulated using Proteus 8.1. After it was tested to work in simulation, the schematic diagram was lay-out and printed on a photo paper. The schematic diagram is now printed on the photo paper using laser printer. The photo paper was then attached on the covered Printed Circuit Board (PCB). Once it is attached, the back side of the photo paper was ironed, using electric iron. This caused the print of the photo paper to be transferred to the PCB. Once the schematic diagram is printed on the covered PCB, the PCB was put into a Ferric Chloride solution to remove the unnecessary copper. Holes were bored on the PCB by using a mini drill. All components were soldered on the PCB, following the circuit diagram and making sure that all the components were positioned correctly as it is in the diagram.

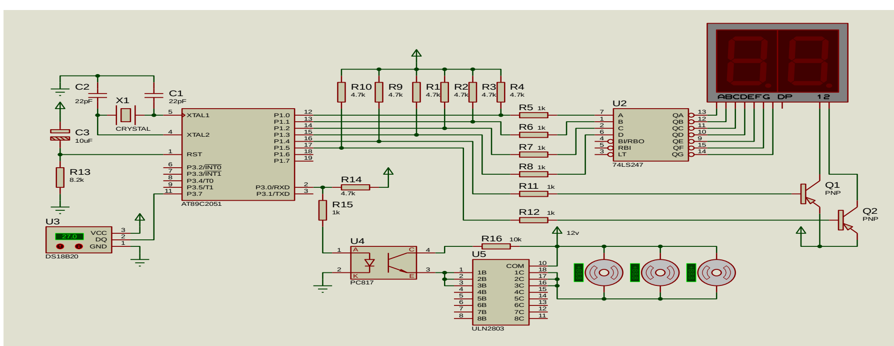

Figure 2. The Schematic diagram of the MCBCCS

Device Programming

The device will be programmed following the percentages of fan rotation with its corresponding temperature range as shown in Table 1. The lowest range of temperature was based on the minimum temperature reading of the unstressed condition. This is also the temperature reading, the moment the computer was turned on.

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Table 1. Temperature Range and the Corresponding Fan Rotation of MCBCCS

Temperature Range (°C)	% Fan Rotation
0 ~ 30	0%
31 ~ 33	25%
34 ~ 36	50%
37 ~ 39	75%
40 ~ above	100 %

Device Testing

The MCBCCS was installed in the Personal Computer. Digital thermometers were strategically placed near the components of the System Unit that generates heat, specifically Hard Disk, Processor, and Video Card. One thermometer is placed outside the chassis of the System Unit to measure the room temperature. The fans were strategically placed in areas where air flows would facilitate the cooling effect of the components inside the System Unit. Fan 1 was placed at the side of the chassis to help cools down the processor by supplementing the air towards the heat sink. Fan 2 was placed at the front of the chassis in which the air flow directly towards the hard disk and video card. Fan 3 was placed at the back of the chassis and served as the exhaust fan. When the device was properly installed, the computer was turned on and put into stressed condition using the software “StressMyPC 2.66”. The temperature, both internal and external was monitored and recorded for six (6) consecutive days. The internal data were taken from the BIOS (motherboard of the System Unit) while the external data were taken from the installed digital thermometer. The recording of data was done from 8:00 A.M. to 8:00 P.M.

Statistical Treatment

Pearson Correlation was used to determine the correlation between the internal temperature from the motherboard of the System Unit and the External Temperature reading of the digital thermometer for the three components.

T-test was used to determine if there is a significant difference of the temperature reading on the three components before and after the MCBCCS is installed. The data were statistically treated using SPSS version 22.

RESULTS AND DISCUSSION

Establishment of Baseline Data

Unstressed Data

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Table 2. Unstressed Data

Time	Processor		Hard Disk		Video Card		Room Temp.
	Int.	Ext.	Int.	Ext.	Int.	Ext.	
08:00	48.6	31.9	37.6	32.0	35.8	33.7	28.2
09:00	49.0	32.4	38.9	32.8	36.2	34.2	28.9
10:00	50.0	32.6	39.2	33.5	37.0	34.7	29.3
11:00	50.5	33.4	39.8	34.1	37.8	35.3	29.9
12:00	50.0	33.0	39.6	33.7	37.4	34.9	30.4
13:00	50.6	33.0	39.0	33.7	37.4	35.0	29.4
14:00	50.2	33.3	39.4	33.8	37.8	35.2	29.7
15:00	50.6	33.5	39.6	34.2	37.8	35.7	29.9
16:00	50.2	33.2	39.6	33.9	37.4	36.2	29.5
17:00	50.0	33.0	39.4	33.6	37.4	35.2	29.2
18:00	49.6	32.6	39.2	33.2	36.8	34.5	28.7
19:00	49.4	32.5	38.8	33.0	36.8	34.6	28.7
20:00	49.2	32.1	38.8	32.6	36.2	34.3	28.2

Table 2 shows the average temperature reading, in degrees Celsius (°C) of specific components of the System Unit per hour, when the computer is in idle state. This data is used to establish the trigger temperature of the Microcontroller-based Computer Cooling System. This temperature reading were gathered when the computer is doing minimal processes.

Stressed Data

Table 3. Stressed Data

Time	Processor		Hard Disk		Video Card		Room Temp.
	Int.	Ext.	Int.	Ext.	Int.	Ext.	
08:00	98.3	35.1	41.3	36.7	53.0	38.2	28.4
09:00	103.0	39.9	46.3	42.1	59.5	42.9	29.0
10:00	103.2	40.1	47.0	42.2	59.8	43.1	29.5
11:00	103.5	39.6	46.8	41.9	55.3	42.8	29.4
12:00	103.8	39.8	46.8	42.0	56.0	43.3	29.6
13:00	103.8	40.2	46.5	42.2	55.3	42.8	30.2
14:00	105.3	40.1	47.3	42.6	60.5	43.9	30.4
15:00	105.0	40.2	47.3	42.2	55.5	43.0	30.4
16:00	103.0	39.4	46.8	41.6	49.8	41.9	30.1
17:00	102.5	38.1	44.8	40.8	53.0	40.8	28.7
18:00	102.3	38.2	53.3	40.6	45.5	41.3	28.5
19:00	102.3	35.8	55.3	41.0	47.3	42.2	28.0
20:00	102.7	35.5	55.7	41.2	47.7	42.4	28.1

Table 3 shows the average temperature reading, in degrees Celsius (°C) of specific components of the System Unit per hour, when the computer is stressed. The data is taken when the computer is simulated to process its maximum capability. During this time it was observed that the computer is already in unstable condition. This data is used to establish the temperature to trigger the Microcontroller-based Computer Cooling System to run at full rotational speed.

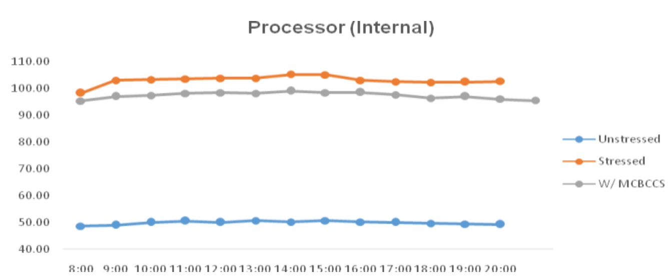
 ISSN: 1656-0264

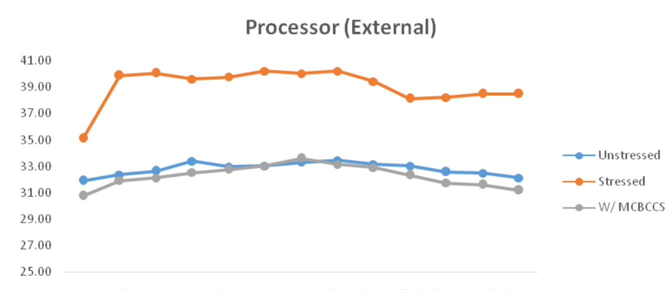
Product Testing

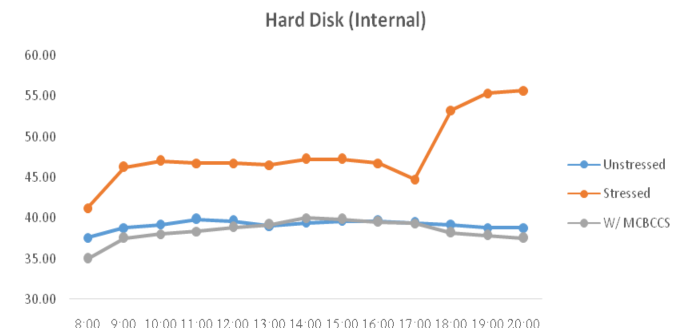
Table 4. Product Testing

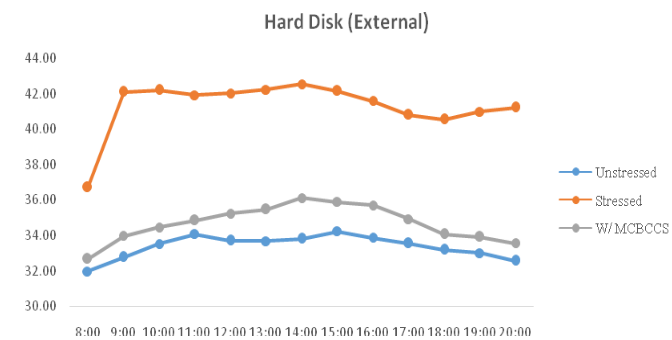
Time	Processor Int.	Processor Ext.	Hard Disk Int.	Hard Disk Ext.	Video Card Int.	Video Card Ext.	Room Temp.	Sensor Temp.
08:00	95.3	30.8	35.0	32.7	43.7	34.9	28.2	39.7
09:00	97.0	31.9	37.5	34.0	45.3	36.3	29.0	40.8
10:00	97.3	32.1	38.0	34.5	46.2	37.0	29.3	41.3
11:00	98.2	32.5	38.3	34.9	43.5	37.1	29.7	41.3
12:00	98.3	32.8	38.8	35.3	44.2	37.5	30.0	42.0
13:00	98.2	33.1	39.2	35.5	44.3	37.8	30.2	42.2
14:00	99.0	33.6	40.0	36.1	45.0	38.4	30.9	42.2
15:00	98.3	33.2	39.8	35.9	45.0	38.2	30.6	42.0
16:00	98.5	32.9	39.5	35.7	41.2	38.0	31.1	41.7
17:00	97.7	32.3	39.3	34.9	43.7	37.1	29.8	41.3
18:00	96.3	31.8	38.2	34.1	42.8	36.3	29.2	40.5
19:00	97.0	31.6	37.8	33.9	42.8	36.1	29.1	40.7
20:00	96.0	31.2	37.5	33.6	42.0	35.7	28.7	40.3
21:00	95.5	31.2	47.5	33.3	42.0	35.5	28.6	40.2

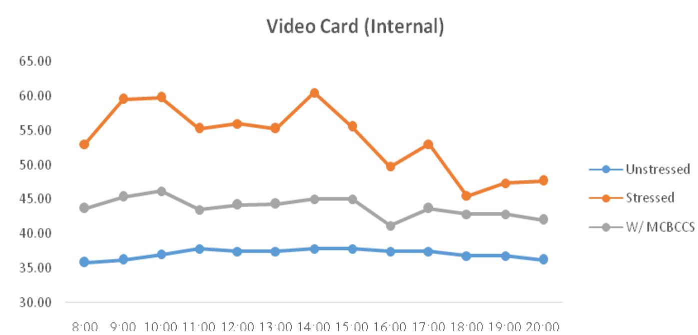
Table 4 above shows the average temperature reading of the different components of the System Unit after the Microcontroller-based Computer Cooling System Device is installed. The data is gathered while the computer had undergone Stressed Test using the software "StressMyPC 2.66". It is assumed that during this time, the computer is simulated to process its maximum capability.

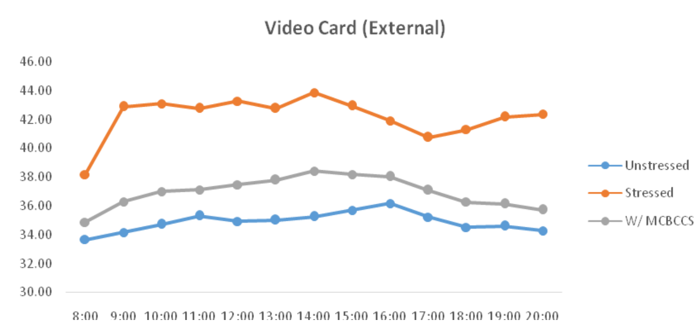












The preceding graphs show the comparison between the temperatures of the different components of the System Unit. It showed that there is a significant decrease of the temperature of the component when the device is installed.

Statistical Treatment

 ISSN: 1656-0264

Pearson Correlation between the internal and external temperature of the three components of the System Unit revealed that there is a positive correlation between the internal and external temperature. The result showed that as the internal temperature rises, there is also a corresponding increase of the external temperature reading. This further denotes the external temperature reading can be used to control the MCBCCS.

T-test results showed that there is significant difference between the temperature data using the ordinary cooling system and the one using Microcontroller-based Computer Cooling System. It is observed that the temperature data of the computer that uses MCBCCS is much lower in all heat points.

CONCLUSION

T-test revealed that the computer that uses the Microcontroller-based Computer Cooling System exhibits lower temperature as compared to the computer that uses the built in cooling system in its chassis. This implies that the device provides benefit in cooling the heated components inside the System Unit.

RECOMMENDATIONS

Microcontroller-based computer cooling system, is designed and developed using a specific brand of components in the System Unit. It is recommended that further studies should be conducted using other brands of System Unit components.

It is also recommended that, this type of cooling system that uses a combination of air exchange cooling, and forced-air-cooling process, be compared with other types of cooling processes, found on some high-end Personal Computers, like liquid cooling.

ACKNOWLEDGMENT

The authors would like to thank Cebu Technological University for the funds provided to support this project. We are deeply grateful to Mr. Harvey Pangandoyon of Cebu Technological University, Argao Campus, and Engr. Paul Zabala of Cebu Technological University Main Campus for sharing their expertise in microcontrollers. Also, we would like to extend appreciation to Dr. Gloria G. Delan, Dr. Rachel Luz V. Rica, and Dr. Rosita D. Bagsit for their support and assistance, to Mr. Jimboy Cantila for the product assembly and programming, to Mr. Elrhey A. Apostol and Marvin Ybañez for the data gathering, and to Engr. Ernesto Saliente, for the statistical analysis.

LITERATURE CITED

Deshmukh et al., Temperature Monitoring and Regulating System for Power Saving, Department of Computer Science and Engineering, Dr. Babasaheb Ambedkar College of Engineering

 ISSN: 1656-0264

and Research, Nagpur: 2013

Moss et al., 1996 “Serial fan cooling subsystem for computer systems” US Patent Office.

Irving et al., 2004 “System and Method for Controlling Server Chassis Cooling Fans”

Takemae et al., 1988 “Cooling Method Control System for Electronic Apparatus”

Giorgio, Paul J., 1999 “Apparatus for Monitoring Environmental Parameters at Network Sites”

Fung, Henry T., 2009 “Apparatus and Method for Modular Dynamically Power Managed Power Supply and Cooling System for Computer Systems, Server Applications, and other Electronic Devices” Chet, Koo Voon et al., 2006 “The 8051 Cookbook, 2nd Edition”