Laptop Cooling Pad Temperature Monitoring System

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Article Info	ABSTRACT
	Cooling pads are commonly used to reduce temperature of laptop to avoid overheating problem. However, existing cooling pads are prone to various limitations: fixed voltage in the hardware component, inaccurate temperature readings and lacked of computer-based temperature monitoring functions. In this paper, a laptop cooling system with multivoltage fan speed controller using real-time processor temperature readings is proposed. A graphical user interface (GUI) and color coded LEDs are also implemented to provide visual inspection of the temperature values captured from the laptop. The temperature values are displayed in graph and tabular form. The performance of the proposed cooling pad with computer-based monitoring application is evaluated against two other types of existing cooling pad systems. The experiments have shown that the temperature values can be monitored clearly with the proposed GUI. More importantly, the proposed cooling pad system has the potential to achieve lower temperature faster than the rest of the existing cooling pad systems.

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1. INTRODUCTION

Overheating problem usually occur due to gaming activities, prolonged usage and CPU intensive applications. Continous overheating of the laptop will eventually reduce the life expectancy of the laptop [1]. Therefore, it is a common practice of laptop users to regularly service their laptop's internal cooling fan and add an external cooling pad to reduce the overheating. Indeed, this is a simple way to increase the life span of the laptop. Essentially, this is the reason why most of IT professionals suggest laptop users to use cooling pad.

There are two types of cooling systems: active cooling system and passive cooling system. Active cooling system will increase the speed of internal cooling fan inside the laptop to reduce the temperature of laptop components such as motherboard, Random Access Memory (RAM) and hard disk drive. On the other hand, passive cooling system will decrease speed of processor operation. As a result, the speed of the internal cooling fan depends on the temperature of the processor. In other words, a passive cooling system will slow down the processor of the laptop and active cooling will use internal cooling fan of the laptop.

Recently, several cooling issues and mechanisms have been investigated in previous research. Ralph Carl et. al [2] investigate problems due to installation-driven fan performance degradation. The arrangement of fan installation could influence the distribution and net air flow through an enclosure. Rodney H.G.T et. al [3] uses EnCool axial fan with on chip temperature sensor. It senses the temperature inside the PC chassis and rotate the fan with adequate speed to exhaust the heat out of the chassis. The authors admitted it only slightly improve the heat ventilation rate. Michele Roffi et. al [4] tested several axial

fan prototypes that were able to gain slightly on the motor efficiency. It offers a better dynamic airflow. It is meant to cool the motor itself. Hiroshi Endo et. al [5] achieved an optimized air-flow to cool a servers in a data center, by relying on only facility fans with a power saving control system. It eliminated the necessity of built-in fans in the server. The system is controlled based on server information such as CPU temperature and rack position. High speed fan produces lower thermal resistance, but consume higher power. Javad Mohebbi Najm Abad et. al [6] proposed a fan controller system based on Neuro-Fuzzy to minimize fan power consumption. However, he noted that there is a minimal temperature overhead as compared to the traditional fan controller. Bilge Acun et. al [7] overcome inefficient fan speed using neural network model to predict CPU core temperatures and activated a preemptive fan control mechanism. It also includes a thermal aware load balancing algorithms that make use of the temperature model. However, it involved re-coding of the software systems and tested for large container of a server room, not a laptop.

Ranchagoda N.H. et. al [8] used thermoelectric coolers (TECs) to dynamically control air flow from the exhaust vent of the laptop to the ambient. Firstly, thermoelectric coolers (TECs) functional as cooling element on this project and able to reduce temperature of the laptop. Secondly, DS18B20 component was used as a temperature sensor for temperature measurement. This cooler is available in 4 modes such as Fans Only, Balanced, Super Cooling and Intelligent. Each mode depends on operation of TECs. It comes with simple graphical user interface (GUI) that facilitates the temperature monitoring task by laptop users. A temperature sensor is placed right at the exhaust vent. As a result, the temperature readings are not accurate as it is read externally from the CPU.

It is also possible to add Adjustable Temperature Setpoint (ATF) to an existing notebook fan [9]. Such cooling system adds several components of hadwares: Digital Humidity and Temperature (DHT11) and organic light-emitting diode (OLED). The DHT11 component is used as a temperature sensor that controls the speed of the fan inside the existing cooling pad. Meanwhile, organic light-emitting diode (OLED) display is used to show temperature of the laptop, along with a mini push button to allow adjustment of temperature setting. This cooler begins with 76 ℃ as initial temperature. If the laptop temperature is above 76 ℃, the fan will be turned on. If the laptop temperature is below 76 ℃, the fan will be turned off. All this information is displayed in the OLED. It provides a button to change the temperature set point.

Similar improvement has been seen also in ACF system [10]. ACF has a temperature sensor that is used to detect heat from the laptop. A motor driver (L293D) is used to control speed and rotation of fan. This cooling pad has also used Liquid Crystal Display (LCD) to display real-time temperature during operation and display status of temperature. In addition, LED component is used to represent the condition of the cooling fan that is green for 1 and red for 0. An external adapter is used as a power supply.

Apparently, these existing cooling pad systems were not designed to get actual temperature from the laptop directly. As a result of this, the readings do not accurately represent the real temperature of the heat source. In addition, the existing cooling pad system systems apply external power supply in the design. Different from the existing cooling pad systems, our proposed cooling pad is designed to capture real temperature and eliminate external power supply usage. In summary, existing cooling pads are prone to various limitations: limitation of voltage control in the hardware component, inaccurate temperature readings and lacked of computer-based temperature monitoring system.

The rest of the paper is organized as follows: Section 2 shows phases of project development such as preliminary analysis, design and implementation, and evaluation. Section 3 explains the results and analysis during integration testing on hardware and software. Finally, Section 4 presents conclusion of the project.

2.   PROPOSED METHOD
The prototype development of the proposed system is divided into three primary phases: preliminary analysis, design and implementation, and evaluation.

2.1   Phase 1: Preliminary Analysis
The major activities in the preliminary phases consists of:
   a)   Identify limitations in existing cooling pad systems.
   b)   Familiarize with the two types of characteristics in cooling system (active and passive).
   c)   Compare features in the existing cooling pad system development.

2.2   Phase 2: Design and Implementation
 a)   Draw a conceptual diagram of the proposed cooling pad (see Figure 1).
Figure 1 demonstrates conceptual diagram for the proposed cooling pad. In the initial step, when a cooling pad is connected, 5V is used to operate on the cooling pad. The reading procedure will continue to

get temperature input, as long as the computer is in use. If the temperature is less than 50 ºC, then the cooling pad will continue to operate at 5V, else the cooling pad will continue to operate at 10V. To demonstrate the difference of the voltage usage, light emitting diode (LED) is used in this prototype. The green LED is turned on to represent the 5V operation. On the other hand, the red LED is turned on to represent the 10V operation. The prototype is also equipped with some graphical user interface utilities to display the status of the temperature.
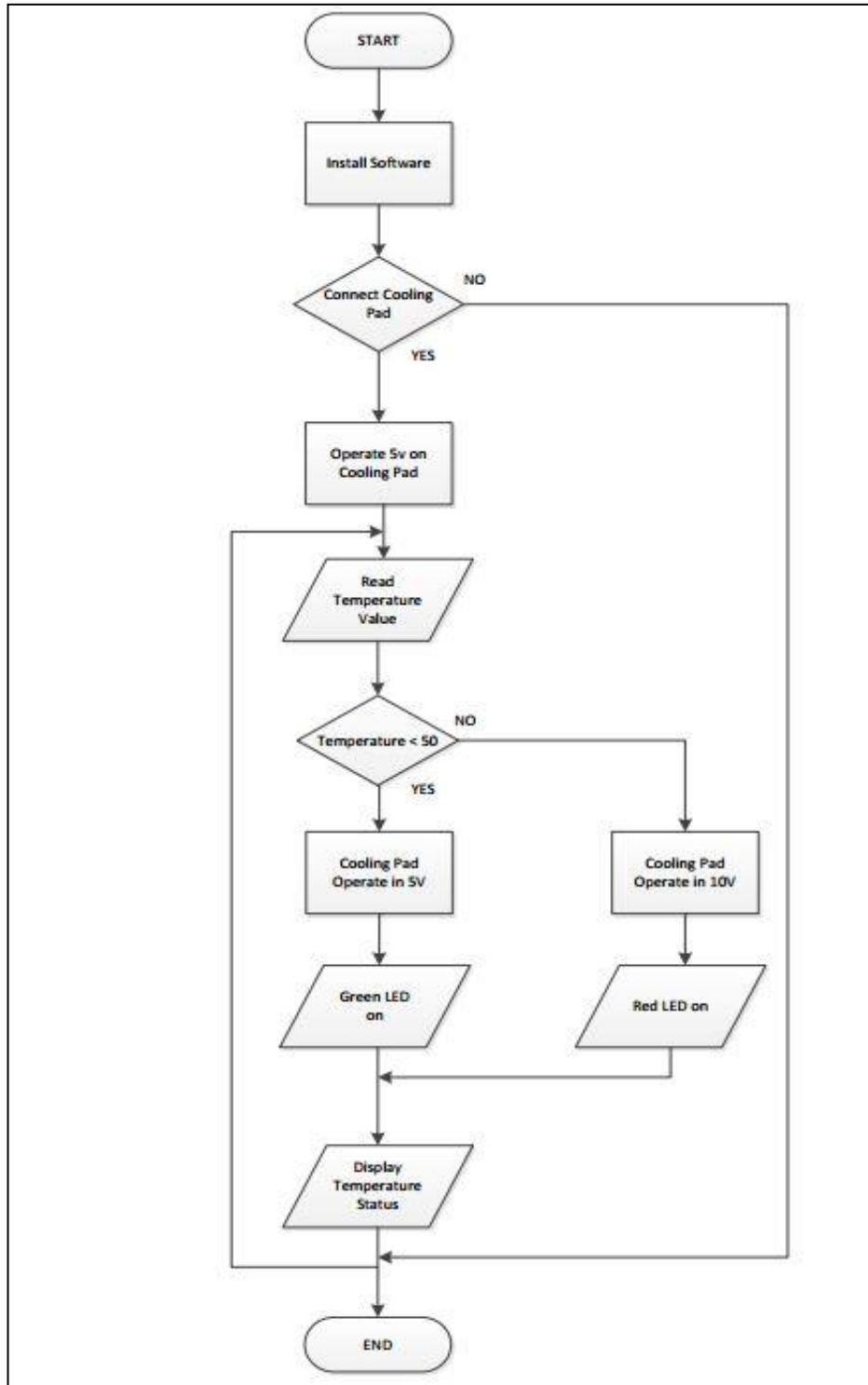

Figure 1. Conceptual Diagram of the Proposed Cooling Pad

b) Determine suitable software development tool and hardware necessary for the proposed pad shown in Table 1 and 2.

   i)   Software Specification

Table 1. Software Specification

No.	Software	Function
1	Microsoft Visual Studio 2013	- Various hardware functions are accessible via this software. - the "System Management" library also provide access to thermal zone utility.
2	Arduino Integrated Development Environment (IDE)	- A development tool to build, compile and upload program into microcontroller (Arduino Uno). - Using simplified version of C++ language. Therefore, it is easy to learn and use.

   ii)   Hardware Specification

Table 2. Hardware Specification

No.	Hardware	Function
1	Arduino Uno	- An open source microcontroller platform. - Ability to control of the power supplied to electronic devices and generate Pulse Width Modulation (PWM) signal.
2	DC – DC Step Up Module (XL6009)	- Function as a power booster capable of increasing input voltage. - Can be applied at portable electronic equipment.
3	Darlington Transistor (TIP 122)	- Generally used as current amplifying device. - Some applications of this component at audio amplifier and motor controllers.
4	DC Cooling Fan	- Low noise and power efficient. - Use less voltage to reduce power consumption.
5	Light Emitting Diode (LED)	- Used as an indicator or signal.

c) Develop code and design Graphical User Interface (GUI) for software implementation (See Figure 2 – Figure 4).
d) Setting up schematic design and conceptual diagram for hardware implementation (See Figure 5 and Figure 6).

The design target of the proposed prototype is set to the following:
 1) To read real temperature inside the CPU, not from the inconsistent air flow ambience inside the enclosure.
 2) To rapidly dissipate high temperature by increasing air suction from inside to outside area of the laptop.
 3) To display current temperature status for visual verification.

To achieve these design targets, the following components are necessary:
 1) A software that interface to the motherboard to read the actual temperature in the CPU.
 2) The cooling fan that support dual or multi-voltage. Furthermore, adding a step-up module enable putting it at normal mode and rapid mode.
 3) Necessary color coded LEDs for clear visual inspections.

   i)   Software Implementation

Figure 2 shows temperature conditions and sets of actions. There are four possible temperature conditions - idle, normal, warm, and hot. For each condition, a suitable fan voltage will be pre-determined to ensure rapid dissipation of heat yet power efficient. In the proposed design, higher voltages are preset for warm and hot temperatures.

Figures 3 and 4 show graph during warm and normal temperature in user interface, respectively. This interface also shows laptop temperature, CPU usage and memory usage from the laptop. The temperature will be collected in every second and consequently, changes in temperature status in the software interface will be updated in every second. As a result, the temperature status changes the fan voltage in the hardware component

```vb
If (celciusTemp <= 30.0) Then
    lblTemp.Text = celciusTemp.ToString
    LblSts.Text = "Idle Temp"
    voltValue = "5"
    SerialPort1.Write("1")

End If

If (celciusTemp <= 45.0) Then
    lblTemp.Text = celciusTemp.ToString
    LblSts.Text = "Normal Temp"
    voltValue = "5"
    SerialPort1.Write("1") 'run fan 5 volt

End If


If (celciusTemp >= 49.0) Then
    voltValue = "10"
    lblTemp.Text = celciusTemp.ToString
    LblSts.Text = "Warm Temp"


    SerialPort1.Write("2") 'run fan 10 volt

End If

If (celciusTemp >= 70.0) Then
    lblTemp.Text = celciusTemp.ToString
    LblSts.Text = "Hot Temp"
    voltValue = "10"
    SerialPort1.Write("2")
```

Figure 2. Temperature Condition and Sets of Actions
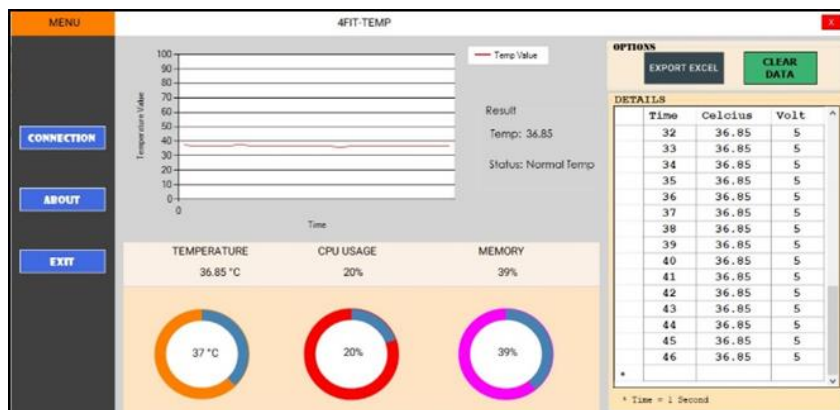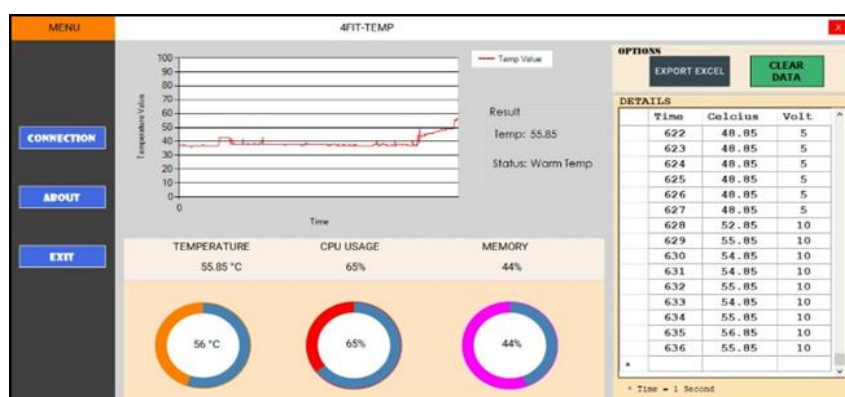

Figure 3. Normal Temperature Interface

Figure 4. Warm Temperature Interface

ii)   Hardware Implementation

Figure 5 shows the conceptual diagram in hardware implementation and Figure 6 shows the prototype of the proposed cooling pad. As shown in Figure 6, the Arduino Uno is used to control two outputs: cooling fans and Light Emitting Diode (LED). The USB cable is used to supply power for Arduino Uno. Then, the power from Arduino Uno can be used to increase voltage by using step-up voltage module.
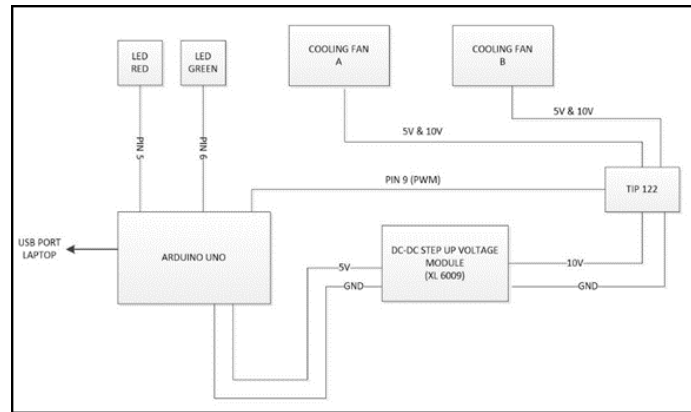

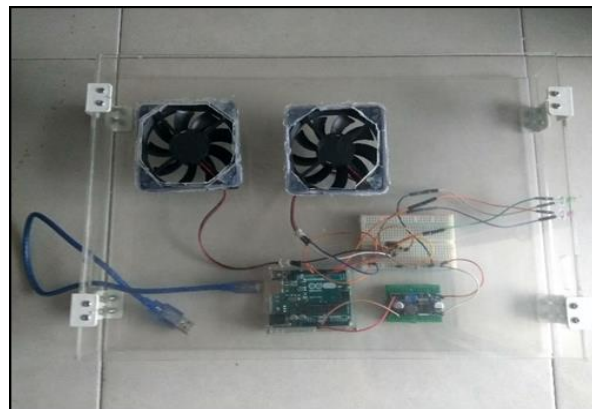Figure 5. Conceptual Diagram for Hardware Implementation

Figure 6. Prototype of Cooling Pad

2.3   Phase 3: Evaluation

The evaluation phase activities include:
1)   Test cooling of the laptop using three different types of cooling pad.
2)   Collect temperature values from three types of cooling pad.
3)   Analyze and discuss the results by comparing which cooling pad is more efficient.

3.   RESULTS AND DISCUSSION

For testing purposes, a laptop with Intel Core i5 6th generation 2.3 GHz processor, 8GB DDR4 RAM and a 2GB NVIDIA GeForce 940MX VGA was operated is used.

Cooling Pad (A) is the existing cooling pad in the market consisting of four cooling fan and 5V DC from USB cable as power supply. Cooling Pad (B) integrate an LM 35 temperature sensor to detect heat from the laptop. Finally, the Cooling Pad (C) is the proposed cooling pad.

Figure 7 shows temperature changes over time.   In the first period, the temperature drops significantly from 65 to 62. It drops one more point in the second phase. Howerver, in period 3, it increased further to where it started in period 2. Finally, at the end of period 4, the temperature stabilize at the 62. Overall there is not much dissipation of heat from the laptop. Furthermore, the temperature is not stable.
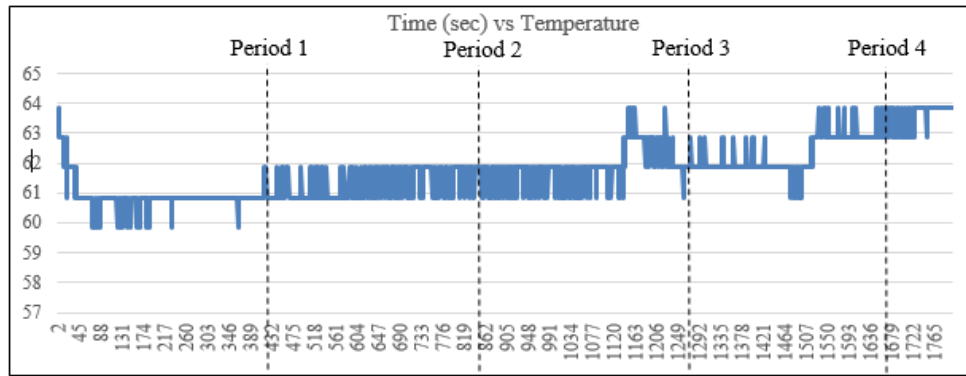
Figure 7. Temperature Values with Cooling Pad (A)

In Figure 8, temperature drop in the first period ath the lower end. It drops further in period 2. There are no significant changes to the consistent fluctuation of temperature in period 3. In Period 4, the temperature stabilize at 62, which is quite similar performance to the first fan.
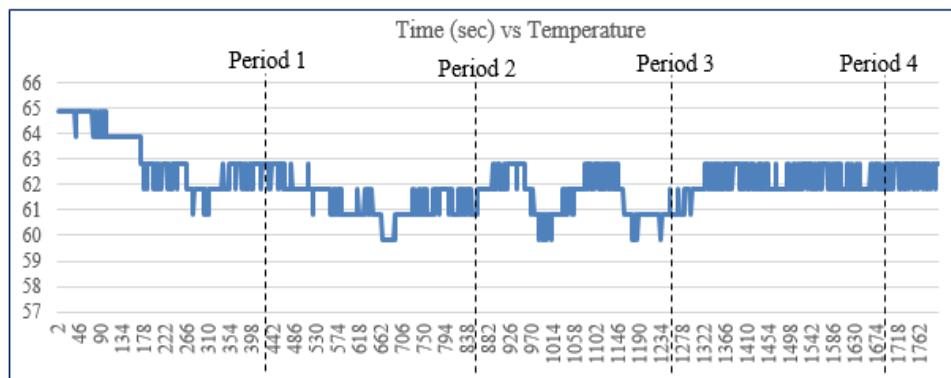

Figure 8. Temperature Values with Cooling Pad (B)

As shown in Figure 9. The temperature drops significantly in the first period to 55. This is much lower than the other fans. In Period 2, it goes slightly lower than period 1. In period 3, it remains the same and looks more stable temperature than other fans. In period 4, the temperature drop went further down to below 50 Celcius.
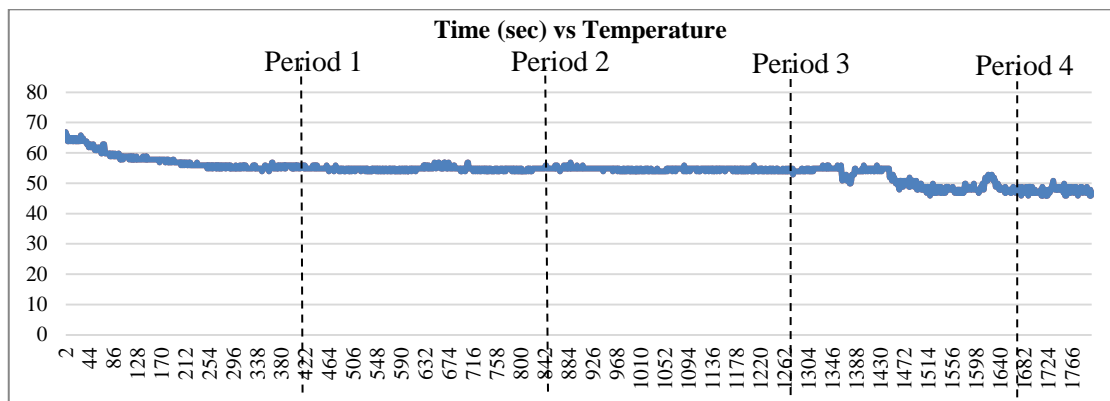

Figure 9. Temperature Values with Cooling Pad (C)

Figure 10 summarizes the overall performance of the three cooling pads. It appears that the Cooling Pad (C) is more efficient than Cooling Pad (A) and Cooling Pad (B) based on the temperature drops of the laptop. The temperature also drops at a more stable rate compare to the other two cooling fans.
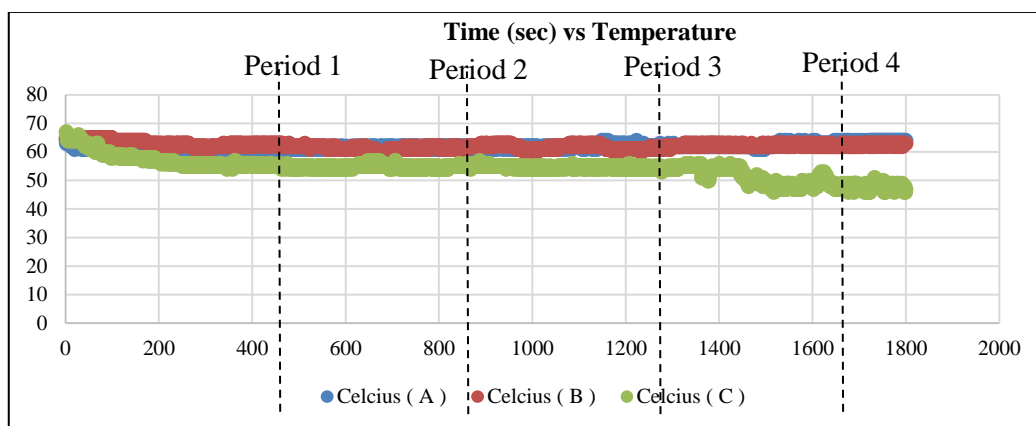

Figure 10. Comparison of Temperature Values with Three Cooling Pads

4.   CONCLUSION

The proposed cooling pad system with computer-based application has shown that it is capable of reducing overheating in laptop. Variable speed of cooling fan contributed to efficient air flow and accurate temperature reading of the heat source enable cooling fan correspond correctly to dissipation requirement. Future improvement may include intelligent prediction of temperature change so that accurate speed can be feed to the multi-speed fan.

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