SMART LAPTOP COOLING PAD WITH TEMPERATURE MONITORING

An Undergraduate Design Project Presented to
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In Partial Fulfillment
Of the Requirements for the Degree of
Bachelor of Science in Computer Engineering

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APPROVAL SHEET

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Abstract

A sophisticated thermal management device called the Smart Laptop Cooling Pad with Temperature Monitoring was created to reduce the risk of laptop overheating. This advanced cooling pad, which uses an Arduino microcontroller, LM35 sensors, and an LCD display, combines intelligent control, user-centric interface, and accurate monitoring. At its core, the Arduino microcontroller orchestrates the functionality of the cooling pad, implementing a meticulously designed algorithm for continuous temperature surveillance. The integration of LM35 sensors ensures good temperature measurements, contributing to the effectiveness of the thermal regulation system. The utilization of Arduino as the microcontroller not only ensures the reliability of the system but also offers a platform for customization. The open-source nature of Arduino facilitates adaptability, allowing users to modify and expand the system's functionality to meet specific requirements or integrate additional features. To achieve this goal, the researchers have conducted several tests with the available market cooling pads and gathering data of their effectiveness, the researchers then conducted several tests using the Smart Laptop Cooling Pad and tested its effectiveness versus the cooling pads available in the market. Based on the various tests conducted and understanding the capabilities of both applications, it showed a significant improvement in temperature management using the Smart Laptop Cooling Pad against the current market cooling pads. The researchers have used software such as HWiNFO64, and FurMark for the testing phases and Arduino IDE ver. 1.8.19 64-bit for the programming of the Arduino Microcontroller.

238 Words

Keywords: Cooling Pad, Smart, Thermal Monitoring.

DEDICATION

I dedicate this thesis to all those who have helped me along the way in my academic career.

To my parents, who have always given me their unwavering love and support. You have instilled in me the importance of diligence, tenacity, and faith. You have served as both my inspiration and my role model. I owe you everything.

To my friends: you have supported me through good times and bad. My hopes, concerns, triumphs, and sorrows have all been shared with you. You've been my confidants and my friends. My life is now richer and more meaningful because of you.

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Thank you all for being part of my journey. I'm extremely grateful that you have all shared in my thrilling experiences. Without you, I could not have completed this.

Dean Alexander Q, Doria

DEDICATION

I dedicate this thesis to all those people who have shown trust in me and my capabilities, and made it a remarkable one for me in any way possible.

To my parents; who are always there and making sure to express their support even they live far away from me; you have given me enough strength and motivation to push through this challenging time. You build me confidence and passion in me to work diligently and making sure that I would not get lost on pursuing my dreams. I owe all this to you.

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And lastly, I dedicated this book to our Mighty Loving God that guides me, giving strength, and power of mind. All of this, I offer to you.

Steven John E. Cuizon

DEDICATION

I dedicate this thesis first of all to our Loving God who gave me strength when I am weak, who provides me His ideas to accomplish this thesis. I dedicate this thesis to all who supported me in my chosen career. To those who motivate me to achieve my step-y-step goals in life.

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To our parents, for providing us moral support and strengths to move forward in our journey as an engineering students. For providing us everything for us to succeed in our dreams in life. For providing us financial support in our studies in order for us to complete our projects. Lastly we thank our parents for their unconditional love to us that molds us to be inspired in our everyday lives.

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THE PROBLEM AND ITS SETTING

1.1 Introduction

Heat is an inevitable consequence of operating any electronic gadget, including cellphones, laptops, and tablets. While some devices are designed to withstand moderate heat, prolonged exposure to high temperatures can adversely affect their performance and durability. Excessive heat can accelerate battery degradation, impair device processing power, and potentially result in hardware failure. It can also pose a safety danger in severe circumstances, such as the risk of a battery exploding. Therefore, understanding how heat affects our devices and taking adequate safety measures to prevent overheating is essential.

In this regard, a device cooling solution such as the smart laptop cooler can assist in maintaining appropriate operating temperatures and extending the lifespan of your computer. Circuit systems within electronics perform optimally at lower temperatures. Allowing systems to run for prolonged periods in high temperatures can decrease the longevity and reliability of devices. Solid-state electronics begin to break down and fry at temperatures much above 120 degrees Celsius (Chambers, 2016).

Computers can tolerate some heat, but beyond a certain point, running your computer too hot could cause shutdowns or even permanent damage. Normal operating temperature is under 60 degrees Celsius, while between 60 and 70 degrees Celsius is generally acceptable. However, if your PC remains in this temperature range, it's advisable to ensure proper cooling. Between 70 to 80 degrees Celsius, unless you have overclocked your system or are engaging in intensive tasks, it's recommended to cool your system down promptly. Having your CPU around 80 to 90 degrees Celsius for too long could cause damage, so it's strongly advised to cool your system as soon as possible. Anything above 90 degrees Celsius is excessively hot, and you should shut down your PC immediately (NEXT7IT, 2020).

The smart laptop cooler operates by monitoring the laptop's temperature and adjusting the cooling power accordingly. When the laptop starts to heat up, the cooler automatically increases its cooling power to dissipate the heat and prevent overheating. Additionally, the cooler is equipped with several sensors and algorithms that detect temperature changes and regulate cooling power accordingly, making it a smart and efficient option for thermal management.

1.2 Statement of the problem

A common challenge faced by various gadgets due to the rising demand for high-performance devices is the risk of overheating. This can lead to reduced performance, higher energy consumption, and potential gadget failure, adversely affecting your equipment. To address this issue, providing proper airflow to laptop devices is crucial, necessitating the use of a laptop cooling pad. Such a solution not only benefits the laptop owners but also enhances their productivity. Thus, Researchers aimed to develop a prototype called the Laptop Cooling Pad to ensure adequate airflow for laptops.

1.3 Objectives of the Study

The objective of the study is to have an upgrade from a traditional laptop cooling pad to a smart laptop cooling which can be programmable and adjustable one.

- Design, innovate and create our own the widely available Laptop Cooling Pads into Smart Laptop Cooling Pad which is a thermal controlled laptop cooler.
- Develop a Smart Laptop Cooling Pad that can give enough airflow to the device.

- Test and evaluate the efficiency of the prototype's cooling capacity. Effectiveness, by using thermal sensors in the cooling pad to detect the minimum, maximum and average temperature of the laptop device mounted onto the pad and detects the laptop's external current operating temperature.
- To test if there are difference in performance from a traditional cooling pad from our smart laptop cooing pad.
- To record the internal and external temperature of the laptop.

1.4 Scope and Limitation of the Study

The general purpose of this research study is to build a prototype of smart cooling pad device for Laptop Computer. To do some little upgrades from the traditional static cooling pad for laptop. The subject of this research focuses only on laptop computer. To help the laptop's built-in fan blow more air to mitigate the heat. The materials to be used in making of the smart laptop cooling pad are based on the researchers' budget and availability of resources.

1.5 Significance of the Study

The study found that creating a Smart Laptop Cooler contributed to improved laptop performance, extended lifespan, enhanced comfort, and a more conducive study or work environment. It proved to be a valuable accessory for laptop users, particularly students, who heavily relied on their laptops for educational purposes. This also contributed to the following:

Community: The user can work with high performance and better cooling efficiency anywhere and any given time while maintaining a portable form factor that could easily be carried around, with its form factor, the cooling pad has a high range of compatibility and is compatible with most of laptop sizes making it very versatile in the community. It might help their laptop to be useful in the future because of a good cooling system

Admin. This study can benefit the school especially to the faculty who uses their laptop as their workstation, using their laptops in an extended period of time may have increased temperatures, the Smart Laptop Cooler will help alleviate temperatures in to safe operational levels.

Future Researcher. This research will help and contribute to studies in the alternatives of mitigating high temperatures in our devices and workstations, this research will motivate future researchers on finding a much more advanced cooling solutions to extend the longevity of our devices. They will have a starting point to create the methods to optimize the existing technology and prototype.

1.6 Definition of terms

The study conducted by Advanced Thermal Solutions (2018) highlighted the significance of creating a Smart Laptop Cooler in improving laptop performance, extending lifespan, enhancing comfort, and creating a more conducive study or work environment. This accessory proved to be invaluable, particularly for students heavily reliant on laptops for educational purposes.

Cooling Pad. A cooler pad or notebook cooler, a hardware accessory placed beneath a laptop, reduces the laptop's overall heat by dissipating it using fans. Additionally, cooler pads can help keep the lap cool while working on a laptop placed on the legs (Computer Hope,2018).

Heat. Energy transferred from one body to another due to a temperature difference (Techterms,2018). Heat can be generated through various processes such as combustion, friction, or electrical resistance. In the context of electronic devices, heat is often produced as a byproduct of their operation, particularly in components like processors and batteries.

Laptop. Portable computers equipped with a screen, keyboard, and a trackpad or trackball, suitable for use in various environments (Tech Terms).

Sensors. Devices that measure physical input from the environment and convert it into interpretable data for humans or machines (Fierce Electronics,2018).

Smart Device. An instrument created for specific purposes such as recording or measuring (Teletech,2019). These gadgets typically offer enhanced functionality, automation, and interactivity compared to traditional devices. Smart gadgets can include various consumer electronics such as smartwatches, smartphones, smart speakers, and smart home appliances. They are designed to streamline tasks, provide personalized experiences, and improve overall convenience and efficiency for users.

Thermal. Referring to or caused by heat or temperature variations (Collins ,2018). The process of controlling the temperature of electronic devices to optimize performance and prevent overheating.

Chapter 2

REVIEW OF RELATED LITERATURE AND STUDIES

This section provides an overview of the relevant literature and studies following the researchers thorough and in-depth search.

2.1 Review of Related Literature

According to Moore's Law, the number of transistors on a chip will double approximately every two years. Since its inception in 2018, this law has withstood the test of time, resulting in significant advancements in computer performance while simultaneously reducing their size. This phenomenon has led to increasingly compact and smaller computers. However, with the increased number of transistors, there is also a corresponding rise in the amount of heat generated within the system.

Computer cooling plays a very vital and significant role in ensuring that the machine works well and that all the components work within their permissible operating temperature limits. Cooling ensures that there is no malfunction or failure of any of the components in computers due to excess heat generated. Though the components in computers are designed in a way to generate minimum heat but off late CPU speeds have increased dramatically, forcing more transistors in CPU in order to push up clock rates.

Increased number of transistors calls for more power input; all this when combined generates heat well in excess of what is recommended for smooth functioning of a computer system.

According to the needs of the servers and systems they should be utilized for, cooling technologies and systems have changed over time. Vacuum tubes were widely utilized in computers prior to the invention and commencement of their widespread use in the 1960s. Large blowers and cooling fans were utilized surrounding the tubes because the heat produced by each tube accumulated into a significant problem for the systems, and air conditioning of the rooms was a must The issue of heat generation was greatly alleviated with the invention of transistors in the 1960s, but the relief was only temporary as the new solid-state technology led to more sophisticated designs and capacities. (Stockill 2006).

Active and Passive Air Cooling

The most extensively used and well-liked method of cooling computers around the world is active air cooling. Given that active air-cooling loses its effectiveness and use at a certain threshold of heat dissipation, this is one of the most traditional methods of cooling. In this scenario, air is blown onto a cooling plate or heat sink that is positioned over the electrical components that need to be cooled and produce heat.

This cooling plate has one flat surface and multiple tiny fins on the opposite side. An essential component of the overall system at the core of air-cooling are the fins. These fins increase the plate's surface area, which helps. (Lazaridis 2009).

2.2 Review of Related Studies

The computer system utilized in the present experiment comprises a high-performance computer, a heat pipe cooling system, and a data acquisition system. The full configuration of the computer includes a chassis, motherboard, CPU, CPU cooler (heat sink), memory modules, power supply, and graphics card.

The commercial sizing of the computer chassis adheres to a standard E-ATX platform, measuring 540 mm x 236 mm x 560 mm, with the option to adjust the inclined angle for optimal positioning.

The heat pipe cooling system, designed for CPU cooling, consists of a cylindrical chamber with dimensions of 31 mm in length and 35 mm in diameter, along with a heat sink unit and an axial cooling fan. The heat pipe is integrated with an aluminum heat sink unit, and a high thermal interface material (TIM) is applied at the interface between the heat pipe surface and the heat sink unit to reduce thermal contact resistance.

An axial cooling fan is situated atop the heat sink unit to facilitate the distribution of heat into the surrounding environment, ensuring efficient cooling of the CPU.

Three different working fluids; R134a, R11, and ethanol (with and without porous media) are used as working fluid inside the heat pipe with constant 50% fill ratio (FR). Air is induced by axial cooling fan and flows through the heat sink unit and distributes into the chassis computer and then flow out of the chassis computer.

In the present study, the measured data are performed to verify with those obtained from the conventional cooling system (copper block embedded with heat sink unit) which have been performed in the air conditioning room with constant temperature of 25 °C. The conventional cooling system, heat is transferred from the CPU to the copper block embedded with heat sink unit via conduction process. Meanwhile the heat pipe cooling system is performed by replacing the copper block with the heat pipe embedded with the heat sink unit and axial cooling fan unit. For the conventional cooling system, the heat is transferred from the CPU to the copper block via conduction mode and is moved to the heat sink and then distributed into the chassis computer by axial cooling fan. The heat pipe cooling system has performed with three different working fluids; R134a, R11, ethanol and with different inclination angles of heat pipe; 0 degrees, 30 degrees, 60 degrees, 90 degrees and with and without porous media inside the heat pipe and different computer loads. The heat pipes with 50% fill ratio are tested.

Due to increase performance of electronic devices, the generated heat from these devices tends to increase which must be removed. Therefore, the thermal management system is significant for cooling these devices in the design operating temperature which heat pipe is selected as cooling system in electronic devices. In this paper, heat pipes with and without porous media for CPU cooling has been studied.

It can be seen that the inclination angle of heat pipe and working fluids types have significant effect on the removal heat capacity of phase change phenomena inside the heat pipe. Therefore, the CPU temperatures for inclination angle of heat pipe are lower than those for the vertical and horizontal alignments. In addition, the heat pipe with porous media gives the CPU temperature lower than without porous media.

A client asked Advanced Thermal Solutions, Inc. (ATS) engineers to provide a more cost-effective and lightweight solution for a custom-designed copper heat sink that drained heat from four components on a PCB. The thermal performance of the copper heat sink was compared to custom aluminum heat sinks implanted with heat pipes by ATS engineers. The challenge was The client requested that a custom copper heat sink be replaced with an equivalent or superior aluminum heat sink with incorporated copper heat pipes.

The Analysis, the junction temperatures between the four components were determined using analytical modeling and CFD (Computational Fluid Dynamics) simulations when covered by a copper heat sink (Design 1), an aluminum heat sink with heat pipes that stop in front of the components (Design 2), and an aluminum heat sink with heat pipes that run underneath the components (Design 3). The investigation revealed the differences in thermal performance of the heat sink designs. The Test, CFD (Computational Fluid Dynamics) study revealed that the original copper heat sink design had an average component case temperature of 158.8°C, Design 2 had a temperature of 158.3°C, and Design 3 had a temperature of 152°C. The average temperature difference between Designs 1 and 2 was 0.5°C, whereas the average temperature difference between Designs 1 and 3 was 6.8°C.

The Solution, Aluminum heat sinks with heat pipes were shown to the client to provide roughly the same thermal performance as the original copper heat sink design at a substantially reduced cost and weight. The component junction temperature variances between Designs 1 and 3 were well within the client-specified tolerance.

The Result, Despite employing conservative thermal conductivity assumptions, aluminum heat sinks with heat pipes were found to be a more cost-effective alternative than copper for meeting the client's thermal needs. Due to the growing desire for more processing power and smaller form factors in the world of modern computing, thermal management continues to be a crucial issue.

The performance, dependability, and durability of computer systems are all significantly improved by using cooling fans to maintain ideal operating temperatures. The complex mechanics, cutting-edge technologies, and optimization techniques for cooling fans in computer systems are all covered in this extensive study. We present insights into the difficulties encountered and future advancements in the field of thermal management through a combination of actual experience, computer simulations, and theoretical research.

The effective dissipation of heat produced by these systems is crucial given the ongoing evolution of microprocessor designs and the expansion of high-performance computing applications. The solution to these problems lies in cooling fans, which serve as the main thermal dissipation mechanism in the majority of computers. The study in question intends to investigate the most recent developments in cooling fan technologies, their design considerations, and the performance effects of various variables.

To maximize their effectiveness, cooling fans must be operated according to several basic principles. The aerodynamics of fan blades, the interaction of airflow with heat exchange surfaces, and the impact of fluid dynamics on cooling efficiency are all covered in this section. In order to boost airflow rates and lower noise levels, particular attention is paid to fan blade design, material qualities, and geometrical configurations.

Numerous technological advancements in recent years have changed how cooling fan designs are made. This section emphasizes technological developments such pulse-width modulation methods, variable-speed fan control, and the incorporation of smart sensors for real-time temperature monitoring. Furthermore, a promising direction for future research is the investigation of innovative materials with enhanced thermal conductivity and lightweight characteristics.

A multifaceted strategy is required to optimize the performance of cooling fans, taking into account things like fan positioning, system layout, and simulations of computational fluid dynamics. The function of computational simulations in foretelling airflow patterns, temperature gradients, and pressure differences inside computer systems is covered in this section. In addition, investigated is the incorporation of machine learning techniques for automatic fan control and predictive thermal management. Despite notable improvements, there are still problems with cooling fan technology. The limitations of current fan designs, noise reduction strategies, and trade-offs between cooling effectiveness and energy consumption are all covered in this section. Future research will focus on enhanced heat pipe systems, thermoelectric devices, and alternate cooling methods such liquid cooling.

In today's computer systems, cooling fans are still a crucial component for reliable operation and extending the life of components. In order to keep up with the changing demands of computing applications, this study underlines the significance of ongoing research and innovation in cooling fan technology. The field holds enormous promise for improving thermal management tactics and advancing computational skills by addressing current issues and utilizing emerging technology.

In today's world, laptops play a crucial role in both personal and professional undertakings. However, because to their small size and portability, they frequently have problems dissipating heat, which could compromise their performance and lifespan. This study explores the world of laptop cooling breakthroughs, examining the development of cooling technologies, their workings, efficacy, and possibilities for the future.

The demand for effective cooling solutions has increased due to the quick technological improvement of laptop hardware, including potent CPUs and GPUs. Performance is hampered by overheating, which also increases the chance of hardware damage. This study explores the underlying theories, benefits, and drawbacks of the many cooling systems that have developed over time. Early laptops depended on simple air-cooling techniques, which frequently failed to dissipate the rising heat produced by more powerful computing.

The first strides toward more efficient cooling solutions were distinguished by innovations like heat pipes and enhanced heat sinks. Dual Fan Design: Laptops have started using two fans, one for the GPU and the other for the CPU. This method increased heat dissipation by more precisely directing airflow. Vapor Chamber Technology: Due to their higher thermal conductivity, vapor chambers have become more popular. They enable effective cooling even in ultra-thin computers by dispersing heat uniformly.

Thermal Interface Materials (TIMs): Phase-change materials have been used in thermal interface materials (TIMs) to improve the thermal interface between components and heat sinks. To maximize thermal conductivity, these materials undergo a state change from solid to liquid. Graphene-based Cooling: Graphene has been included into cooling solutions due to its remarkable thermal capabilities, which improve heat dissipation and provide a lightweight alternative to conventional materials.

Closed-Loop Liquid Cooling: Similar to desktop PCs, certain high-performance laptops now use closed-loop liquid cooling systems. These systems efficiently transport heat away from components, improving thermal performance noticeably.

Aeroacoustics Cooling: This innovative technique uses liquid coolant to reduce the noise that laptop fans make while also cooling down the components. Dual-Chamber Architecture: To separate CPU and GPU heat dissipation and reduce thermal interference, laptops like the Asus ROG Zephyrus Duo use a dual-chamber architecture. Advanced Airflow Dynamics: To improve laptop chassis and fan blade designs and enable more effective air circulation and heat dispersion, engineers are using computational fluid dynamics.

Nano-enhanced Cooling: Researchers are investigating the use of nanomaterials to improve thermal conductivity, which might completely alter cooling processes. Phase Change Cooling: A high-performance computer technique that is frequently employed in laptops, phase change cooling uses the vaporization and condensation of a refrigerant to control heat.

Although laptop cooling technology have advanced tremendously, problems including limited space, inefficient energy use, and loud noise still exist. Future developments may combine several cooling methods or use AI-driven adaptive cooling systems that modify performance in response to real-time temperature data. A fascinating journey of inventive advancements has been the development of laptop cooling solutions, spurred by the rising desire for performance and mobility. Further developments in cooling technologies are not only predicted but necessary to maintain optimal performance, lifespan, and user experience as laptops continue to play an essential role in contemporary life.

Chapter 3

RESEARCH METHODS

3.1 Conceptual Framework

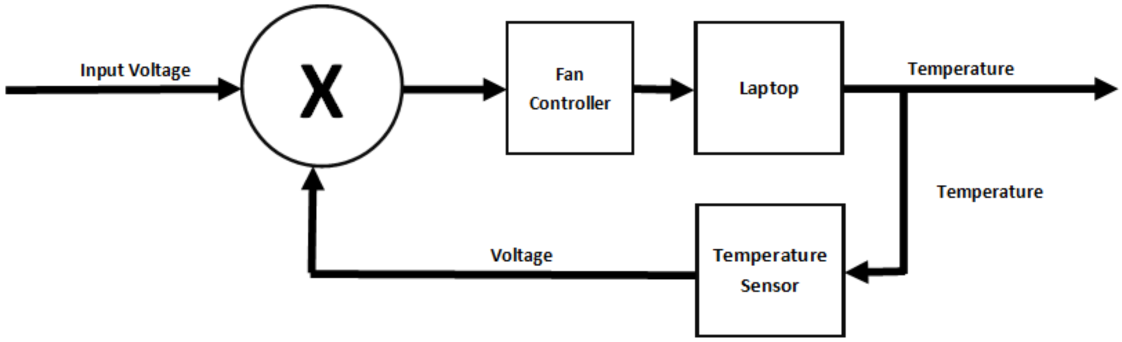


Figure 3.1, shows the conceptual framework of the Smart Laptop Cooling Pad concept of blowing the air towards the device. Using the LM35 3-pins temperature sensor will detect the temperature in Celsius for the Arduino Uno.

3.2 Temperature Sensing and Fan Enabling

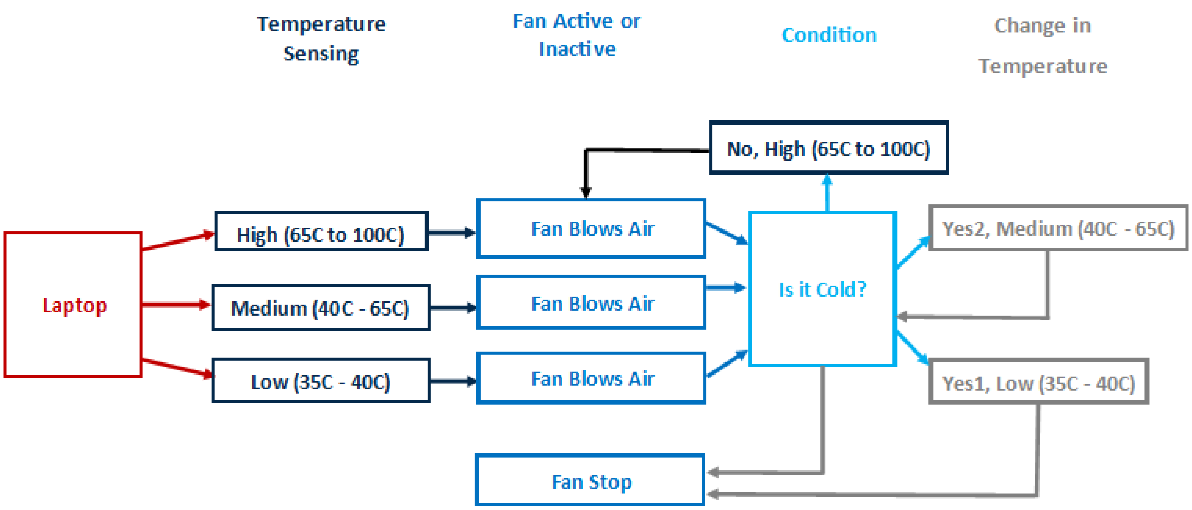


Figure 3.2 Temperature Sensing Enabling and Disabling of fans

Figure 3.2, shows the process of sensing the external temperature of the heat produced by the Laptop Computer. With the use of LM35 Temperature Sensor and relay module it shows the enabling and disabling of the cooling fans.

3.3 Summary of Materials and Specifications

Materials	Specifications
Microcontroller	Arduino Uno
Microcontroller	ATmega328P
Operating Voltage	5V
Digital I/O Pins	14 (of which 6 provide PWM output)
Sensors	DHT11
Operating Voltage	3.5V to 5.5V
Output Voltage	5.5V
Sensitivity	+-1
Fans	40mm Oil Bearing Fans
Voltage	DC 5V
Current Rating	0.25A
Power Consumption	1.25W
Revolution	5000+ 10% for RPM
LCD	I2C LCD
Display capacity	16 Character x 2 row
Display color	Green backlit
Voltage requirements	5 VDC +/- 0.5V
Fan Trigger	Relay Module
Voltage	5 Volts
Trigger Type	Low Trigger
Number of Channel	Single Channel

Table 3.3.1 Summary of Materials and Specifications

3.4 Hardware Requirements

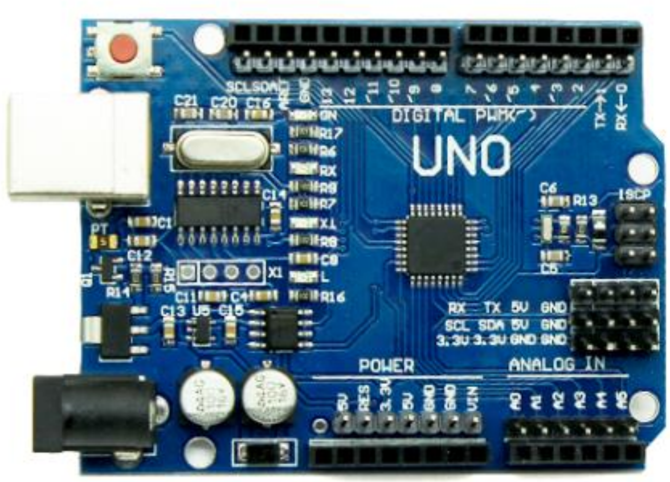


Figure 3.4.1 Arduino Uno R3 CH340G

Arduino Uno R3 CH340G is a microcontroller for development board. It serves as the processing unit of a system. It is a newer version of the traditional Arduino Uno board which has smaller built-in Integrated Circuit or IC. It uses a USB-B type as and input. It also uses USB type A version 2.0 to USB type B cable.

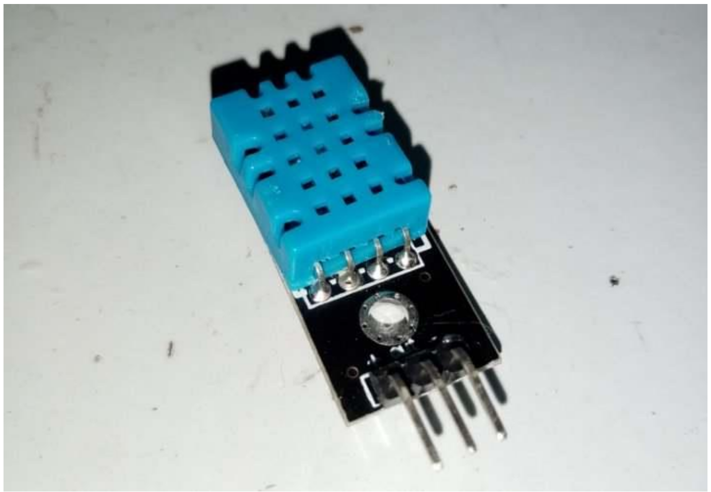


Figure 3.4.2 DHT11 Temperature Sensor

LM35 is a temperature measuring device having an analog output voltage proportional to the temperature. It has an operating voltage 3.5V to 5.5V and an operating temperature from 20 degrees Celsius to 60 degrees Celsius.

Figure 3.4.3 5V 40x40x10mm PC Mini Fan

A mini fan used for active cooling. Fans are used to draw cooler air into the case from the outside, expel warm air from inside and move air across a heat sink to cool a particular component.

Figure 3.4.4 I2C LCD

The I2C LCD is use to display the digital output produced by the sensor. From analog read to digital output.

Figure 3.4.5 5V Low Trigger Relay Module

The relay module is used to activate the DC motors or fans after the sensors senses high temperature and triggered the module by the microcontroller.

3.5 Schematic Diagram

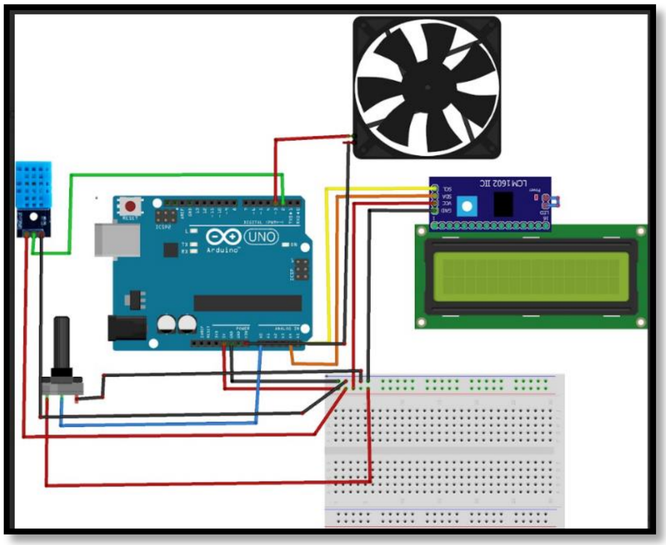


Figure 3.5 Schematic Diagram

3.6 Hardware Architecture

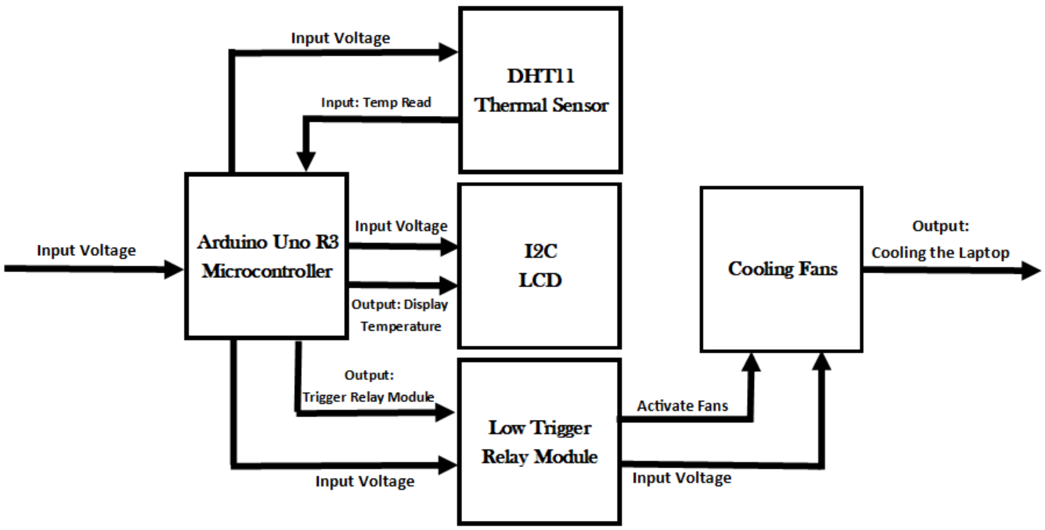


Figure 3.6 Hardware Architecture

3.7 Software Requirements

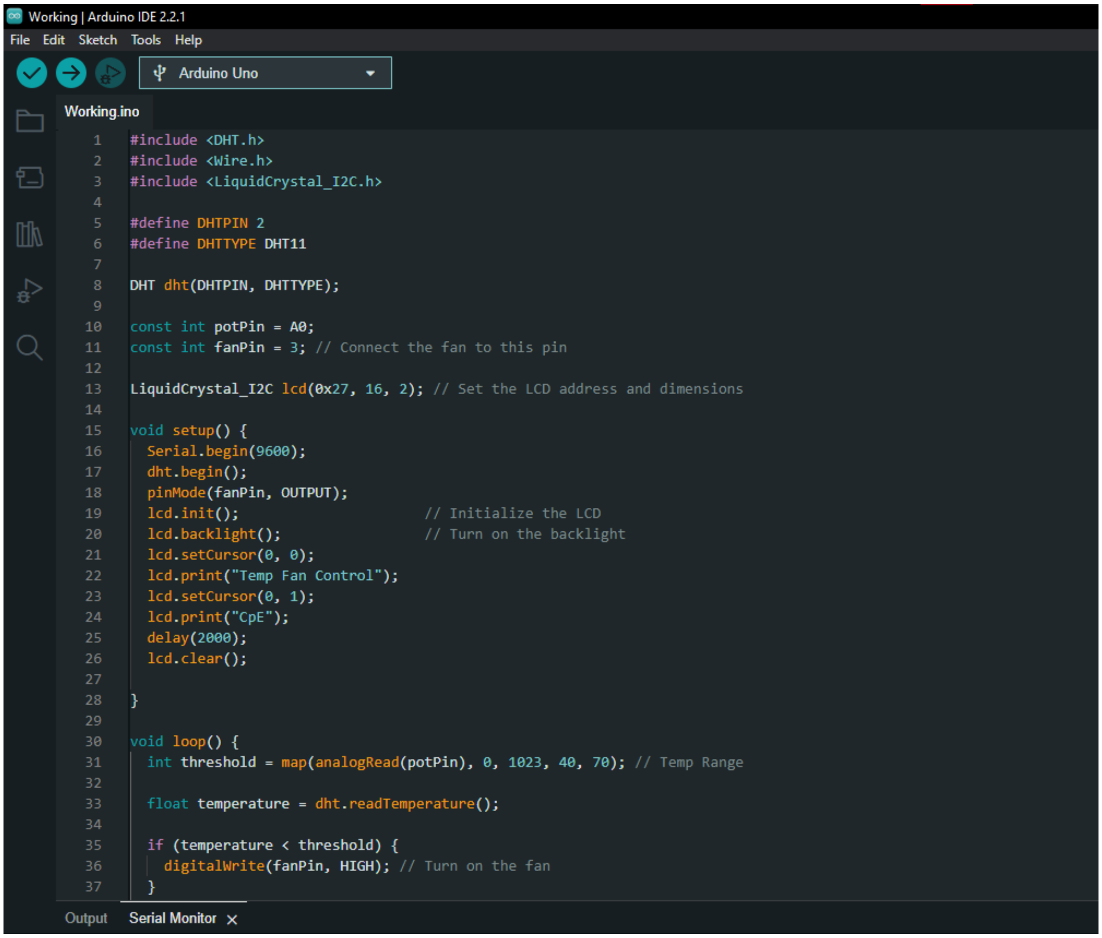


Figure 3.7 Using Arduino IDE

Figure 3.6 the Arduino IDE, which uses the C programming language, is the most popular method of programming language. This IDE helps us to code the algorithms to program the Arduino Uno microcontroller

3.8 Flow Chart

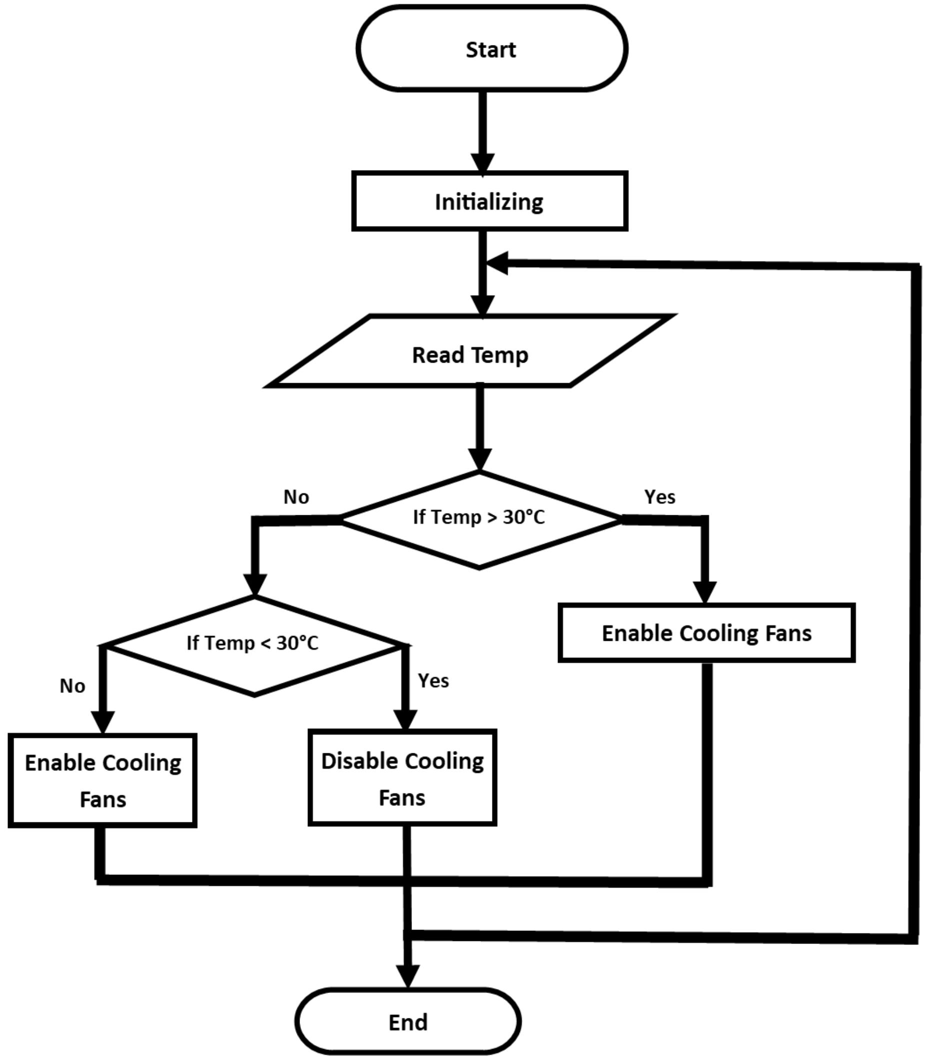


Figure 3.8 Shows the Flow of the Program of the Smart Laptop Cooling Pad using temperature sensor to enable or activate and deactivate fan based on the temperature sensing.

3.9 Cost of Electronic Components

Hardware Components	Price
1pc. Arduino Uno R3 CH340G	Php 200
1pc. 400 Tie Breadboard	Php 45
4pcs. 5V Single Channel Relay Module	Php 112
4pcs. Temperature Sensor (DHT11)	Php 109
4pcs. 5V 40x40x10mm PC Mini Fan	Php 168
1pc. I2C+16x2 LCD	Php 154
1 set Arduino Jumper	Php 42
Total	Php 830

Table 3.9 The cost analysis of materials or electronic components used to build the Smart Laptop Cooling Pad with Temperature Monitoring Prototype.

3.10 Design Prototype Mockup

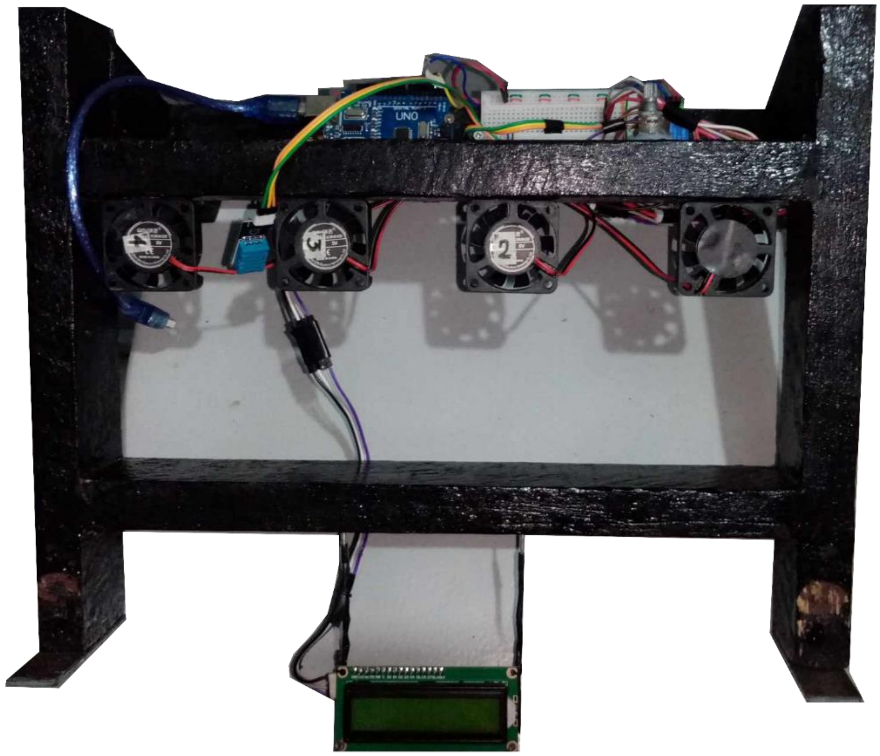


Figure 3.10 The prototype design of the Smart Laptop Cooling Pad with Temperature Monitoring.

3.11 Testing Procedure

The Researchers will conduct the test on the functionality of the Smart Laptop Cooling Pad. Many fans will be installed to blow air on the laptop pc as it's backup cooler as it performs its task for productivity.

Figure 3.11.1 Experiment Plan 1: No Laptop Cooling Pad

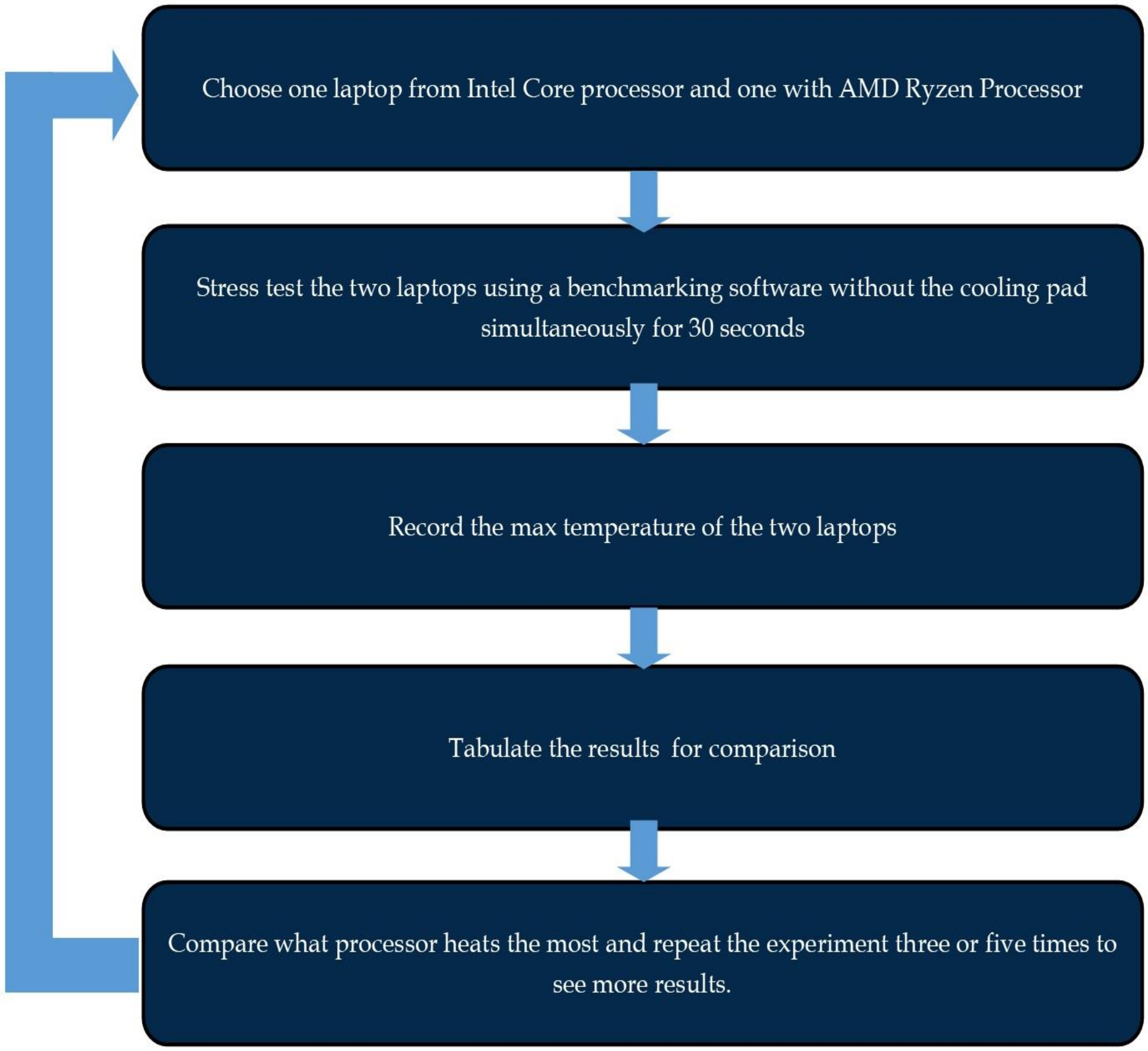
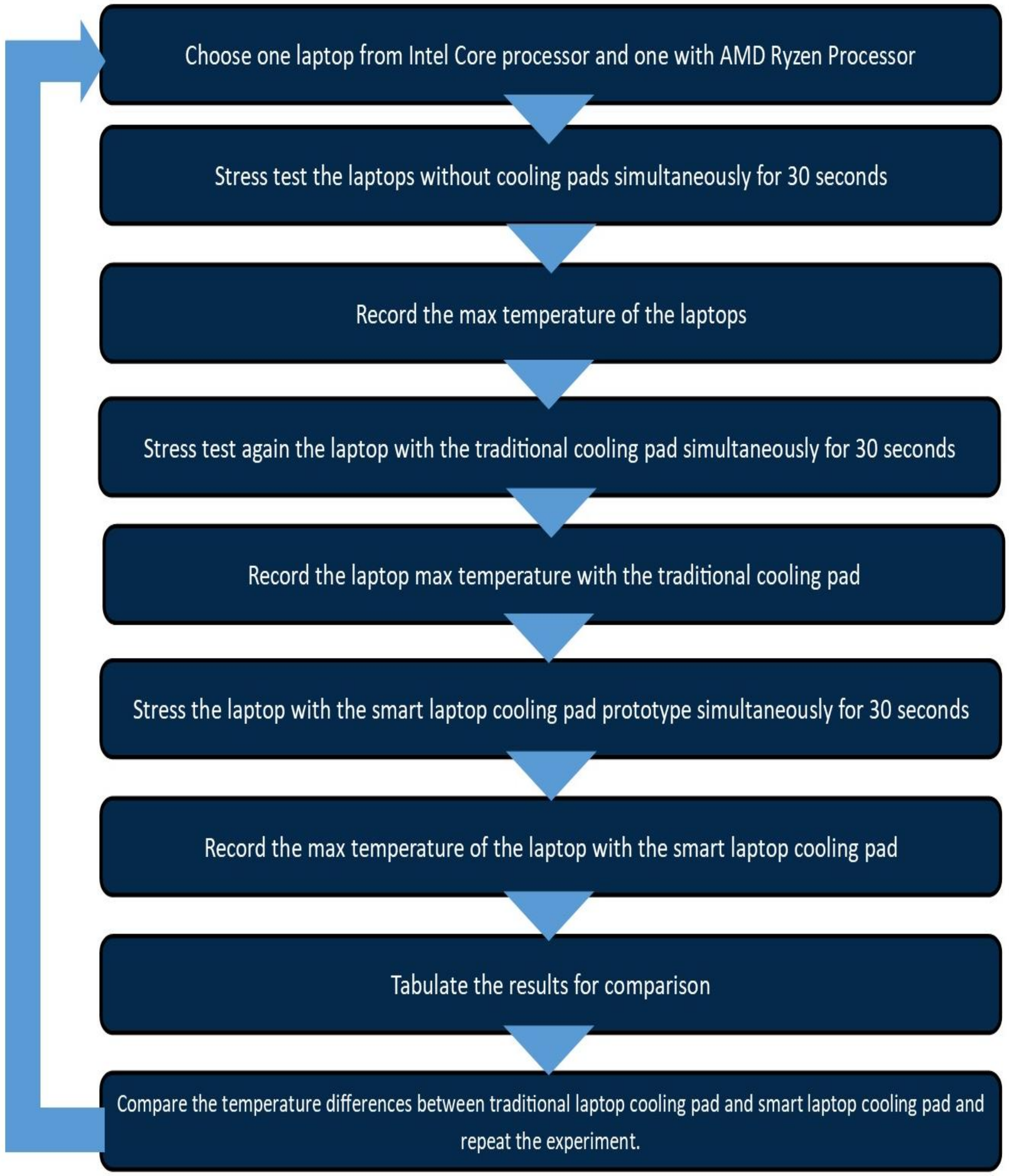


Figure 3.11.2 Experiment Plan 2: Traditional Laptop Cooling Pad vs. Smart Laptop



Chapter 4

RESULTS AND DISCUSSIONS

This chapter shows the processes of the hardware and software of the Smart Laptop Cooling Pad.

4.0 The Preparation before the Testing

4.0.0 The four cooling fans

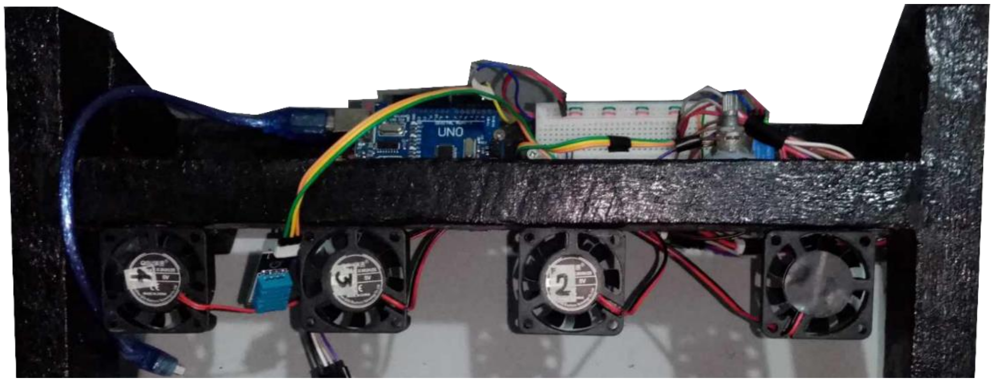


Figure 4.0.0 The four cooling fans

Figure 4.0.0 The prototype uses the four (4) cooling fans to occupy the spaces where laptop's vents are located and to target the possible vents where the cooling fan can blow air. The purpose of the small fans with a dimension of 40x40x10mm is to focus blow cool air on small holes of the laptop's vent according the cooling fan's locations. It was placed at the top part to target the air ventilations of the laptop underneath.

4.0.1 The DHT11 Thermal Sensor

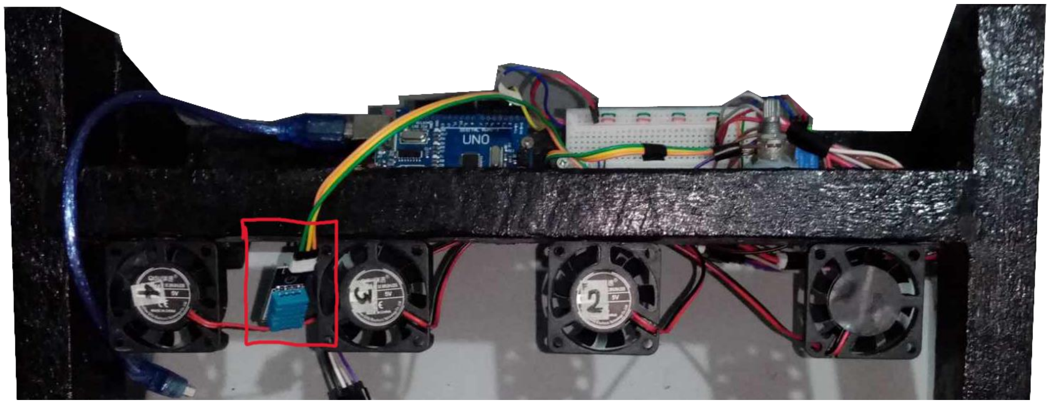


Figure 4.0.1 The DHT11 thermal sensor

Figure 4.0.1 Shows the four LM35 thermal sensor beside the cooling fans. The purpose of the four thermal sensor with different placements are to detect the external temperature underneath the laptop. Once the thermal sensor 1 detects high temperature on the location, the cooling fan will enable and blow cool air.

4.0.2 The Traditional Laptop Cooling Pad

Figure 4.0.2 The Traditional Cooling Pad

This is the traditional cooling pad, no temperature monitoring and no thermal sensors. The same with our prototype, we use USB type A for the input power source. This traditional cooling pad uses a single 120mm fan. The surface is made up of thin metal mesh for dust filter. Giving the laptop an airflow underneath.

4.0.3 Installation of Components and the Design of the Prototype

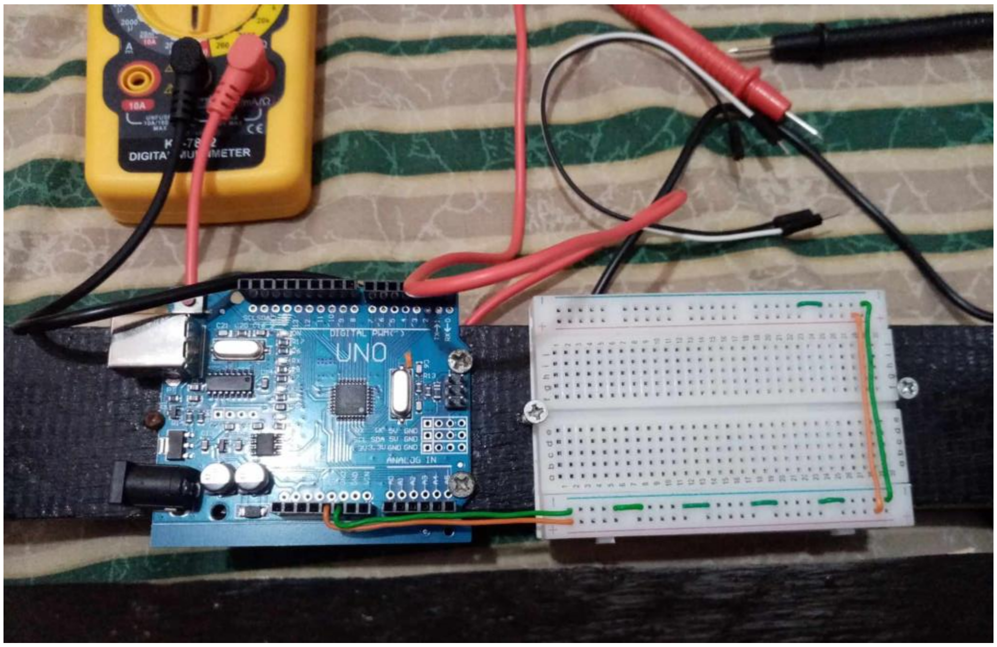


Figure 4.0.3 Installation of Components and the Design of the Prototype

Figure 4.0.3 illustrates the installation and the construction of the design of the prototype, the researchers have carefully designed the prototype to be able to support laptops of different sizes ranging from 13 inch laptops and supports up to 15.6 inch laptops. Necessary components such as the temperature sensors, fans, microcontroller, relay module etc. are carefully into the prototype, temperature sensors are strategically installed in places where the laptop's air exhaust are located allowing a versatile support for laptops with different exhaust designs and placements.

4.0.4 CPU-Z CPU Benchmarking Software

Figure 4.0.4 Shows the Software to be used in benchmarking the CPU

Figure 4.0.4 This is the CPU-Z software we use to bench the laptop's CPU. The CPU-Z bench the laptop's CPU for 30 seconds. The 30 seconds benchmarking od the CPU-Z software is its default benchmarking test duration. It pushes the CPU usage to 100% to reveal the temperature of the CPU's max temp during a 100% utilization.

4.0.5 The Hardware Info (HWinfo) Software

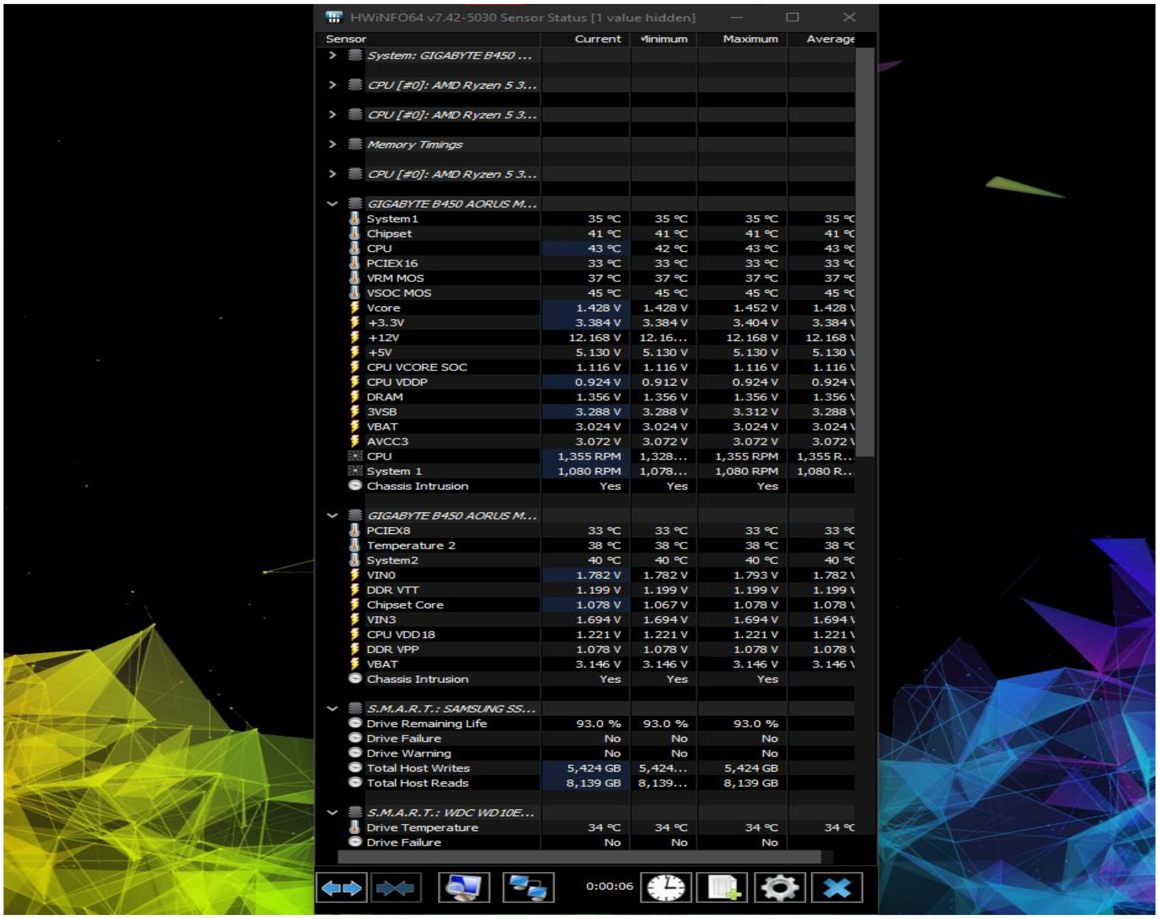


Figure 4.0.5 The Hardware Info (HWinfo) Software

This is the hardware information software where we can monitor the current, minimum, maximum and average internal temperature of the laptop. This software helps us in recording the internal temperature of the laptop while running the benchmarking software mentioned in Figure 4.4.

4.0.6 Acer Nitro Sense

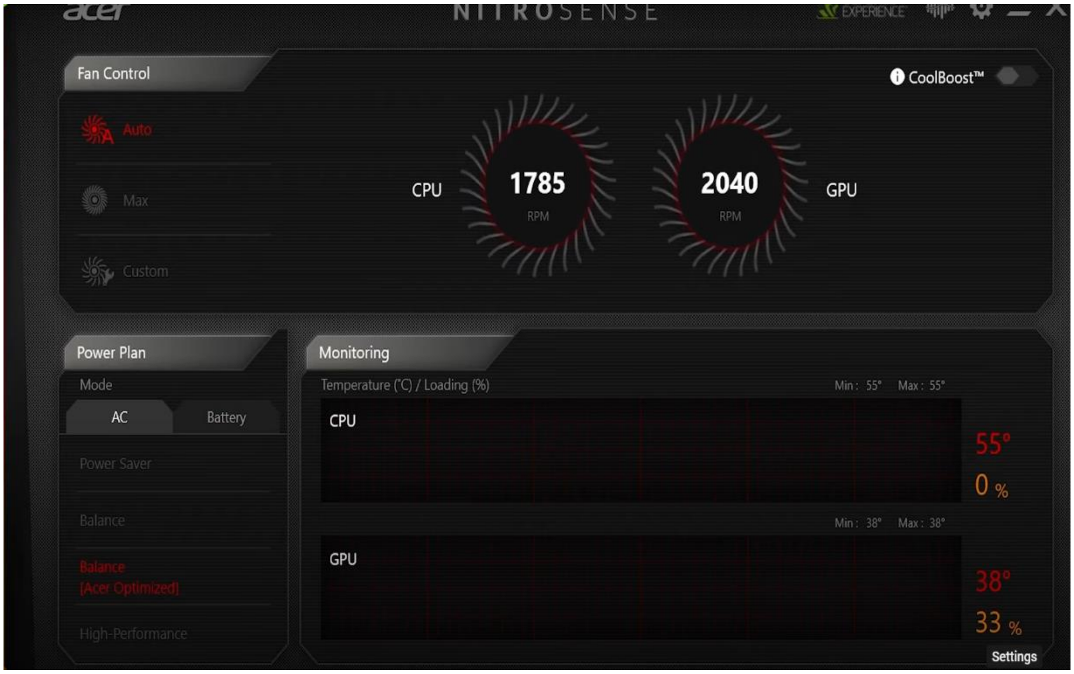


Figure 4.0.6 The Acer Nitro Sense for acer nitro gaming laptop monitoring

The acer nitro sense exclusively for acer nitro gaming laptops used for temperature the internal temperature from the laptop's motherboard thermal sensors. It shows the CPU, the GPU temperature and the built-in cooling fans' speed. We used acer nitro sense for monitoring the temperature of the acer nitro sense gaming laptop for the results.

4.0.7 FurMark CPU Stress Test Software

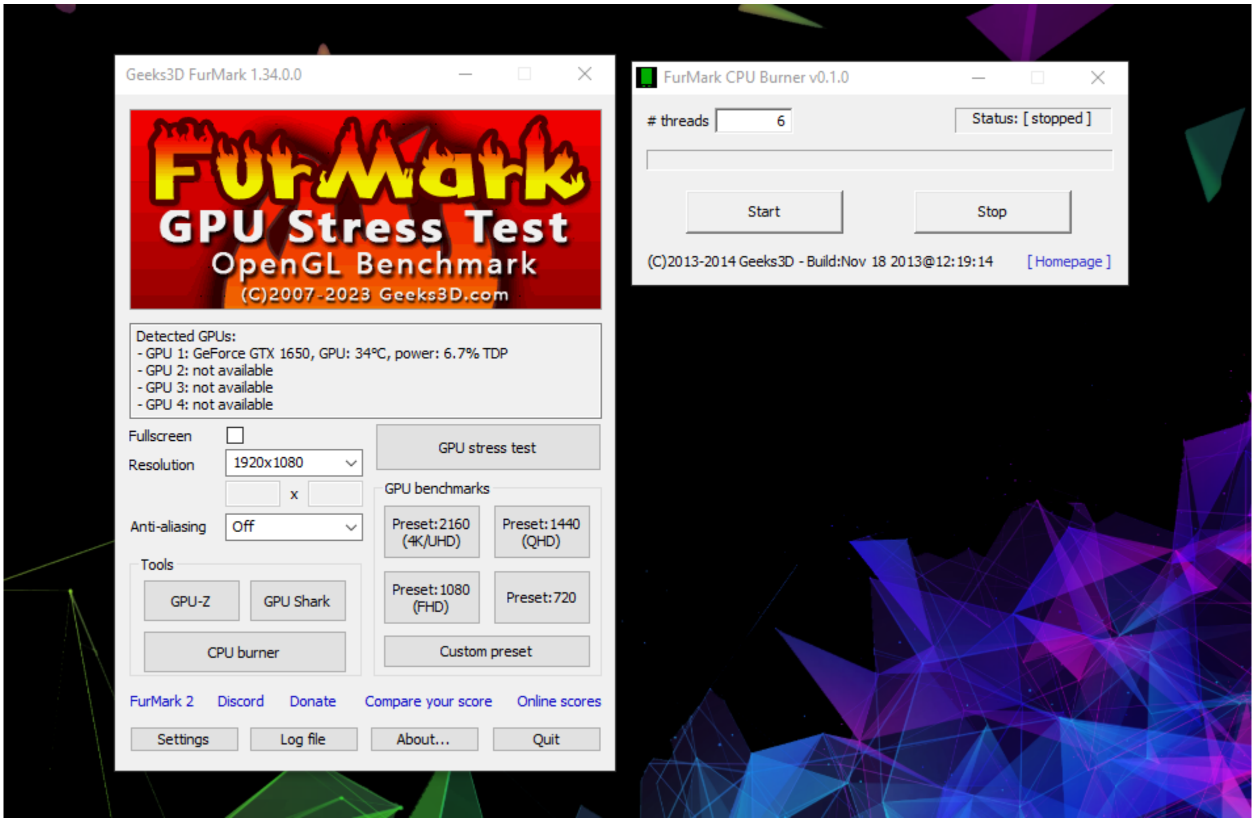


Figure 4.0.7 The FurMark CPU Stress Test Software

This is the furmark CPU stress test software used for high end Desktops and Laptops in benchmarking. We used this software to test a high end gaming laptop to gather the data we need. We still used a 30 seconds benchmarking so that we will have the same time duration of the other benchmarking software. It both stress test CPU and GPU to see if there are issues of the said components.

4.1 The Uploading of Codes and the Testing

4.1.0 Testing the Components

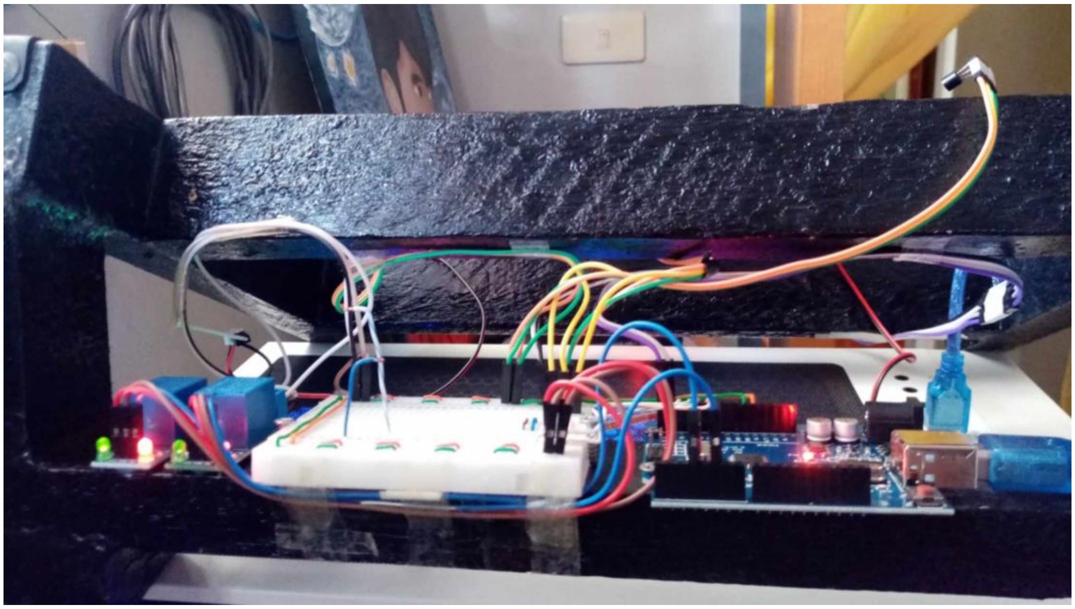


Figure 4.1.0 Testing the components

Figure 4.1.0 shows the testing of the components installed on the prototype to ensure that all electronic devices and components are working correctly and is functional, by making sure that the components runs and is working correctly, the researchers are able to install the components correctly to the prototype.

4.1.1 Uploading and Testing the Code.

Figure 4.1.1 A Screenshot of the Arduino IDE code uploading and testing.

Figure 4.1.1 Shows that in order to run the system, the researchers utilized IoT projects to create code and upload it to power up the Arduino Uno. After uploading the custom code to the Arduino Uno microcontroller while conducting the series of tests and evaluations, the researchers encountered a challenge with the fan RPM control behavior. Initially, the fan RPM readings were inconsistent and not as precise as desired. However, the researchers persisted in their efforts and made necessary adjustments to the fan control calibration. Through diligent troubleshooting and calibration refinement, they were able to resolve the accuracy issues effectively. The researchers meticulously conducted a series of tests and evaluations. These tests aimed to assess the system's performance in real-world scenarios.

4.1.2 Testing the Temperature Sensor

Figure 4.1.2 Testing the Temperature Sensors

Figure 4.1.2 shows the LM35 temperature sensors being tested during the testing phase to ensure that it is working properly and is giving accurate data readings, the temperature sensors are a vital component in the prototype as it will sense the temperature of the user's laptop and use the data to run into the microcontroller and execute specific behavior to the fans based on the data that is detected by the sensors.

4.1.3 Testing the Smart Laptop Cooling Pad Prototype

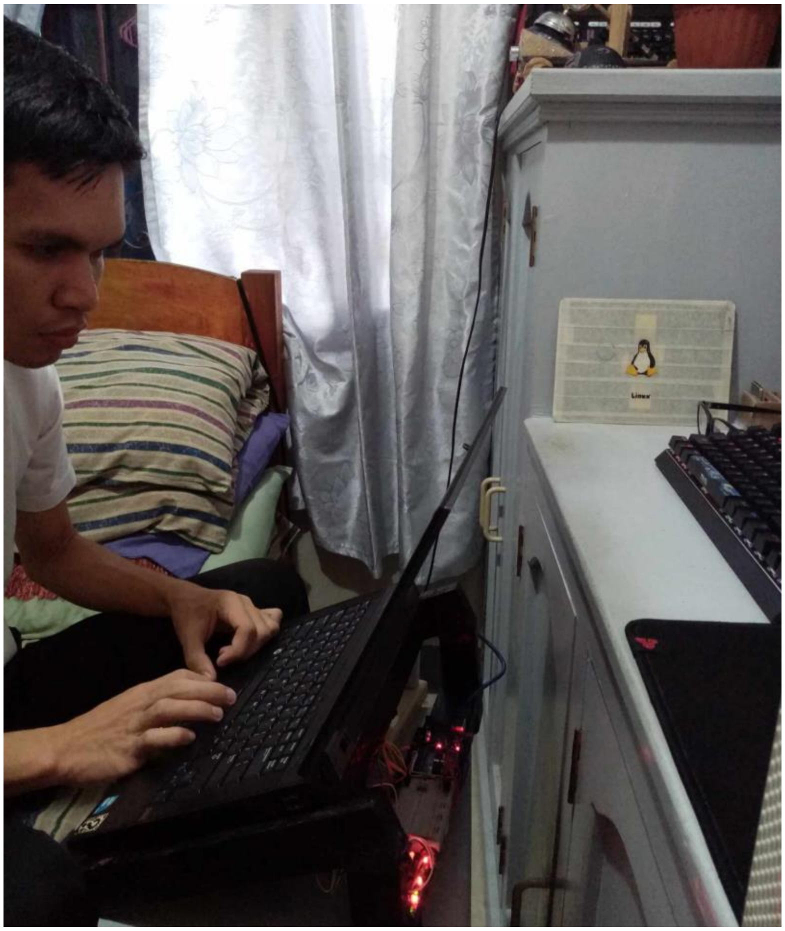


Figure 4.1.3 Testing the Smart Laptop Cooling Pad Prototype

Figure 4.1.3 exhibits the prototype being tested for real world applications, the researchers used different laptops with different applications in real world working conditions, the researchers tested the prototype and its effectiveness to office laptops and gaming laptops to demonstrate the additional cooling capabilities of the prototype and its smart adaptive feature.

4.1.4 Testing the Traditional Laptop Cooling Pad

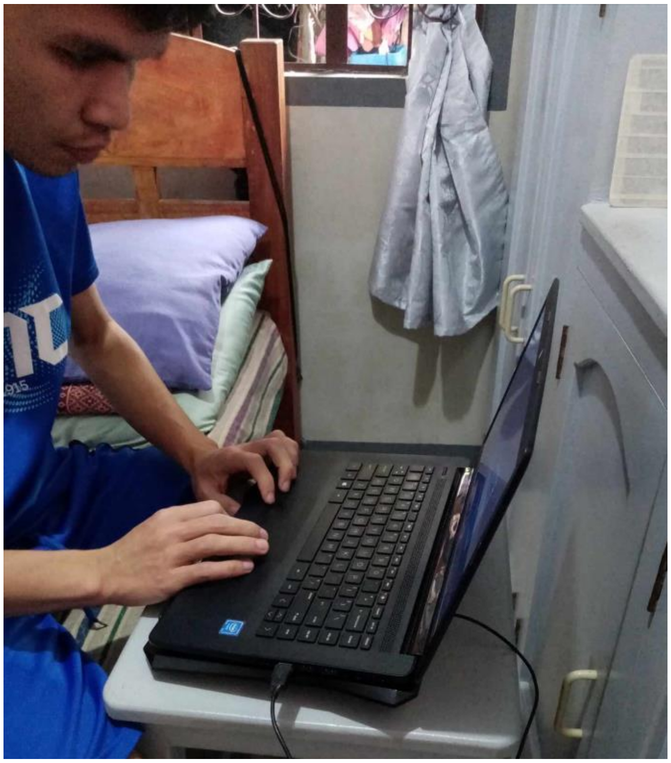


Figure 4.1.4 Testing the Traditional Laptop Cooling Pad

the prototype being tested for real world applications, the researchers used different laptops with different applications in real world working conditions, the researchers tested the prototype and its effectiveness to office laptops and gaming laptops to demonstrate the additional cooling capabilities of the prototype and its smart adaptive feature.

4.1.5 100% CPU Utilization when Benchmarking CPU using CPUZ Software

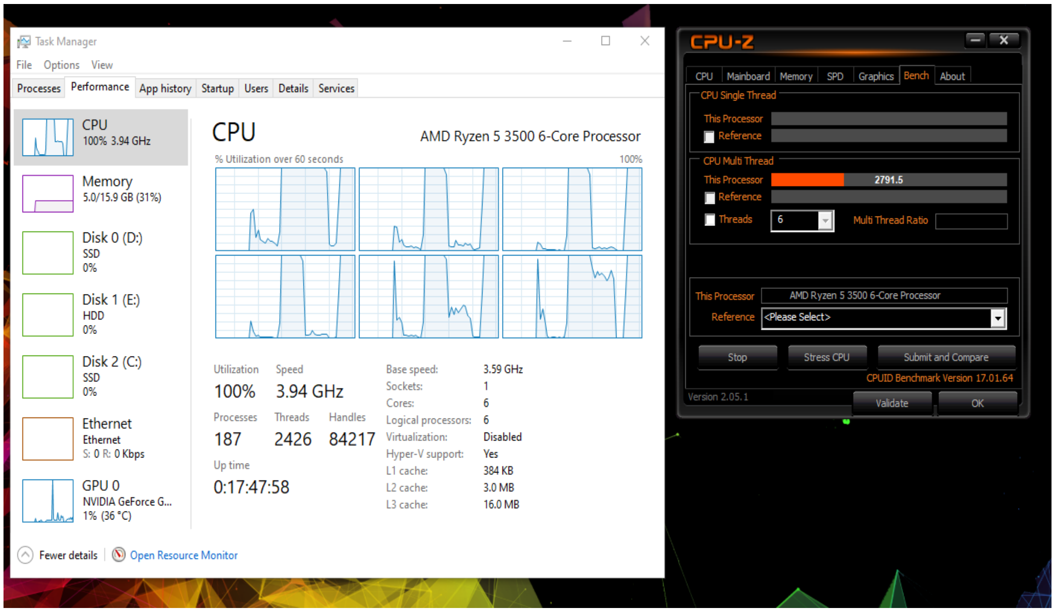


Figure 4.1.5 The 100% CPU Utilization by CPUZ Software

The 100% CPU Utilization when Benchmarking CPU using CPUZ software, which can reveal the minimum, maximum and average temperature of the laptop. It shows how the CPU utilization rose if after we activate benchmark the CPU. The CPU utilization can be monitored using the built-in feature of all laptop with a Windows 10 or higher Operating Systems by Windows called the Task Manager. In order to open the task manager on your laptop click keyboards ctrl+shift+esc at the same time. After opening the Task Manager go to Performance ribbon and select CPU, and all are set. Task Manager helps you to monitor what are the apps running in the background and monitor its utilization.

4.1.6 100% CPU Utilization when Benchmarking CPU using FurMark Software

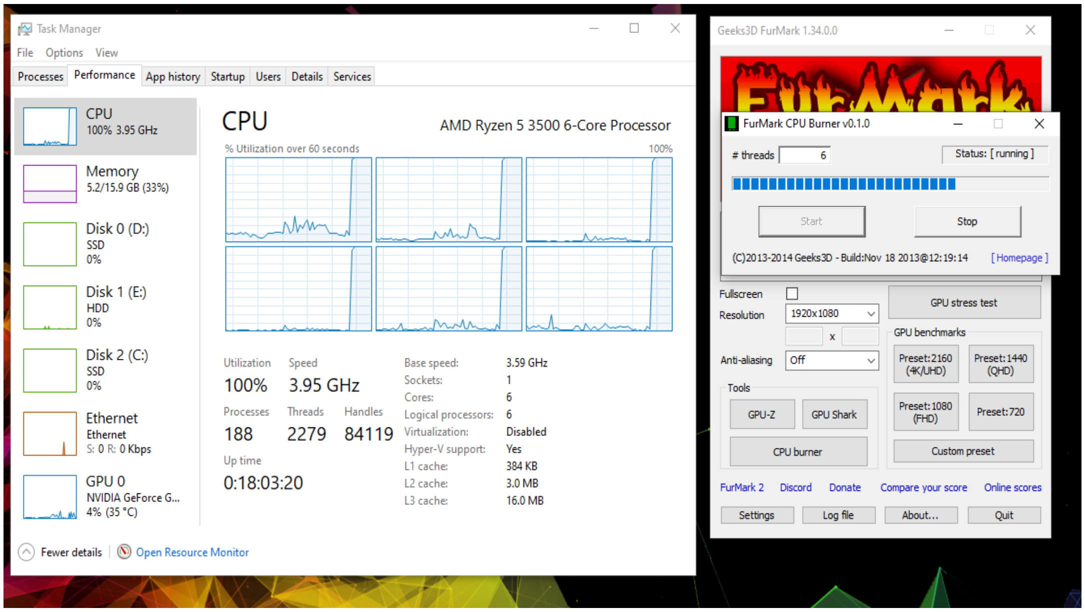


Figure 4.1.6 The 100% CPU Utilization by FurMark Software

The 100% CPU Utilization when Benchmarking CPU using FurMark software, which can reveal the minimum, maximum and average temperature of the laptop. It shows how the CPU utilization rose if after we activate benchmark the CPU. The CPU utilization can be monitored using the built-in feature of all laptop with a Windows 10 or higher Operating Systems by Windows called the Task Manager.

4.2 Benchmarking and Results

Table 4.2.0 Laptop Stress Testing 1

Testing I. No Cooling Pad (No built-in fan (Passive Cooling))							
Specifications	Time / Location	Weather	Surface Type	Test Duration	Minimum Temperature	Maximum Temperature	Average Temperature
14 inch HP Office Laptop Intel Celeron N400 CPU (2.60 Ghz)	10:53 AM Bedroom	Sunny	Wood	30 sec	41 degrees Celsius	58 degrees Celsius	50 degrees Celsius

Table 4.2.0 shows the data of the first test with an office laptop without the cooling pad

Table 4.2.1 Laptop Stress Testing 2

Testing II. With Traditional Cooling Pad (No built-in fan (Passive Cooling))							
Specifications	Time / Location	Weather	Surface Type	Test Duration	Minimum Temperature	Maximum Temperature	Average Temperature
14 inch HP Office Laptop Intel Celeron N400 CPU (2.60 Ghz)	11:07 AM Bedroom	Sunny	Wood	30 sec	40 degrees Celsius	58 degrees Celsius	45 degrees Celsius

Table 4.2.1 shows the data of the second test of the same laptop now using the traditional cooling pad that are readily available in the market.

Table 4.2.2 Laptop Testing 3

Testing III. With Smart Cooling Pad (No built-in fan (Passive Cooling))							
Specifications	Time / Location	Weather	Surface Type	Test Duration	Minimum Temperature	Maximum Temperature	Average Temperature
14 inch HP Office Laptop Intel Celeron N400 CPU (2.60 Ghz)	11:54 AM Bedroom	Sunny	Wood	30 sec	39 degrees Celsius	56 degrees Celsius	43 degrees Celsius

Table 4.2.2 shows the data of the third test of the same laptop using the smart cooling pad. The smart cooling pad showed promising results.

Figure 4.2.3 Chart Comparison 1

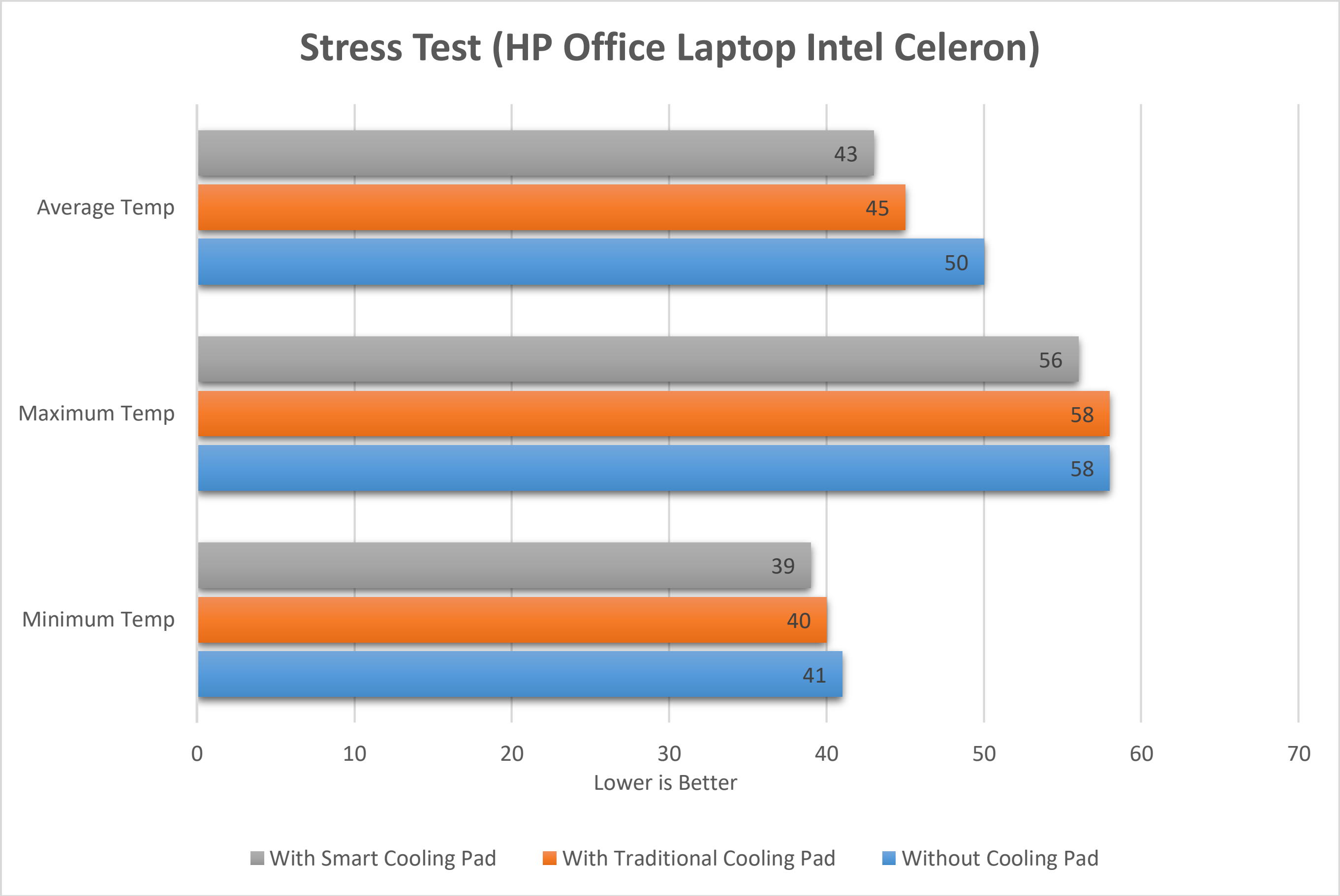


Table 4.2.3 shows the overall results of the 3 stress tests, the smart cooling pad yields better cooling performance than the traditional cooling pad on the market thus proved the effectiveness of thermal management.

Table 4.2.4 Laptop Stress Testing 4

Testing IV. No Cooling Pad (With built-in fan)							
Specifications	Time / Location	Weather	Surface Type	Test Duration	Minimum Temperature	Maximum Temperature	Average Temperature
14 inch ASUS Vivobook OLED M1503Q **AMD Ryzen 5 5600H CPU (3.30 Ghz)**	9:00 AM Living Room	Sunny	Glass	30 sec	44.9 degrees Celsius	91.9 degrees Celsius	62.2 degrees Celsius

Table 4.2.4 shows the data of the stress test on a AMD Ryzen powered mid ranged office laptop

Table 4.2.5 Laptop Stress Testing 5

Testing V. With Traditional Cooling Pad (With built-in fan)							
Specifications	Time / Location	Weather	Surface Type	Test Duration	Minimum Temperature	Maximum Temperature	Average Temperature
14 inch ASUS Vivobook OLED M1503Q **AMD Ryzen 5 5600H CPU (3.30 Ghz)**	9:10 AM Living Room	Sunny	Glass	30 sec	43 degrees Celsius	89 degrees Celsius	57 degrees Celsius

Table 4.2.5 shows the data of the second stress test on the same laptop using the traditional cooling pad.

Table 4.2.6 Laptop Stress Testing 6

Testing VI. With Smart Cooling Pad (With built-in fan)							
Specifications	Time / Location	Weather	Surface Type	Test Duration	Minimum Temperature	Maximum Temperature	Average Temperature
14 inch ASUS Vivobook OLED M1503Q **AMD Ryzen 5 5600H CPU (3.30 Ghz)**	9:47 AM Living Room	Sunny	Glass	30 sec	42.7 degrees Celsius	84 degrees Celsius	53.2 degrees Celsius

Table 4.2.6 shows the third stress test of the same laptop using the smart cooling pad, the rest revealed promising results and cooling performance of the smart cooling pad.

Figure 4.2.7 Chart Comparison 2

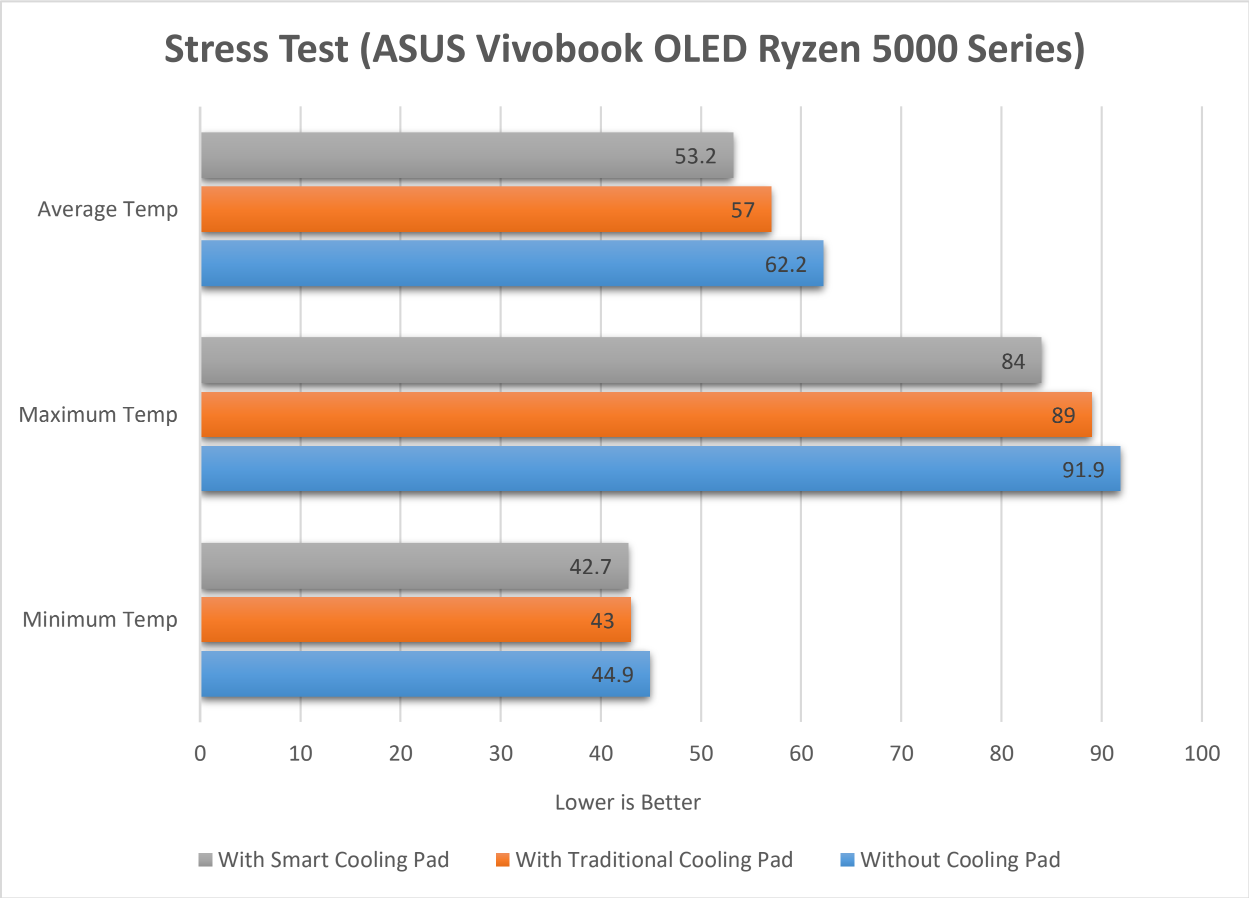


Table 4.2.7 shows the significant temperature change using the traditional cooling pad versus the smart cooling pad, the smart cooling showed better results compared to the existing traditional cooling pad that is on the market.

Table 4.2.8 Laptop Stress Testing 7

Testing VII. No Cooling Pad (With built-in fan)							
Specifications	Time / Location	Weather	Surface Type	Test Duration	Minimum Temperature	Maximum Temperature	Average Temperature
15.6 inch ACER Nitro 5 AN515-52-56HJ **Intel Core i5 8300H CPU (4.00 Ghz)**	9:50 AM Living Room	Sunny	Glass	30 sec	70 degrees Celsius	96 degrees Celsius	88 degrees Celsius

Table 4.2.8 show the data of the stress test on a mid-ranged gaming laptop, thermals are much higher than the previous two laptops as this laptop is used for heavy workloads.

Table 4.2.9 Laptop Stress Testing 8

Testing VIII. With Traditional Cooling Pad (With built-in fan)							
Specifications	Time / Location	Weather	Surface Type	Test Duration	Minimum Temperature	Maximum Temperature	Average Temperature
15.6 inch ACER Nitro 5 AN515-52-56HJ Intel Core i5 8300H CPU (4.00 Ghz)	9:54 AM Living Room	Sunny	Glass	30 sec	58 degrees Celsius	87.2 degrees Celsius	69.4 degrees Celsius

Table 4.2.9 shows the data of the second stress test on the same laptop with the traditional laptop cooler on, the data shows significant temperature drops as the traditional laptop cooler cools the laptop.

Table 4.2.10 Laptop Stress Testing 9

Testing IX. With Smart Cooling Pad (With built-in fan)							
Specifications	Time / Location	Weather	Surface Type	Test Duration	Minimum Temperature	Maximum Temperature	Average Temperature
15.6 inch ACER Nitro 5 AN515-52-56HJ **Intel Core i5 8300H CPU (4.00 Ghz)**	10:30 AM Living Room	Sunny	Glass	30 sec	56 degrees Celsius	85 degrees Celsius	67.2 degrees Celsius

Table 4.2.10 shows the data of the stress test on the same laptop with the smart cooling pad, the test results showed an effective temperature drops when using the smart cooling pad compared to the traditional cooling pad.

Figure 4.2.11 Chart Comparison 3

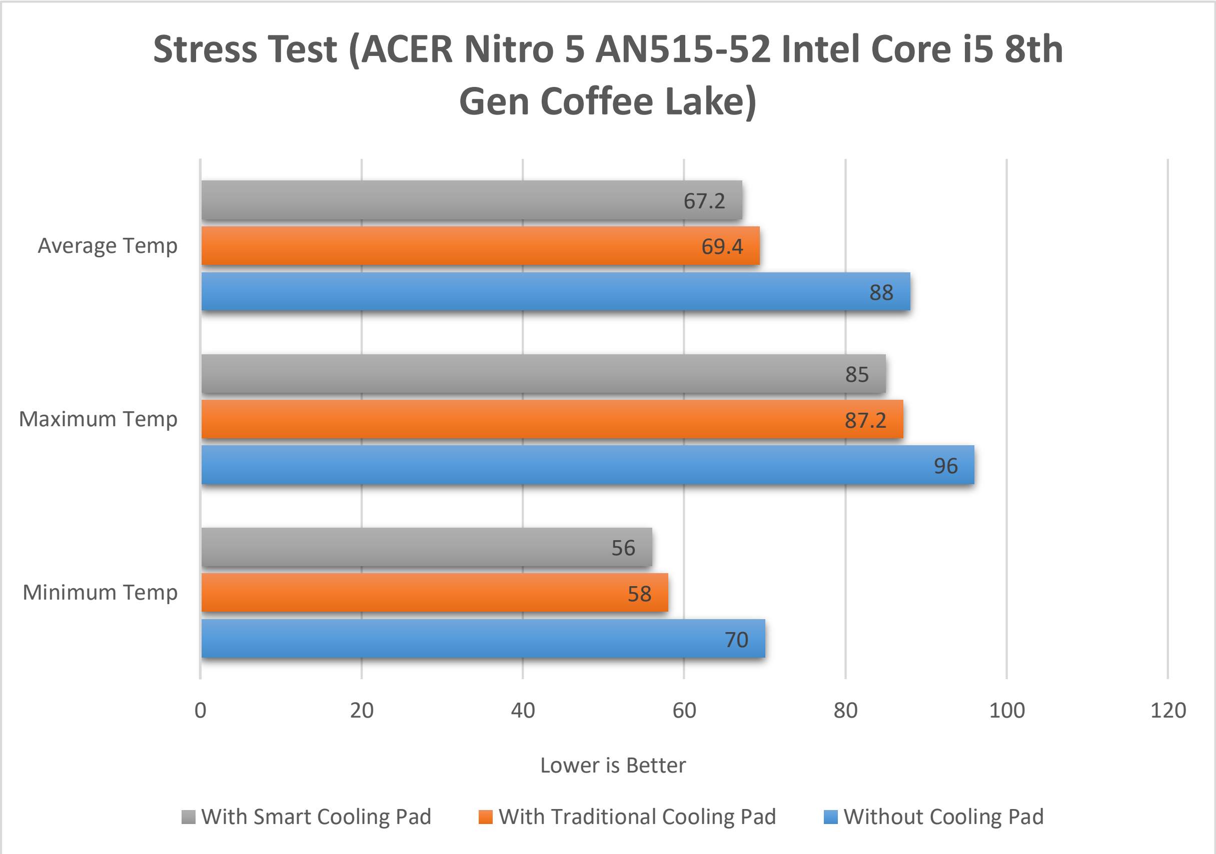


Table 4.2.11 shows the significant differences of the three tests conducted on the laptop, these tests showed that the smart laptop cooling pad was able to yield more thermal management than the traditional cooling pad, thus proving it very effective for its intended use.

CHAPTER 5

SUMMARY, CONCLUSION AND RECOMMENDATION

The objective of this research is to summarize the findings and propose recommendations for future research. The document aims to provide an overview of the researchers' accomplishments in accordance with the project's design and objectives.

5.1 Summary of Findings

The relevant findings if the study is followed:

• The DHT11 temperature sensors are capable of accurately detecting temperature data emanating from the laptop's exhaust port. This precise data enables the microcontroller to adjust the cooling fan's RPM, either increasing or decreasing it based on the laptop's temperature, thereby fulfilling the purpose of creating an efficient, adaptive, and energy-efficient cooling pad system.

• Due to limited resources and time available for further development, the cooling pad system remains a prototype. However, despite these constraints, the researchers successfully achieved their goal in conducting this research.

• The study indicates that the low-cost smart laptop cooler can be significantly enhanced with further research design and development. Furthermore, the study demonstrates that the laptop cooler effectively provides additional cooling to laptops, especially under heavy use.

- The researchers conducted tests on three different laptops, each with varying sizes, designs, CPU power, and applications. Out of two tests on each laptop, they achieved a success rate of 100 percent in providing additional cooling, resulting in internal temperature decreases of up to 10 percent compared to laptops relying solely on built-in cooling mechanisms.

5.2 Conclusion

In conclusion, the Smart Laptop Cooler represents a significant advancement in addressing the thermal challenges inherent in contemporary laptop design. These intelligent cooling solutions, equipped with cutting-edge sensors and algorithms, epitomize a sophisticated approach to thermal management. By dynamically adapting to the varying heat profiles of laptops, smart coolers optimize heat dissipation, ensuring consistent and reliable performance while mitigating the risk of thermal throttling. Furthermore, the user-friendly nature of these devices, coupled with automated temperature monitoring and fan speed adjustments, enhances operational convenience. The incorporation of energy-efficient design elements not only promotes sustainability but also contributes to a more economical and environmentally conscious computing experience. As laptops continue to evolve in complexity and power, the deployment of smart cooling solutions emerges as an integral component in sustaining peak performance and user satisfaction.

5.3 Recommendations

The researchers recommend the following.

- Conduct further research and design to improve the portability of the Smart Laptop Cooler and make alternatives to other electronic components used in the prototype that is more efficient than the latter.
- Source out more resources to aid the study into much more developed state as resources will be readily available.
- Create a design that is more uses lightweight materials to improve the portability of the cooler and to research much efficient commands for the microcontroller to execute.

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APPENDICES

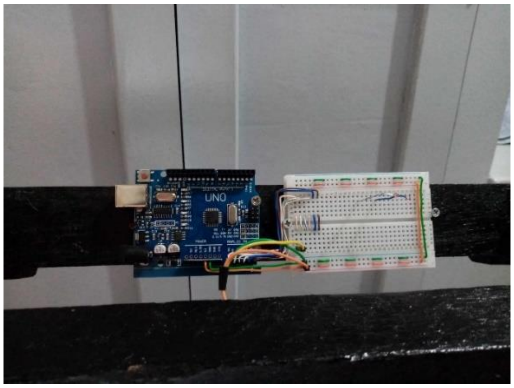
Appendix A: Gantt Chart

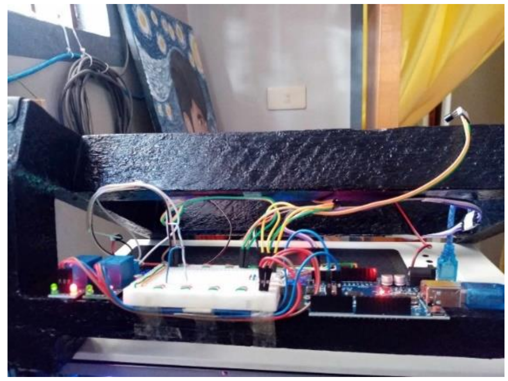
Activity	Time Table							
	06/15/23 - 07/15/23	8/14/23	11/22/23	11/25/23	11/26/22	12/27/23	01/13/24 - 05/02/24	05/04/24
Chapters 1-3								
Prototype Building								
Prototypes Testing								
Chapter 4								
Chapter 5								
Revision								
Submission								

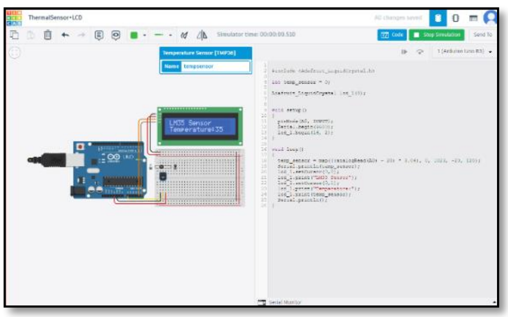
Appendix B: Code

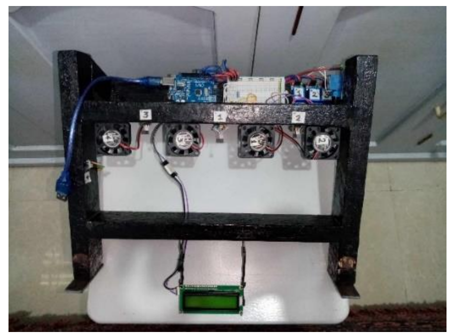
```
#define DHTTYPE DHT11

DHT dht(DHTPIN, DHTTYPE);

const int potPin = A0;
const int fanPin = 3;

LiquidCrystal_I2C lcd(0x27, 16, 2); // Set the LCD address and dimensions

void setup() {
  Serial.begin(9600);
  dht.begin();
  pinMode(fanPin, OUTPUT);
  lcd.init();
  lcd.backlight();
  lcd.setCursor(0, 0);
  lcd.print("Temp Fan Control");
  lcd.setCursor(0, 1);
  lcd.print("CpE");
  delay(2000);
  lcd.clear();
  digitalWrite(fanPin, LOW);

}

void loop() {
  int threshold = map(analogRead(potPin), 0, 1023, 40, 70); // Temp Range


  int temperature = dht.readTemperature(); // DHT11 Temp Reading
  Serial.print("threshold");
  Serial.println(threshold);
  Serial.print("temperature");
  Serial.println(temperature);
  Serial.print("potPin");
  Serial.println(potPin);


  if (temperature < threshold) {
    digitalWrite(fanPin, HIGH); // Turn on the fan
    Serial.println("On");
  }
  //else {
   // digitalWrite(fanPin, LOW); // Turn off the fan
   //Serial.println("Off");
  //}

  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Temp: ");
  lcd.print(temperature);
  lcd.print("C");

  lcd.setCursor(0, 1);
  lcd.print("Threshold: ");
  lcd.print(threshold);
  lcd.print("C");

  delay(1000);
}
```

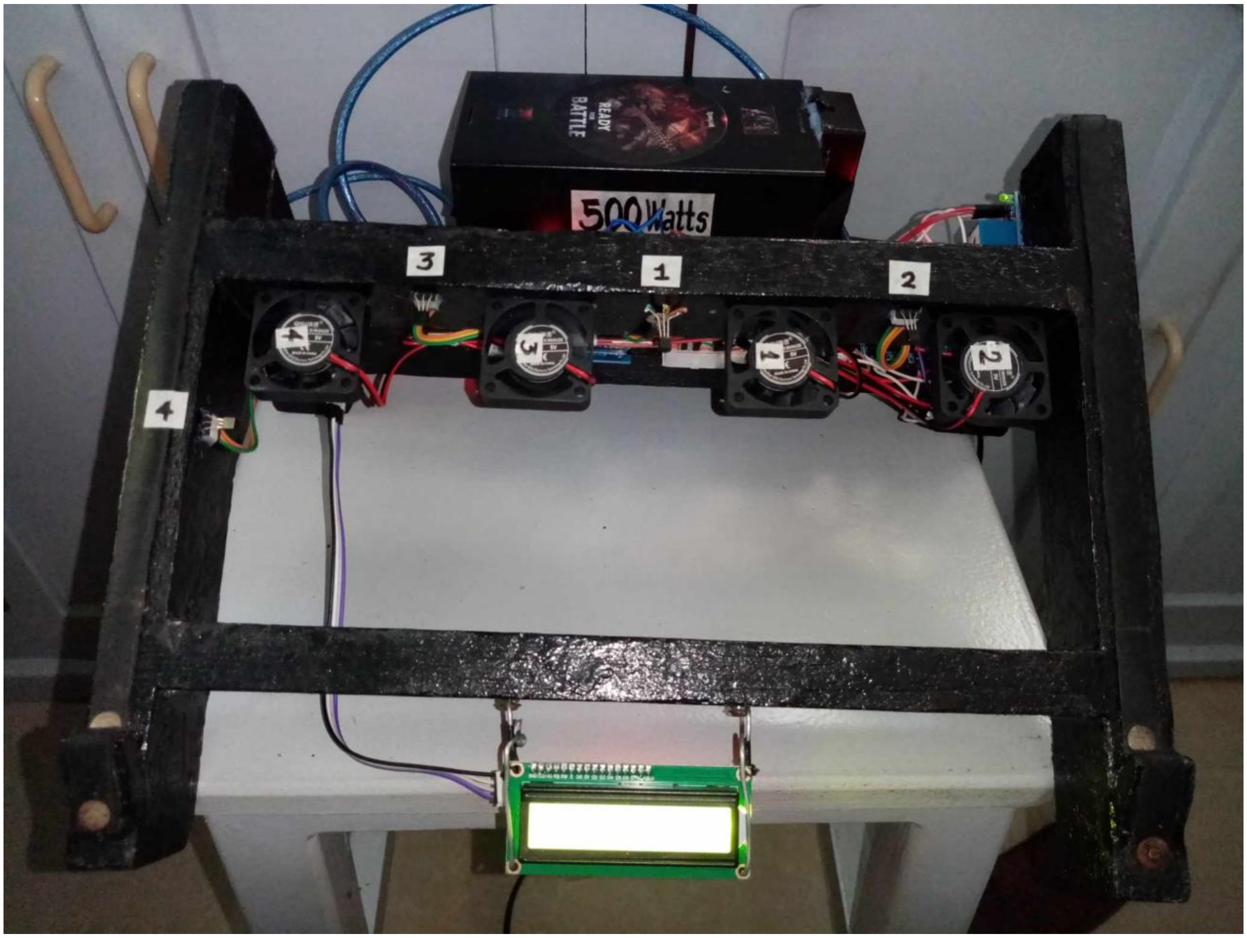
Appendix C: Documentations










500Watts
3
1
2
4

Jayrton Manuel P. Gutib
Contact No: 0975-477-0142
Email Address: jayrtonmanuel@gmail.com

OBJECTIVE

Undergraduate student currently enrolled in a Computer Engineering Program at St. Michael's College. Seeking a career that fits my skills in arts and being a Computer Engineering.

EDUCATION

- St. Vincent's Academy, Inc.
  Junior High School
  2014-2018
- St. Vincent's Academy, Inc.
  Senior High School
  2018-2020
- St. Michael's College
  2020- Present Year
  Expected Graduation: May 2024

SKILLS

- Proficient in the following:
  - Computer Troubleshooting
  - Networking
  - AutoCAD
  - SketchUp
- Relevant Skills:
  - Microsoft: Excel, Powerpoint, Publisher,Word
  - Adobe: Photoshop, Lightroom, InDesign, Premiere, After Effects

ACHIEVEMENT

- ICpEP.SE Member

PROJECT

- Call Bell Ringer Robot
- Smart Laptop Cooling Pad with Temperature Monitoring

REFERENCE

- Engr. Jane K. Zaportiza
  Dean if College of Engineering
  St. Michael's College

- Stephanie R. Visitacion
  Faculty of College of Engineering
  St. Michael's College

Steven John E. Cuizon
Contact No: 0969-076-6186
Email Address: stevencuizon8@gmail.com

OBJECTIVE

Undergraduate student currently enrolled in a Computer Engineering Program at St. Michael's College. Seeking a career that fits my skills in arts and being a Computer Engineering.

EDUCATION

- Corpus Christi Parochial School of Iligan
  Junior High School
  2014-2018
  Corpus Christi Parochial School of Iligan
  Senior High School
  2018-2020
- St. Michael's College
  2020- Present Year
  Expected Graduation: May 2025

SKILLS

- Proficient in the following:
  - Computer Troubleshooting
  - Video Editing
  - AutoCAD
- Relevant Skills:
  - Microsoft: Excel, Powerpoint, Publisher,Word
  - Canva, Da Vinci Resolve, Premiere, After Effects

ACHIEVEMENT

- ICpEP.SE Member

PROJECT

- Robot Arm
- Smart Laptop Cooling Pad with Temperature Monitoring

REFERENCE

- Engr. Jane K. Zaportiza
  Dean if College of Engineering
  St. Michael's College

- Stephanie R. Visitacion
  Faculty of College of Engineering
  St. Michael's College

Dean Alexander Q. Doria
Contact No: 09306027344
Email Address: progamer12279@gmail.com

OBJECTIVE

A highly motivated and detail-oriented undergraduate, currently enrolled in the Computer Engineering program with a passion for software development, cybersecurity and problem-solving. Seeking a challenging position where I can apply my technical skills, collaborate with interdisciplinary teams, and contribute to innovative projects.

EDUCATION

- Our Lady of Perpetual Help Academy
  Junior High School
  2014-2018
  Our Lady of Perpetual Help Academy
  Senior High School
  2018-2020
- St. Michael's College
  2020- Present Year
  Expected Graduation: May 2025

SKILLS

- Proficient in the following:
  - Computer Troubleshooting
  - Computer Virtualization
  - AutoCAD
- Relevant Skills:
  - Microsoft: Excel, PowerPoint, Publisher, Word
  - VMWare, Oracle Virtual Box, Microsoft Sandbox

ACHIEVEMENT

- ICpEP.SE Committee Officer

PROJECT

- Robot Arm
- Smart Laptop Cooling Pad with Temperature Monitoring

REFERENCE

- Engr. Jane K. Zaportiza
  Dean if College of Engineering
  St. Michael's College

- Stephanie R. Visitacion
  Faculty of College of Engineering
  St. Michael's College