



KEMENTERIAN PENDIDIKAN TINGGI

PITRAM 2026

Pertandingan Inovasi Antara Asasi Malaysia

Extended Abstract Book



11 dan 12 APRIL 2026

Dewan Berlian

Universiti Teknologi MARA

Cawangan Selangor

Kampus Puncak Alam



UNIVERSITI
TEKNOLOGI
MARA

Pusat
Asasi



KEMENTERIAN PENDIDIKAN TINGGI



MAJLIS DEKAN/PENGARAH ASASI
UNIVERSITI AWAM MALAYSIA

i-MagArctic: An Intelligent Thermoelectric Cooling System with Anti-Condensation Control for Smartphones

Samsur Nongkang, Azijul Soidon, Muhammad Daniel Haiqal Rostam, Jasnie

Politeknik Sandakan Sabah, Education Hub, Batu 10 Sg.Batang, 90000 Sandakan, Sabah,
Malaysia

*samsur@pss.edu.my

ABSTRACT

The increasing use of smartphones for high-intensity applications such as mobile gaming has resulted in significant thermal management challenges, affecting device performance and reliability. This project introduces i-MagArctic, an intelligent cooling system that integrates thermoelectric technology with liquid cooling and incorporates an anti-condensation mechanism based on dew point control. The system was evaluated through a 20-minute experimental test, with temperature data recorded at two-minute intervals. The analysis focused on key parameters including peak temperature, average temperature, heating rate, thermal stability, and cooling efficiency. The results indicate that i-MagArctic successfully reduced the smartphone peak temperature from 44°C to 35.9°C and the battery temperature from 41°C to 32.3°C. Additionally, the heating rate was significantly reduced, and temperature stability improved based on lower standard deviation values. The system achieved a cooling efficiency of 18.41% for the smartphone and 21.2% for the battery. Overall, i-MagArctic demonstrates strong effectiveness in managing smartphone thermal performance and shows high potential for commercialization as a mobile gaming accessory.

Keywords: i-MagArctic, thermoelectric cooling, smartphone, anti-condensation, thermal management

1. INTRODUCTION

In recent years, the demand for high-performance smartphone applications, particularly mobile gaming, has increased significantly. However, prolonged usage under intensive workloads leads to excessive heat generation, which negatively impacts device performance and user experience.

1.1 Scope of the Project

This project focuses on the development of i-MagArctic, an intelligent thermoelectric cooling system designed to regulate smartphone temperature during high-intensity usage. The system integrates thermoelectric cooling, liquid cooling, and anti-condensation control to enhance thermal performance.

1.2 Problem Statement

- Smartphones experience overheating during prolonged gaming sessions.
- Thermal throttling reduces device performance.
- Existing cooling solutions are insufficient and lack condensation control.

1.3 Objectives

- To design and develop a hybrid thermoelectric cooling system.
- To implement an intelligent temperature control mechanism with anti-condensation.
- To evaluate the effectiveness of the system through experimental analysis.

2. METHODOLOGY

The development of i-MagArctic follows a structured process involving system design, implementation, and experimental validation.

2.1 System Design

- **Hardware Design:** Peltier Module, ESP32-C3 Super Mini microcontroller, Water pump, Fan for radiator & Circuit board, Radiator, Ambient & Humidity Sensor (DH11), Thermistor Sensor (NTC), MOSFET, DC-DC Buck Converter Module.
- **Software Design:** Arduino IDE programming, Android Studio Apps for data monitoring, Temperature-based control logic and PWM regulation.

2.1 Implementation

- Assemble of cooling components and integration with control system.
- Programming of ESP32 for real-time temperature monitoring

2.2 Experimental Testing

- A 20-minute mobile gaming session was conducted.
- Temperature data recorded every 2 minutes.
- Comparison between:
 - Without i-MagArctic system
 - With i-MagArctic system

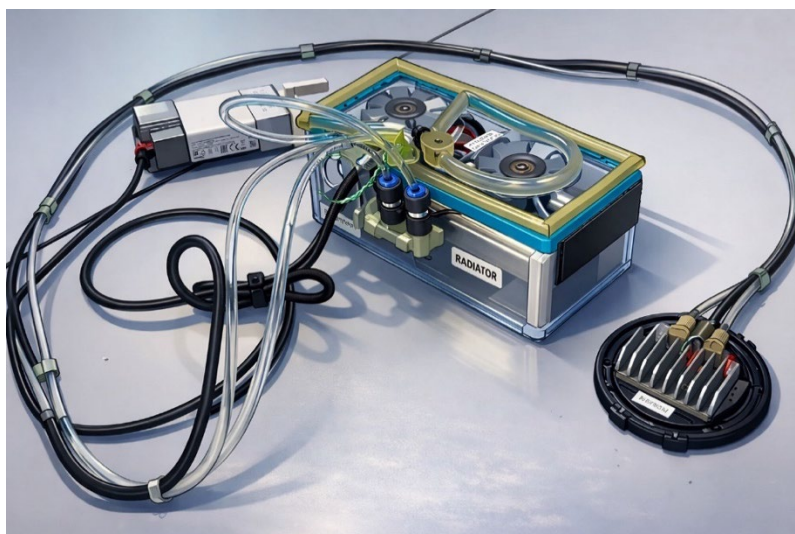


Figure 1. Final Product

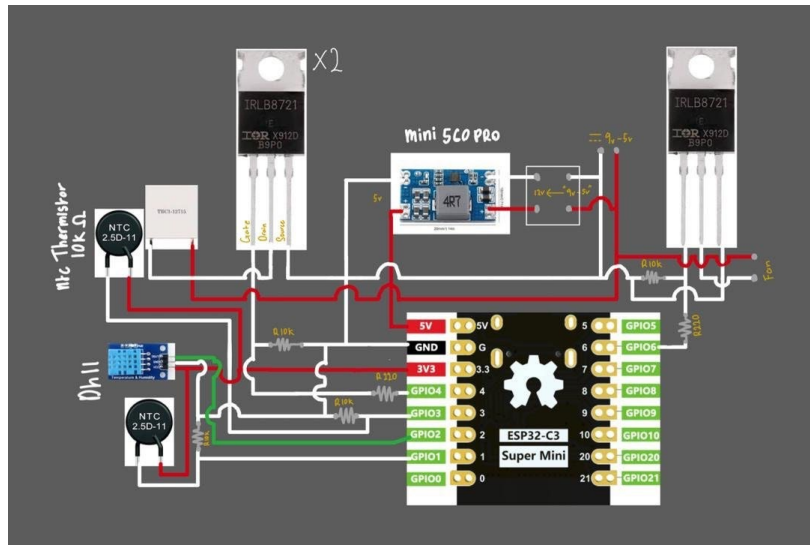


Figure 2. Circuit Diagram

3. RESULTS AND DISCUSSION

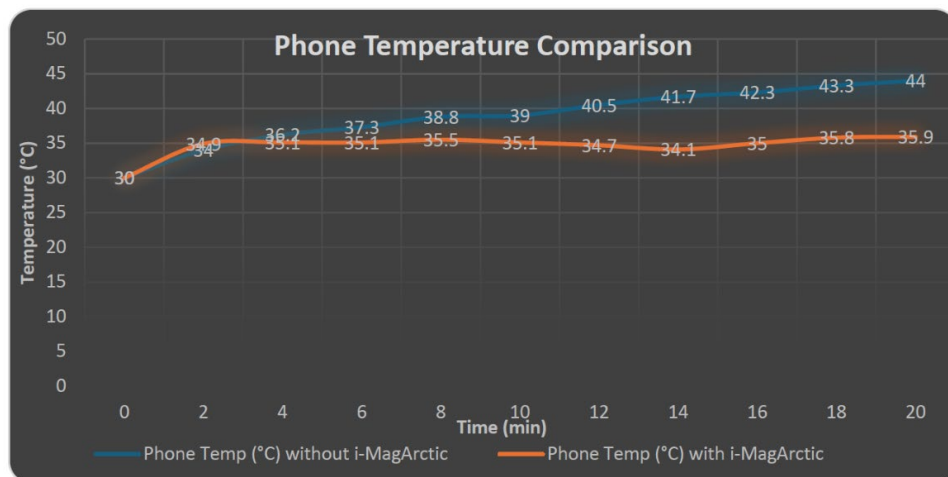


Figure 3. Smartphone Temperature Comparison with and without i-MagArctic

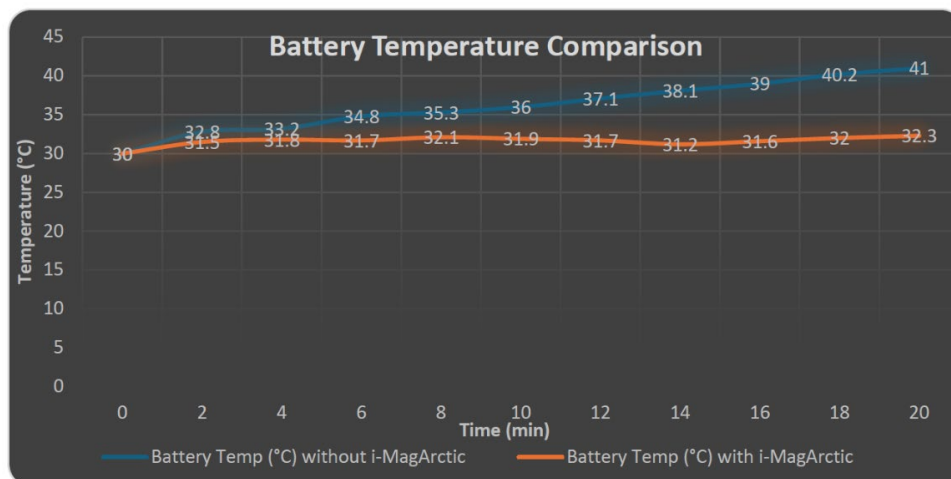


Figure 4. Battery Temperature Comparison with and without i-MagArctic

3.1 Finding

The experimental results are illustrated in Figure 3 and Figure 4, which present the temperature comparison of the smartphone surface and battery, respectively, under conditions with and without the i-MagArctic cooling system. As shown in **Figure 3**, the smartphone temperature without cooling increased steadily from 30°C to a peak of 44°C over the 20-minute period. In contrast, with the implementation of i-MagArctic, the temperature remained relatively stable, fluctuating within a narrow range and reaching a significantly lower peak of 35.9°C. This demonstrates the system's capability to effectively suppress excessive heat build-up during prolonged usage. Similarly, **Figure 4** shows the battery temperature trend. Without the cooling system, the battery temperature rose continuously from 30°C to 41°C. However, when i-MagArctic was applied, the temperature increase was minimal and stabilized around 32.3°C. This indicates that the cooling system provides strong thermal protection not only at the surface level but also for internal components. In addition, both figures reveal a clear reduction in the rate of temperature increase when the cooling system is activated. The smoother and more consistent temperature profiles further indicate improved thermal stability, with reduced fluctuations throughout the experiment. Overall, the graphical results confirm that i-MagArctic significantly enhances thermal management performance by lowering peak temperatures, reducing heating rates, and maintaining stable operating conditions during high-intensity smartphone usage.

4. CONCLUSION AND POTENTIAL COMMERCIAL

In conclusion, i-MagArctic successfully addresses the limitations of conventional smartphone cooling methods by providing an efficient, stable, and intelligent thermal management solution. The integration of thermoelectric cooling, liquid cooling, and anti-condensation control ensures both performance enhancement and operational safety. From a commercial perspective, the system has strong potential as a portable cooling accessory for mobile gaming users. Its compact design, effectiveness, and scalability make it suitable for mass production and market adoption.

ACKNOWLEDGEMENT

The authors would like to express their sincere appreciation to Politeknik Sandakan Sabah for providing continuous support, facilities, and a conducive environment throughout the development of the i-MagArctic project. The encouragement and guidance from the academic staff have been instrumental in ensuring the successful completion of this innovation.

The authors also wish to acknowledge the contributions of all team members involved in the design, development, and testing phases of the system. Their commitment, collaboration, and technical efforts have played a significant role in achieving the project objectives. Special thanks are extended to individuals who provided technical insights and assistance during the experimental validation process.

REFERENCES

- Chen, G. (2019). *Fundamentals of thermoelectric energy conversion*. CRC Press.
- Pop, E., Sinha, S., & Goodson, K. E. (2006). Heat generation and transport in nanometer-scale transistors. *Proceedings of the IEEE*, 94(8), 1587–1601.
- Riffat, S. B., & Ma, X. (2003). Thermoelectric applications: A review of current developments. *Applied Thermal Engineering*, 23(8), 913–935.
- Snyder, G. J., & Toberer, E. S. (2008). Complex thermoelectric materials. *Nature Materials*, 7(2), 105–114.
- Zhang, X., Liu, Y., & Wang, L. (2020). Advances in thermal management for mobile electronic devices. *Journal of Electronics Cooling*, 15(2), 45–52.