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Smart Cooling: Wearable AC Dress-Design and Development

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Abstract: Keeping in view the increasing heat crisis in the world and the present scenario of difficulty to work in hot and humid conditions, a cutting-edge idea of a smart, innovative AC dress is required for workers in the field, medical professions, industries, education, and any area where comfort and efficiency are essential. This project presents the design and development of a wearable Air-Conditioning (AC) dress that provides personal cooling using thermoelectric technology. The system uses Peltier modules powered by a rechargeable battery and supported by renewable energy sources such as solar panels. The aim is to create a lightweight, portable, and energy-efficient cooling solution for use in hot climates. The proposed design focuses on comfort, safety, and practicality, making it suitable for daily use, industrial workers, and outdoor environments.
Keywords: Energy Efficient Design, Heat Stress Management, Smart Garments, Thermoelectric Cooling, Wearable Cooling System.

I. INTRODUCTION

With rising global temperatures and an increasing heat crisis, working in field conditions, industries, healthcare, and outdoor environments has become significantly more challenging. Conventional air-conditioning systems are fixed infrastructure and cannot accompany individuals in dynamic work environments. This gap motivates the development of a personal, wearable cooling solution. The primary objectives of this research are: (1) to reduce body temperature in hot environments; (2) to harness renewable energy (solar energy) for charging the system; (3) to improve comfort and work efficiency; and (4) to develop a lightweight, portable, and wearable smart cooling system.

II. BACKGROUND AND ALTERNATIVE COOLING TECHNIQUES

Several techniques exist for personal cooling in wearable systems. Each approach involves distinct trade-offs in terms of weight, cooling capacity, battery life, and practicality.

A. Liquid Cooling

Chilled water is circulated through microtubing embedded in the garment. While effective, this method adds considerable weight due to the water reservoir and pump assembly, making it less practical for extended field use.

B. Phase Changing Materials

Microencapsulated phase-change materials (PCMs) are integrated into fabric layers. PCMs absorb body heat during the solid-to-liquid phase transition, providing passive cooling without electricity. However, they have limited capacity and require recharging (re-freezing) between uses.

C. Fan Ventilation

Miniature fans placed at the lower back sides enhance convective and evaporative heat loss. Each fan consumes approximately 4–12 W, providing a battery life of 4–12 hours. This approach is lightweight but provides limited cooling in highly humid environments where evaporation is suppressed.

D. Thermoelectric (Peltier Effect)

An electric current creates a cold junction in the Peltier module, achieving skin-contact temperatures 15–20°C below ambient. This method provides the best targeted cooling performance and forms the basis of the proposed system.

III.SYSTEM DESIGN AND METHODOLOGY

A. *Cooling Module and Mechanism*

The proposed system makes use of the Peltier Effect, in which heat is transferred from one side of a thermoelectric module to the other when an electric current flows through it. One side becomes cold and is used for cooling the body, while the other side becomes hot; the heat from the hot side is dissipated using exhaust fans. Figures 1–3 illustrate the Peltier Effect, the thermoelectric cooling mechanism, and the working module, respectively.

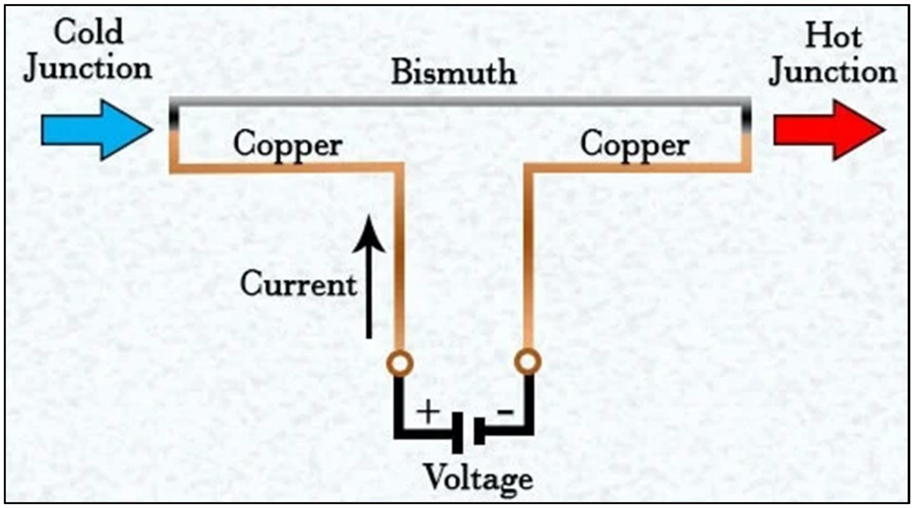

Fig. 1 Peltier Effect

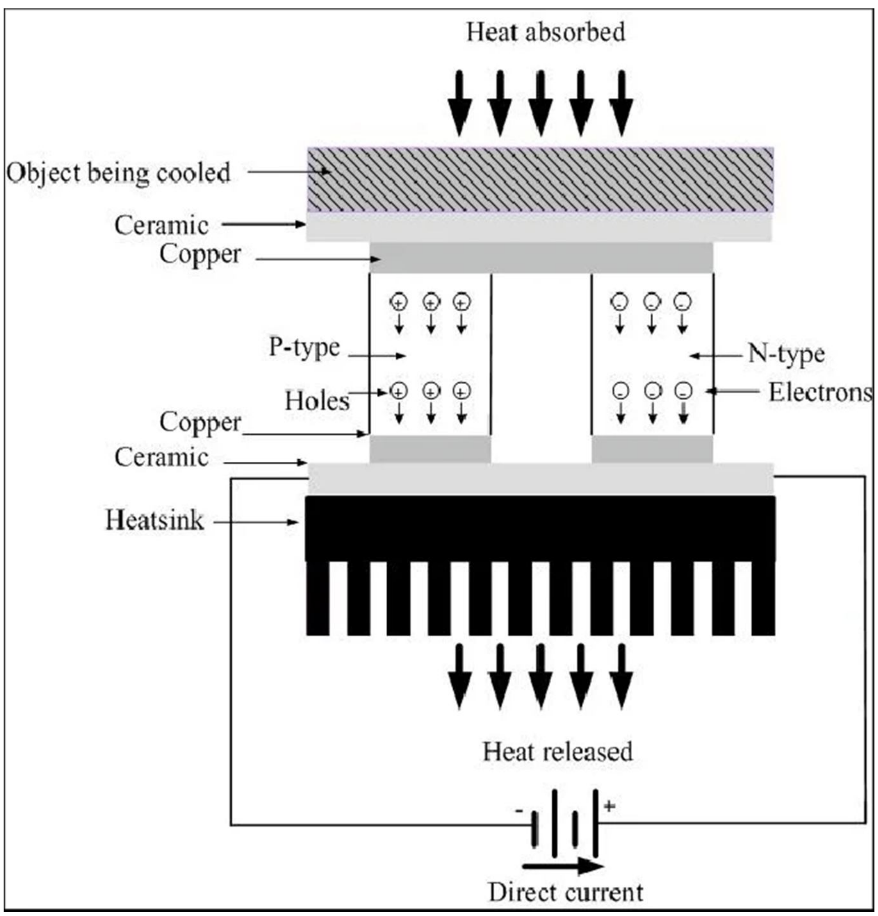

Fig. 2 Thermoelectric Cooling

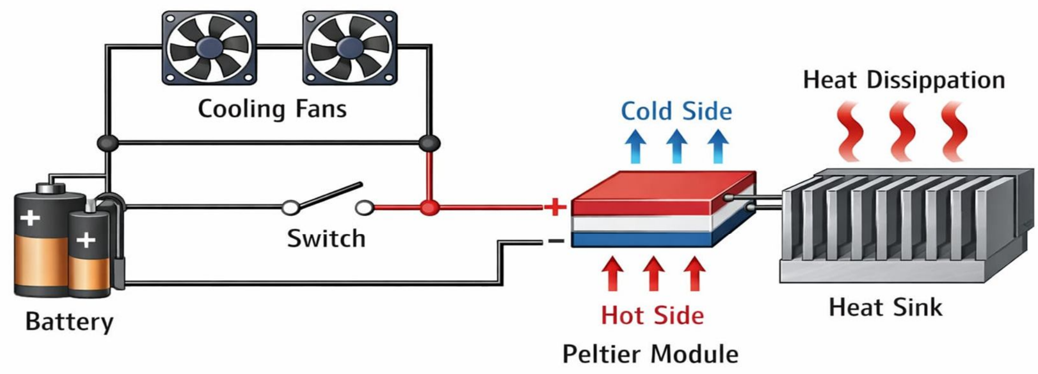

Fig. 3 Working Peltier Module

B. Components

The system comprises the following components: cooling fan (12 V DC); heat sink (aluminum); Peltier module (TEC1-12706); rechargeable battery (Li-ion, 12 V); solar panel (for renewable charging); temperature controller; switch and wiring; breathable fabric; and an insulation layer.

C. Fabrication Process

A lightweight breathable cloth is selected as the base garment. Pockets are stitched to hold the Peltier modules, with the cooling side placed inside (near the skin). Fans and heat sinks are mounted on the outer side to facilitate heat dissipation. The battery pack is fixed securely at the waist.

D. System Layout

The wearable layout is described as follows. The front view presents the cooling airflow path from the chest cooling zone through flexible air ducts to the Peltier cooling module, heat sink, fan assembly, and waist-mounted battery pack, with air outlet vents at the chest. The back view shows the exhaust heat vent (hot-side dissipation), dual fan system, and the control unit (temperature and speed control).

Air Outlet Vents
|
Chest Cooling Zone
|
Flexible Air Ducts
|
Cooling Module Peltier
|
Heat Sink + Fan
|
Batter Pack (Waist Mounted)

Frontal-View

Exhaust Heat Vent
|
(Hot Side Cooling)
|
Dual Fan System
|
Control Unit
(Temperature + Speed Control)

Back-View

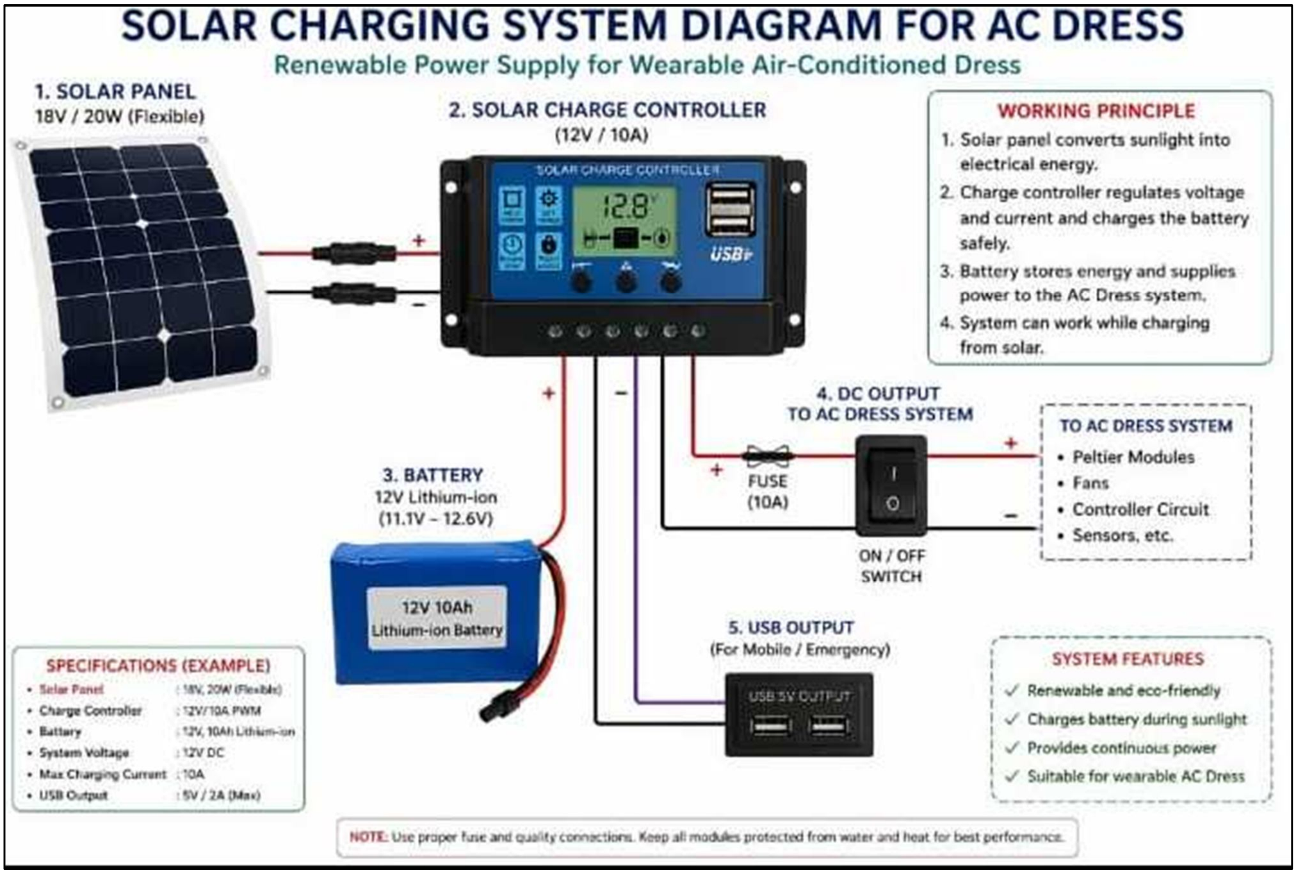

Fig. 4 Solar Charging

E. Working Explanation

The operational sequence is as follows: the solar panel charges the battery; the battery supplies power to the system; a switch controls ON/OFF operation; the temperature controller maintains the desired cooling level; the Peltier module creates the cooling effect; and the fan combined with the heat sink removes heat from the hot side of the module.

F. Wiring Details

1) *Battery Connection:* Red wire to Positive (+); Black wire to Negative (−).
2) *Peltier Module:* Red wire to +12 V; Black wire to Ground.
3) *Fan Connection:* Connected in parallel to the Peltier module on the same 12 V supply.
4) *Temperature Controller:* Input from battery; output to Peltier module and fan; sensor placed near the body surface.
5) *Safety Measures:* Insulation prevents electric shock; the Peltier module is not placed directly on skin (a fabric layer is interposed); and proper heat dissipation is ensured throughout operation.

G. Power Computations

Power consumed by a Peltier module is given by $P = V \times I$. For example, at $V = 12$ V and $I = 5$ A, $P = 60$ W. The major cooling factors are: (1) number of Peltier modules; (2) surrounding temperature; and (3) heat dissipation efficiency.

IV. RESULTS AND DISCUSSION

A. Performance Graphs

Fig. 5 shows the variation of cooling temperature over time, and Fig. 6 illustrates the relationship between power consumption and cooling capacity.

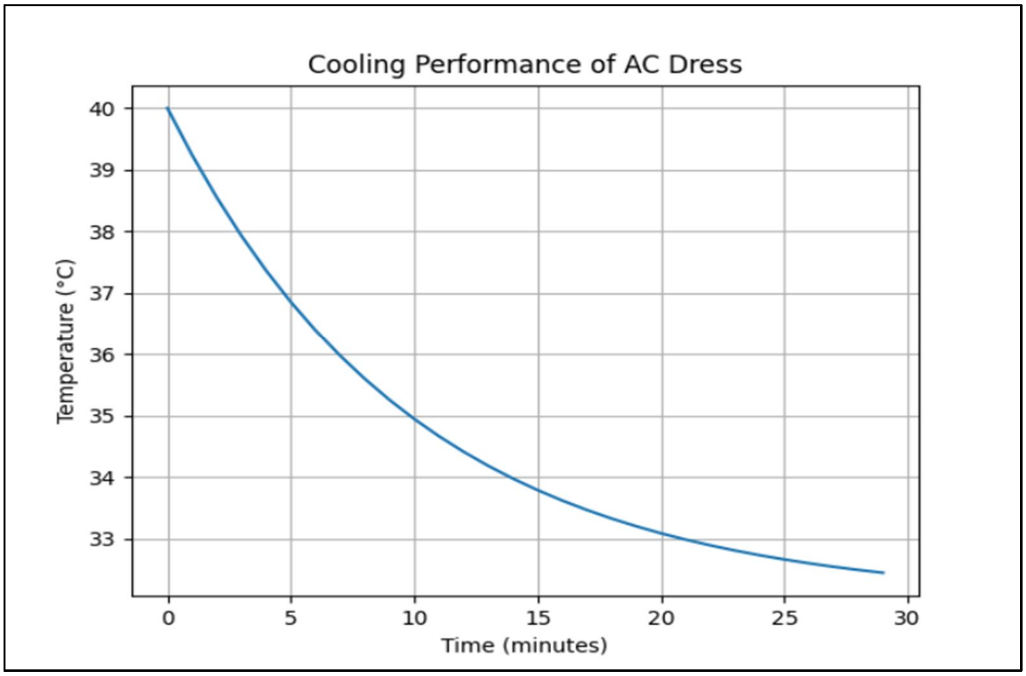

Fig. 5 Cooling vs. Time

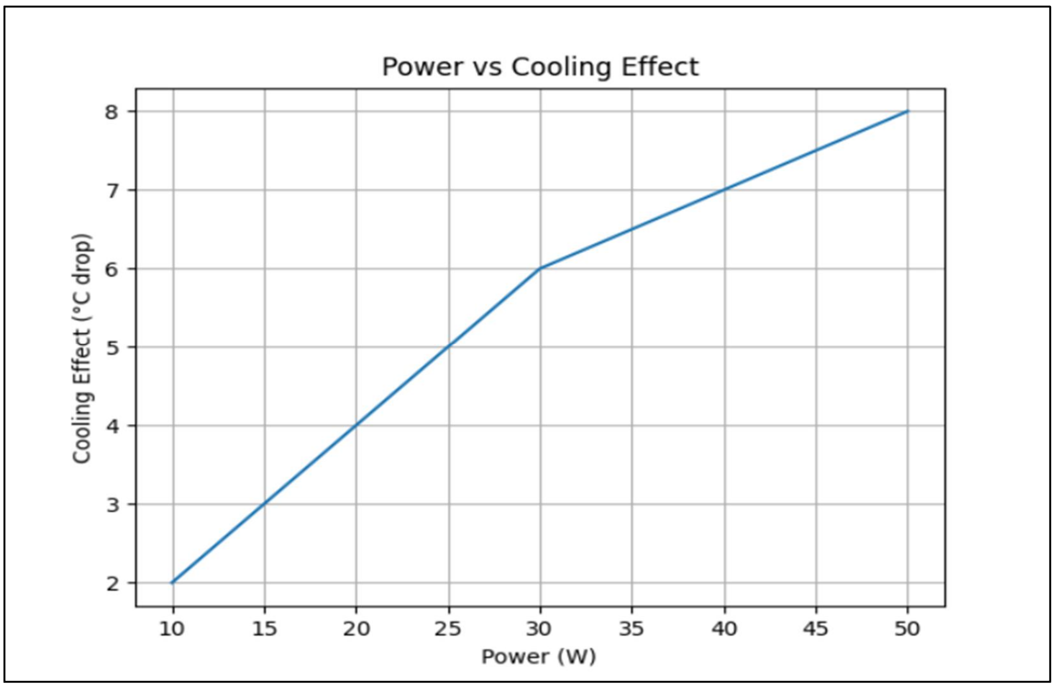

Fig. 6 Power vs. Cooling

B. Advantages and Limitations

The system offers the following advantages: portability and wearability; energy efficiency; use of renewable energy; and particular utility for outdoor workers. Present limitations include heat dissipation challenges; limited cooling capacity relative to ambient conditions; a slight increase in overall garment weight; and reduced solar charging effectiveness in the absence of direct sunlight.

V. APPLICATIONS AND FUTURE SCOPE

A. Applications

The wearable AC dress is applicable across a wide range of sectors including farmers and outdoor labour; industrial workers; military personnel; sports and trekking; and medical cooling garments for patients requiring thermoregulation support.

B. Future Potential

Future enhancements may include improved battery technology for longer runtime; lighter structural materials; use of flexible Peltier modules for better body conformity; and automatic temperature control with adaptive feedback mechanisms for dynamic comfort management.

VI. CONCLUSION

The wearable AC dress is a promising innovation for personal cooling. It provides a portable, wearable, energy-efficient, and eco-friendly solution that addresses the growing challenge of heat stress in outdoor and industrial environments. With further improvements in battery technology, flexible thermoelectric modules, and adaptive control systems, it has the potential to become a practical and commercially viable product for daily use, industrial applications, and diverse fields of human activity.

VII. ACKNOWLEDGEMENT

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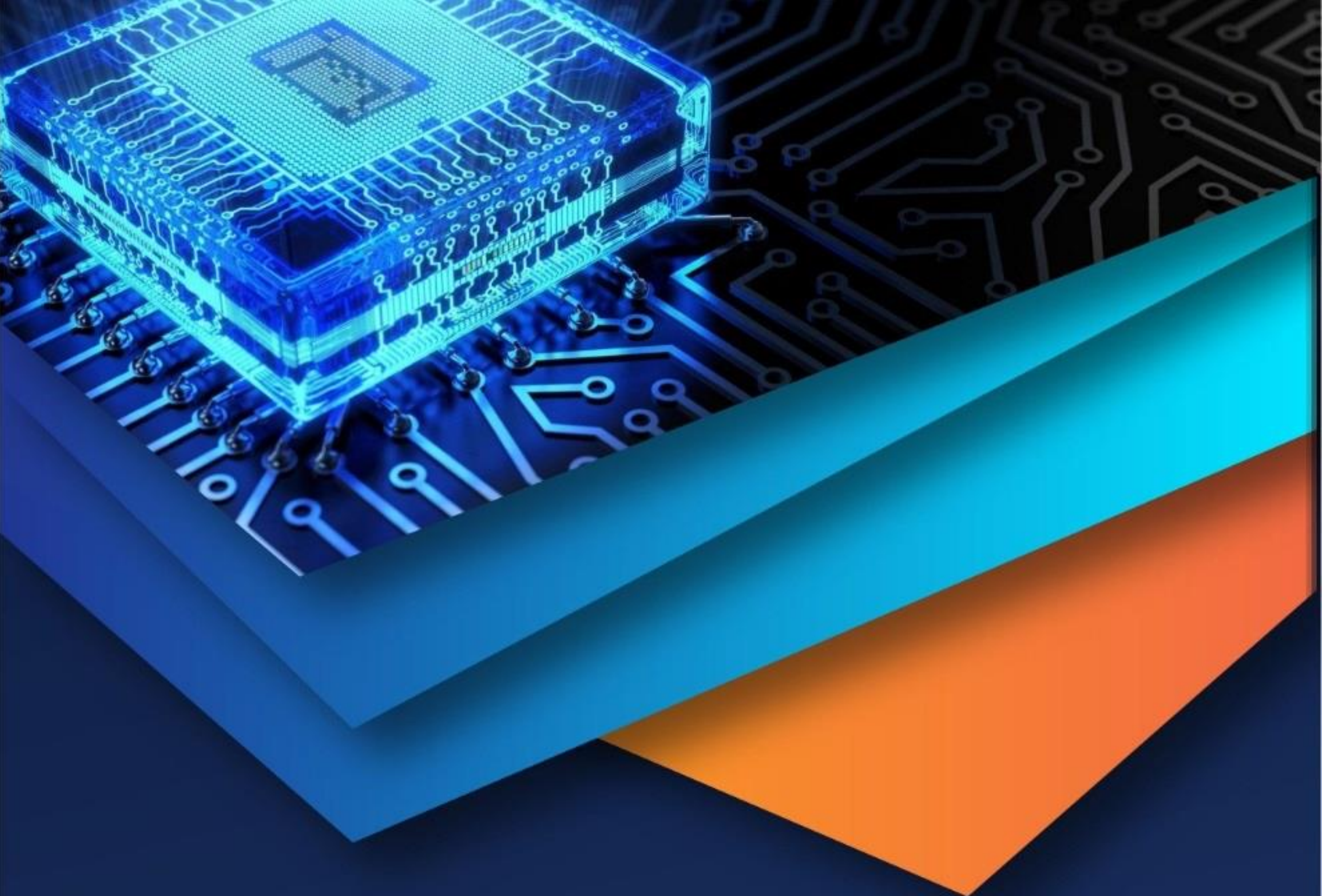
REFERENCES

[1] Peng et al., “Radiative Cooling Textile That Enables Outdoor Personal Thermal Management,” Advanced Materials, 2021.
[2] M. Luo et al., “Wearable Thermoelectric Devices for Personal Thermal Management,” Applied Energy, 2021.
[3] H. Zhang et al., “A Review of Wearable Cooling Systems for Personal Thermal Management,” Applied Thermal Engineering, vol. 149, pp. 128–148, 2019.
[4] P. C. Hsu et al., “Personal Thermal Management by Metallic Nanowire-Coated Textile,” Nano Letters, vol. 15, no. 1, pp. 365–371, 2016.
[5] Jin et al., “Organic Thermoelectrics,” Materials Today Physics, 2018.
[6] Ji et al., “Battery Management for Wearable Systems,” Journal of Power Sources, 2023.
[7] He et al., “Medical Applications of Thermoelectric Cooling,” Biomedical Engineering Reviews, 2017.
[8] J. C. A. Peltier, “Nouvelles expériences sur la calorificité des courants électriques,” Annales de Chimie et de Physique, vol. 56, pp. 371–386, 1834.
[9] H. Lenz, Practical Demonstration of Cooling by the Peltier Effect, 1838.
[10] D. M. Rowe, Ed., Handbook of Thermoelectrics. Boca Raton, FL: CRC Press, 1995.
[11] COMSOL Multiphysics, “Peltier and Seebeck Effects Simulation,” [Online]. Available: https://www.comsol.com
[12] DroneBot Workshop, “Peltier Effect Cooling Experiments,” [Online]. Available: https://dronebotworkshop.com
[13] D. M. Rowe, Thermoelectrics Handbook: Macro to Nano. Boca Raton, FL: CRC Press, 2006.
[14] J. Smith, “Wearable Cooling Systems,” IEEE Transactions on Industrial Electronics, 2020.
[15] Government of India, Climate Report 2023. New Delhi: Ministry of Earth Sciences, 2023.



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