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Solar Powered Air Conditioner

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***Abstract:** This project presents the design and implementation of a solar-powered air conditioning system using thermoelectric Peltier technology. The system is built around a 12V 20W solar panel that charges a 12V 12Ah lead-acid battery through a PWM-based solar charge controller. The stored power is used to run a cooling unit consisting of three TEC1-12706 Peltier modules housed inside a metal box. These modules create a temperature difference, producing a cold side for cooling and a hot side for heat dissipation. Air blower is used inside the box to circulate air across the cold surface, enhancing the cooling effect*

I. INTRODUCTION

In recent years, the growing demand for air conditioning has significantly increased global energy consumption. Traditional air conditioning systems rely heavily on grid electricity and refrigerants that contribute to environmental issues such as greenhouse gas emissions and ozone layer depletion. With the rise in global temperatures and a heightened awareness of climate change, there is a need to explore alternative cooling solutions that are both energy-efficient and eco-friendly. Solar-powered air conditioning presents a promising solution, especially in areas with abundant sunlight and limited access to grid power.

This project focuses on the development of aAutomated Cricket Bowling Machine using thermoelectric Peltier modules, which utilizes solar energy to generate cooling without the use of harmful gases or compressors. The system operates using a 12V 20W solar panel that charges a 12V 12Ah lead-acid battery via a PWM solar charge controller. The battery powers a cooler kit comprising three TEC1-12706 Peltier modules, which create a cooling effect when current is passed through them. These modules are installed inside a metallic enclosure designed to optimize heat transfer and ensure efficient temperature regulation. To enhance the airflow and maximize cooling efficiency, a 12V 5Ah air blower is placed inside the inner box to circulate air over the cold side of the Peltier modules. Additionally, a 4-inch 12V 5Ah heavy-duty DC fan is mounted on the cooling side to direct the cold air into the room or desired space. The absence of moving parts like compressors makes this system quieter, lighter, and more suitable for personal cooling applications. The setup also demonstrates a practical approach to using thermoelectric technology in real-world cooling systems powered solely by renewable energy.

II. COMPONENTS USED

1) Solar panel
2) Lead acid battery
3) PWM based solar controller
4) TEC1-12706 peltier modules
5) Air blower
6) Heavy duty dc fan

III. LITERATURE SURVEY

Ajay Sankar N R et. al (2015) Studied the comparison the performance between conventional systems and vapour absorption system using solar thermal energy. 2) I.Daut Fitra et. al (2013) It will help to improve the stability and efficiency of the system for greener solutions to the world's energy needs. 3) Ravi Gugulothu Banoth et. al (2015) It is observed that, the energy and water are the basic necessity for all of us to lead a normal life on this beautiful earth. Solar energy technologies and its usage are very important and useful for the developing and under developed countries to sustain their energy needs. Solar cooling systems are the substitution of electricity as the premium energy sources for air conditioning system by a renewable heat source. Design and Fabrication of Solar Powered Air-Conditioner (IJSRD/Vol. 9/Issue 03/2021/066) All rights reserved by www.ijsrd.com 262 The main motivating for solar cooling systems is the substitution of electricity as the premium energy sources for air conditioning systems by a renewable heat source that is low grade heat from solar collectors.

4) Zhifeng Sun et. al (2017) Remove heat from equipment, provide energy for fresh-air treatment, which depends on the number of people inside the building. 5) Ali Al-Alili et. al (2014) Desiccant evaporation cooling technology is environmental friendly and can be used to condition the indoor environment of buildings. Unlike conventional air conditioning systems, the desiccant air conditioning systems can be driven by low grade heat sources such as solar energy and industrial waste heat. 6) Ravi Gugulothu et. al (2014) This can be done through passive solar, solar thermal energy conversion and photovoltaic conversion(sunlight to electricity). We are combining the Refrigerant Cycle and Vapor Absorption Cycle. 7) Ali Al-Alili et. al (2018) Photovoltaic Cells is the main equipment for this project, sunlight is absorbed the PV cells and is converted to electricity by the inverter and battery and is passed to DC Motor and then the cooling air spreaded to the entire room. These all eco-friendly, and renewable. 8) Khaled Alqdah et. al (2011), purposed to study the design and performance of the system in AlMadinah AlMunawwarah to cool the indoor environment by solar air conditioning system because the temperature in summer is around 42◦C, so the air conditioning system is almost every building of Saudi Arabia. And the coefficient of performance varies from 2.16 to 4.22 for the system and the result compare with conventional is better. The absorption cycle was found to be an ideal option. The COP values of these equipment's are directly proportional with increasing generator and evaporator temperatures. The proposed system decreases vehicle operating costs and environmental pollution caused by the heating system. 9) Reinhard Radermacher et. al (2014) The removal of moisture from the supply air using conventional air conditioner represents a considerable portion of the air conditioning load in the hot and humid areas. 10) Akeel Ahmad et. al (2017) The purpose of this is the climate panel developed is to be used as a compliment to an existing heating system in order to pre-heat and precool the air coming into the house. The venture fundamental target was to build up a packed sun oriented aeration and cooling system and this has been effectively done. 11) R.Nasker et. al (2018) The design and construction of DC air conditioning system integrated with PV system which consists PV panel, battery and inverter which can be operated on solar power and can be used in nonelectrified areas. 12) Pooja Abhiman et. al (2018) The use of solar energy to drive cooling cycles is attractive since the cooling load is roughly in phase with solar energy availability. In this, a focus is made on reduction in Air Conditioning capacity savings and emission reductions attainable through the use of solar energy. 13) B.Moncef et. al (2005) Energy from the collector is stored, then transferred to a heat exchanger which, in turn, transfers energy to the heat engine. The heat engine drives a vapor compressor, finally producing a cooling effect at the evaporator. Air cooler gives the cool and humid air. Humidity of air can be absorbed by cooling coil which is cheap and effective design conceptualization in comfort application. 14) Amitkumar Gupta et. al (2016) It is observed that today the human society facing problem is energy. And by using solar energy w will save our environment from greenhouse gases and keep our environment clean and green for coming generation. So using of the electrical equipment like air conditioner, fans, etc, for our comfort by using fossil fuel like coal, petrol and natural gas which from CO2 after burning of this fuel. Many place were solar energy can be use and government also giving a good policy for solar energy user and it also have long life, investment cost can be recovered within 4-5 year of span.

1) 12V 20W Solar Panel

A 12V 20W solar panel is a photovoltaic (PV) device that converts sunlight into electrical energy. It consists of multiple solar cells made from semiconductor materials like silicon. When sunlight hits the surface of the cells, it excites electrons, creating an electric current. This current is then converted into usable DC voltage (12V in this case). Solar panels provide renewable energy, making them an environmentally friendly and sustainable power source. The 12V rating indicates that the panel is designed to work with 12V systems, typically used in off-grid applications, solar-powered devices, and battery charging setups. In this project, the solar panel charges a 12V battery, ensuring that the system can operate continuously, even during periods of limited sunlight.

2) 12V 12Ah Lead-Acid Battery

A 12V 12Ah lead-acid battery is an energy storage device commonly used in off-grid and renewable energy systems. It consists of lead plates submerged in an electrolyte solution, typically sulfuric acid, which stores electrical energy in a chemical form. When the battery is connected to a load, such as the cooling system in this project, the chemical reaction releases energy in the form of electricity. With a 12Ah rating, this battery can provide 12 amps of current for one hour, or a lower current for a longer duration. Lead-acid batteries are known for their durability, cost-effectiveness, and wide availability. However, they require proper maintenance and regular charging cycles to maximize lifespan.

3) PWM-Based Solar Charge Controller

A PWM (Pulse Width Modulation)-based solar charge controller is an electronic device that regulates the charging process of a battery from a solar panel. It controls the voltage and current to ensure that the battery is charged efficiently and safely.

The PWM controller does this by switching the current supplied to the battery on and off at a high frequency, adjusting the pulse width to regulate the amount of power transferred. This helps prevent overcharging, which can damage the battery, and optimizes charging efficiency. In solar-powered systems, PWM controllers are essential for prolonging battery life and ensuring stable power output to the connected loads, such as the cooling unit in this project.

4) TEC1-12706 Peltier Modules

TEC1-12706 Peltier modules are thermoelectric devices that operate on the principle of the Peltier effect. When current flows through the module, it creates a temperature difference between its two sides: one side becomes hot, and the other becomes cold. These modules are made up of a series of semiconductor materials arranged in a configuration that allows heat transfer when a current is applied. The cold side of the module is used to cool the space or device, while the hot side must be actively dissipated using a heat sink or fan. Peltier modules are compact, reliable, and efficient in low-power cooling applications, making them ideal for use in small-scale air conditioning systems like this project

5) 12V 5Ah Air Blower

A 12V 5Ah air blower is a mechanical fan designed to circulate air, enhancing cooling effects by increasing airflow over the cold side of a thermoelectric cooling unit. The blower operates on a 12V DC power supply and is capable of providing a moderate airflow, which helps in heat dissipation and ensures that the cold air produced by the Peltier modules is effectively spread throughout the space. The 5Ah rating indicates the blower's power consumption, meaning it draws 5 amps of current when operating at full capacity. This blower is essential for maintaining the temperature differential required for efficient cooling in this solar-powered air conditioning system.

6) 4-Inch 12V 5Ah Heavy-Duty DC Fan

A 4-inch 12V 5Ah heavy-duty DC fan is used to push cold air produced by the thermoelectric cooling unit into the room. The fan is powered by a 12V DC source and operates with a power consumption of 5Ah. This fan plays a critical role in maintaining a continuous flow of cold air, which is necessary to ensure that the cooling effect is felt throughout the room. The fan's heavy-duty design ensures long-term operation under various conditions, making it suitable for use in a compact air conditioning system like this one. The small size (4 inches) allows the fan to fit within the design while still delivering effective airflow

IV. PROPOSED SYSTEM

The proposed system utilizes solar energy to power a thermoelectric air conditioning system using TEC1-12706 Peltier modules. This system avoids the use of compressors and refrigerants by applying the thermoelectric effect to produce cooling. A solar panel charges a battery through a PWM charge controller, and the stored energy powers the Peltier modules, a 12V air blower for airflow inside the box, and a 4-inch 12V fan on the cooling side to push cool air into the room. The entire system is compact, silent, and eco-friendly, making it ideal for small-scale, off-grid, and personal cooling needs.

A. Working Principle

The solar-powered air conditioning system operates by harnessing solar energy to power a thermoelectric cooling unit. The 12V 20W solar panel captures sunlight and converts it into electrical energy, which is then stored in the 12V 12Ah lead-acid battery through the PWM-based charge controller. This stored energy is used to power the Peltier modules, which are the core components of the cooling system. When current flows through the TEC1-12706 Peltier modules, they create a temperature difference, with one side becoming cold and the other hot. The cold side is used to cool the air, while the hot side must be dissipated through heat sinks.
To enhance cooling, a 12V 5Ah air blower circulates air across the cold side of the Peltier modules, helping to maintain a constant cooling effect. Additionally, a 4-inch 12V 5Ah heavy-duty DC fan is used to push the cold air into the room, ensuring effective airflow and maintaining a continuous cooling cycle. The system operates without the need for traditional refrigerants or compressors, making it more energy-efficient and eco-friendly. The compact design makes it ideal for off-grid applications, smallspaces, or environmental conscious cooling solution.

B. Merits:

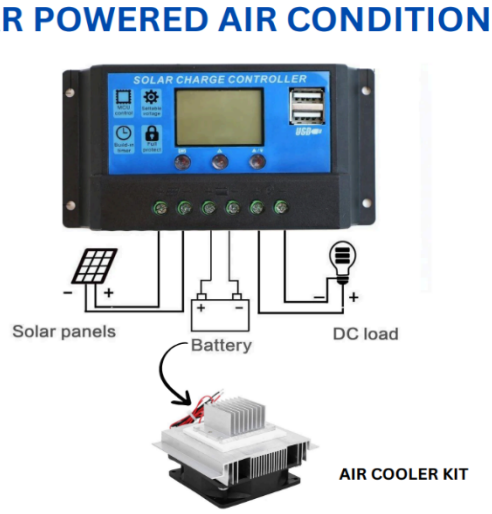
1) Eco-Friendly: The system is powered by solar energy, reducing dependence on fossil fuels and minimizing carbon footprints.
2) Energy Efficient: The absence of a traditional compressor-based system makes it highly efficient in using power.

3) Low Maintenance: The system has fewer moving parts compared to conventional air conditioners, reducing maintenance needs.
4) No Refrigerants: It eliminates the need for harmful refrigerants, making it environmentally safe.
5) Compact Design: The system's compact design makes it suitable for small spaces and off-grid applications.
6) Quiet Operation: The system operates quietly compared to traditional air conditioners due to the absence of compressors.
7) Sustainable: Utilizes renewable solar energy, making it a sustainable solution for cooling needs.
8) Cost-Effective: Once installed, it reduces electricity costs significantly due to reliance on solar power.
9) Portable: Can be used in remote areas where conventional electricity sources are unavailable.
10) Simple Installation: The system is easy to install and requires minimal infrastructure.
11) Scalable: Can be scaled for larger applications by adding more solar panels or Peltier modules.
12) Low Power Consumption: The system uses low power compared to conventional air conditioners.
13) Ideal for Off-Grid Homes: Perfect for areas that are not connected to a power grid.
14) No Moving Parts in Cooling: The cooling system is based on Peltier technology, which involves no mechanical compression, reducing wear and tear.
15) Safe to Use: Operates at low voltages (12V), ensuring safety for the user.
16) Versatile: Can be used for small rooms, cabins, greenhouses, and more.
17) Zero Emissions: The system has no direct emissions, making it highly environmentally friendly.
18) Portable Cooling for Remote Locations: Ideal for providing cooling in places without reliable power grids.
19) Temperature Control: Can provide precise control over the temperature with the right setup.
20) Low Noise Levels: The lack of a compressor means much less noise, ideal for quiet environments.
21) Self-Sufficient: It is autonomous, requiring minimal external input once set up.
22) Improves Air Quality: By circulating fresh, cool air, it improves indoor air quality without chemicals.
23) Supports Sustainable Living: Ideal for eco-conscious users looking to reduce their environmental impact.
24) Cost Savings Over Time: Although initial costs may be higher, it saves on long-term electricity bills.
25) Improves Comfort in Small Areas: Provides efficient cooling for small spaces without the bulk of traditional systems.

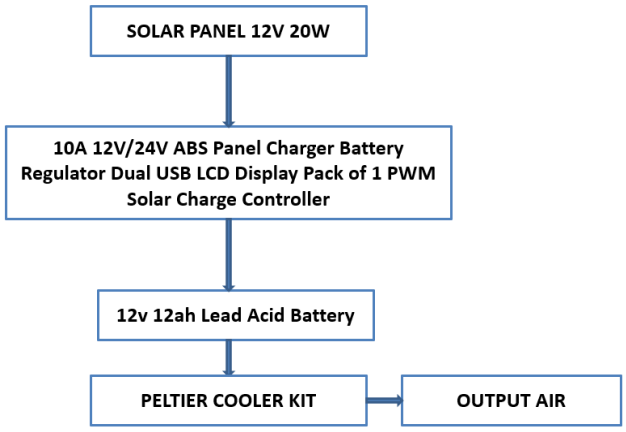
C. *Demerits:*

1) Limited Cooling Capacity: The system may not provide enough cooling for large rooms or high-heat environments.
2) Dependence on Sunlight: The system's efficiency is heavily dependent on available sunlight, limiting performance during cloudy days or at night.
3) Initial Setup Cost: The installation cost for the solar panels, batteries, and components can be high.
4) Requires Maintenance of Solar Panel: Solar panels need occasional cleaning and maintenance to ensure optimal performance.
5) Battery Limitations: The battery's limited capacity may not allow for extended use, requiring frequent recharging

V. BLOCK DIAGRAM



SOLAR POWERED AIR CONDITIONER



VI. BILL OF MATERIALS

1) *Solar Panel (12V, 20W) – ₹2,500*
   The solar panel is essential for converting solar energy into electrical power, which charges the battery.
2) *12V 12Ah Lead-Acid Battery – ₹3,500*
   The battery stores the energy from the solar panel and provides power to the system when sunlight is unavailable.
3) *PWM-based Solar Charge Controller – ₹1,200*
   The charge controller regulates the charging of the battery from the solar panel to avoid overcharging and ensures optimal battery life.
4) *Peltier Modules (TEC1-12706 x 3) – ₹2,400*
   These thermoelectric modules generate the cooling effect by creating a temperature difference when powered.
5) *12V 5Ah Air Blower – ₹1,500*
   The blower circulates air across the cold side of the Peltier modules, improving the cooling effect.
6) *4-inch 12V 5Ah DC Fan – ₹1,000*
   This fan is used to push the cooled air into the room, providing effective airflow and cooling.
7) *Metal Box for Housing Peltier Modules – ₹1,000*
   A metal box is used to house the Peltier modules and ensure proper heat dissipation.
8) *Wiring, Connectors, and Miscellaneous Components – ₹1,50*
   Includes wiring, connectors, screws, and other small parts needed for the assembly of the system.
9) *Cooling Fin and Heat Sink for Peltier Modules – ₹1,00*
   These are necessary for dissipating the heat generated on the hot side of the Peltier modules, ensuring efficient cooling.
10) *Labor and Miscellaneous Costs – ₹3,900*
    Covers the cost of assembling the system, testing, and any unexpected expenses that may arise during the build process.

Total Estimated Cost: ₹20,000

This cost is an approximation and could vary depending on the specific components chosen, local market prices, and any additional features or modifications to the system.

VII. CONCLUSION

The solar-powered air conditioning system utilizing thermoelectric Peltier technology offers a sustainable, energy-efficient, and environmentally friendly solution for personal cooling needs. By harnessing the power of the sun, it eliminates the need for traditional refrigerants and compressors, significantly reducing energy consumption and environmental impact. This system is particularly ideal for small spaces, off-grid homes, and eco-conscious users looking to reduce their carbon footprint.

While the system offers many advantages such as low maintenance, quiet operation, and portability, it is important to note its limitations, such as limited cooling capacity and dependency on sunlight. However, with the proper setup and efficient use of solar energy, this system proves to be a practical and effective alternative to conventional air conditioning systems. As renewable energy technology continues to evolve, solar-powered cooling solutions like this have the potential to become a staple in sustainable living, providing cooling solutions in areas with limited access to traditional power grids while supporting global efforts to reduce environmental impact.

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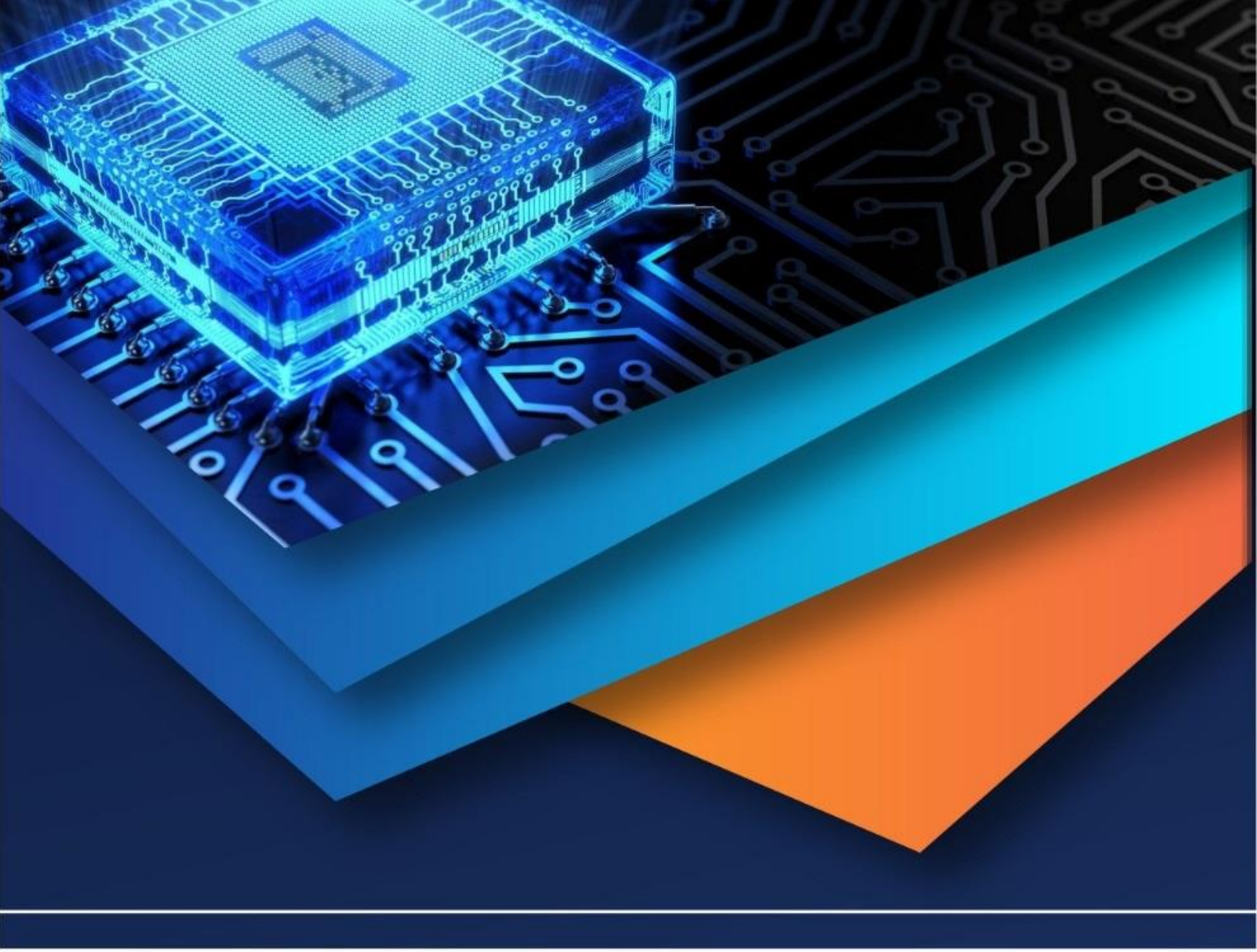

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