iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 **Issue:** XI **Month of publication:** November 2023

DOI: https://doi.org/10.22214/ijraset.2023.56437

www.ijraset.com

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue XI Nov 2023- Available at www.ijraset.com

To Enhance the Efficiency of PV Solar Panel by Integrating Materials such as Copper or Aluminium behind Solar Panel

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Abstract: ***Photovoltaic (PV) solar panels play a pivotal role in the global transition to sustainable and clean energy sources. To maximize the potential of solar energy generation, it is imperative to enhance the efficiency of these panels. This study focuses on the integration of materials such as copper and aluminum behind the solar panel, aiming to boost its overall performance.***
The research presents a novel approach to improving the efficiency of PV solar panels by introducing copper and aluminum backsheets. The incorporation of these metallic materials offers several advantages, including enhanced heat dissipation, reduced electrical losses, and increased mechanical strength. Copper and aluminum's exceptional thermal conductivity helps dissipate excess heat more efficiently, reducing the risk of hotspots and improving overall panel reliability. Additionally, the lower electrical resistivity of these materials minimizes energy losses during the transmission of generated electricity.
To investigate the impact of copper and aluminum backsheets, a comprehensive experimental study was conducted, involving the fabrication of prototype panels and their performance evaluation. The results demonstrate significant improvements in energy conversion efficiency, with increased power output and reduced degradation over time. Furthermore, the enhanced mechanical strength provided by these materials contributes to the panels' durability and resistance to environmental stressors.
In conclusion, integrating copper and aluminum backsheets behind PV solar panels represents a promising avenue for improving their efficiency and longevity. This innovation has the potential to play a vital role in accelerating the adoption of solar energy and reducing the world's dependence on fossil fuels, making a substantial contribution to a sustainable and cleaner energy future.
Keywords: Photovoltaic solar panels, Efficiency enhancement, Copper and aluminum integration, Energy, conversion efficiency, Renewable energy technology, Sustainable energy generation, Backsheet materials, Thermal conductivity, Mechanical durability.

I. INTRODUCTION

Solar energy is very important as it is a clean and renewable source of energy. Thus, this means it will not damage the earth in any way. In addition, it is available on a daily basis. Similarly, it does not cause any kind of pollution. As it is environment-friendly, it is very important in today's world. It is better than other pollution sources of energies like fossil fuels and other non-renewable sources also it has low maintenance costs. Solar panel systems do not require a lot of solar power energy. Moreover, they come with 5-10 years of warranty which is very beneficial. Most importantly, it reduces the cost of electricity bills. In other words, we use it mostly for cooking and heating up our homes. Thus, it drops the utility bills cost and helps us save some extra money. Further, solar energy also has many possible applications. India has great potential for solar energy because of its location lies between the equator & tropic of cancer. Maximum regions of our country are exposed to direct sunlight throughout the year and sunlight energy is straightly converted into electricity with the help of solar panel. Solar power is a fastest developing industry in world as well as in India. The country's solar installed capacity was 70.01 Gigawatt as of 30 June 2023.

India as a founding member of "INTERNATIONAL SOLAR ALLIANCE" (ISA) headquarter:- Gurugram (Haryana) put forward the concept of Solar power generation in India ranks fourth globally in 2021.

"One sun one world one grid" and world solar bank to harness abundant solar power on a global scale. Solar energy is the radiation energy from the Sun capable of producing heat, causing chemical reactions, or generating electricity. The total amount of solar energy received on Earth is more than the world's current and anticipated energy requirements. If suitably harnessed, solar energy has the potential to satisfy all future energy needs of the world.

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
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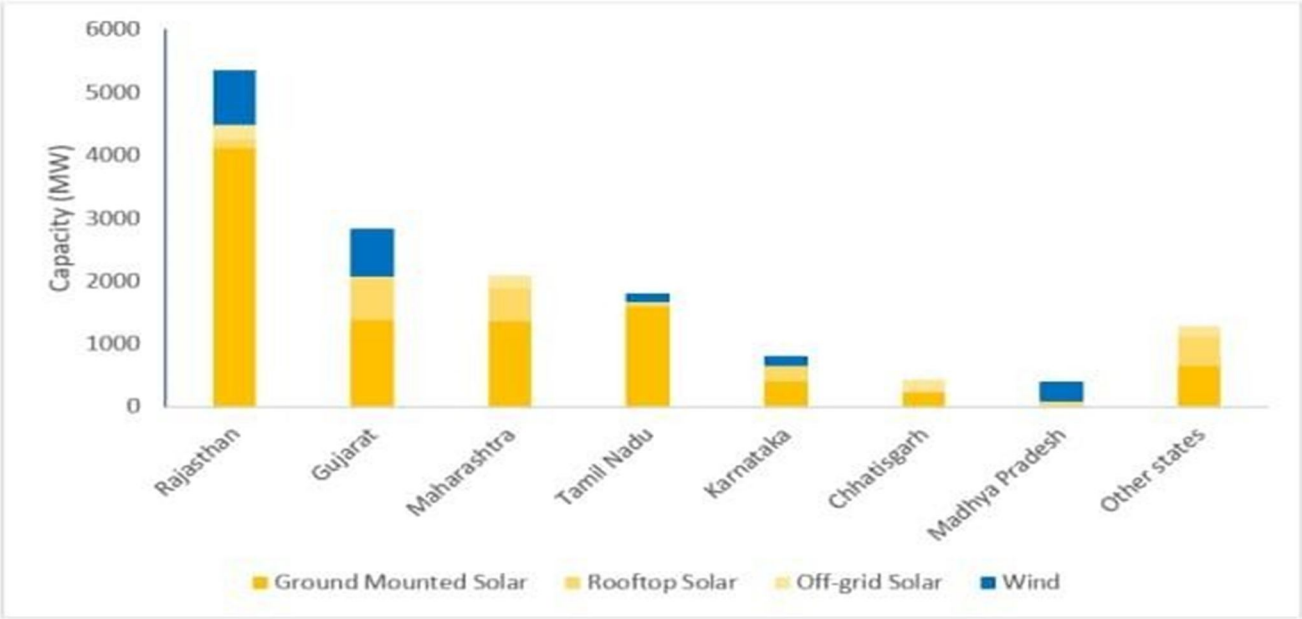

The above pictograph represents the distribution of solar & wind energy in different regions of our country.

Rajasthan, Gujarat, Maharashtra & Tamilnadu are major producer of ground & rooftop mounted solar energy & wind energy. These states play a key role in achieving nation target to reach its 450-gigawatt renewable energy by 2030.

A. Rajasthan

Rajasthan has a higher potential for solar power generation than any other region in the country – but it still trails behind Karnataka and Telangana.

As of June 2023, the operational solar power projects in Rajasthan accounted for about 4,400MW of solar energy, while 1,900MW more are in the pipeline. By 2025, Rajasthan aims to install a total capacity of 30,000MW of solar energy.

The 14000 acre Bhadla Solar Park in Jodhpur is currently the world's largest operational solar park , with a capacity of 2,245MW of installed solar energy. Rajasthan is also home to India's only tower type solar thermal power plant.

The central government has revealed plans for a 25,000MW ultra- mega renewable energy park. In the next three years, during the project's first phase, 10,000MW of solar power capacity will be installed in the state.

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B. Gujarat

India needs a lot more solar power as part of its plans to get half of its electricity requirements from renewable energy sources by 2030, and ultimately reach net – zero emissions by 2070.solar now accounts for around 7% of India's electricity generation according to the Central Electricity Authority of India – at more than 60GW. Solar power in Gujarat a state of India, is a fast developing industry due to mostly desert. It was one of the first states to develop solar generation capacity in India.

As of 31 March 2023, total installed solar power generation capacity of the state was 7,285 MW.

As we know that Gujarat is a coastal area an installed capacity of 8,900 megawatts of wind power and 6,200 megawatts of solar power, Gujarat stands second and third in the country in the respective sectors.

In the wind power sector, Gujarat stands second in the country with a 22 per cent share. In solar energy, Gujarat is the third with a13%share. We are encouraging people to set up solar rooftops on their residences. Gujarat tops the list of states in setting up solar rooftops. Out of the total solar rooftop capacity in India, 25 per cent (1,640 megawatts) is in Gujarat. In the last five years, 1,258 megawatts of solar rooftops have been set up on houses. More than

3.25 lakh residents have been given Rs 2,151 crore during this five- year period. NTPC Limited will build the country's single largest solar park of Rann of Katch in Gujarat from where it also plans to generate green hydrogen on a commercial scale. NTPC Renewable Energy - subsidiary of state-run NTPC Limited received the government's approval to establish a 4,750 MW renewable energy park at Rann of Kutch in Khavada Gujarat.

This will be the country's largest solar park to be established by the largest power producer in India. NTPC the country's largest energy integrated company, has aimed to establish 60 GW renewable energy capacity by 2032, as part of its green energy project.

Solar park of Rann of Katch in Gujarat

II. TYPES OF ENERGY

Energy can be classified in following ways:-

A. Renewable Energy

Wind
Solar
Hydrothermal
Geothermal
Biogas

B. Non-Renewable Energy

Fuel &Coal
Natural gas

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III. MATERIALS & METHODS

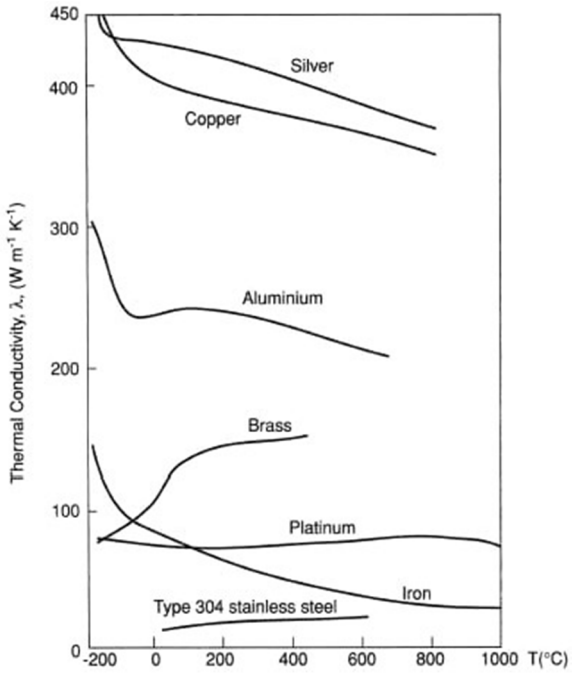
After reading all the pervious paper and their data, I had decided to change the back supporting stand or panel of solarplate with materials having higher thermal conductivity so that maximum amount of heat can be dissipated from thepanel which help to obtain a better and higher efficiency

Back panel are generally used are of iron or steel which maybe economical but provide less output, if we use aluminium or copper it will provide better efficiency as it behave as fins .

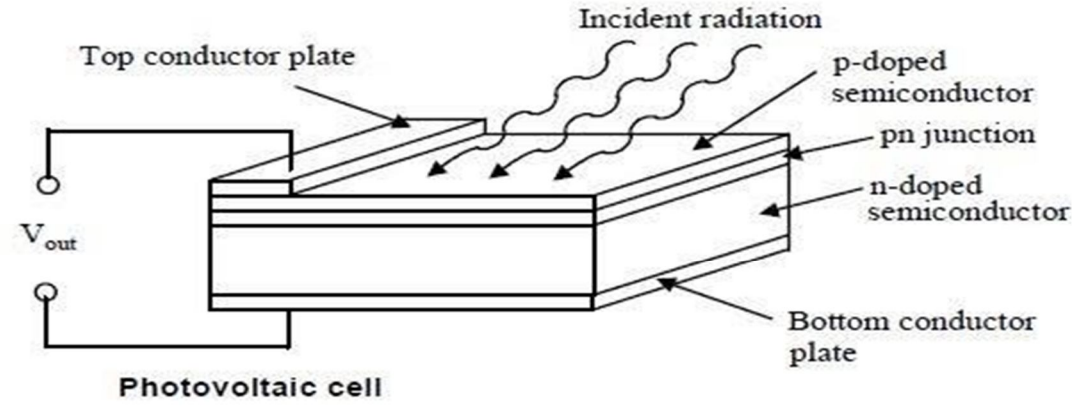
Fins are extensions on exterior surface of objects thatincreases the rate of heat transfer from the object.

Different materials and their thermal conductivity is given inchart mention below :-

Materials	Thermal conductivity(k)
Diamond	2000-2200 w/mk
Silver	429 w/mk
Copper	398 w/mk
Gold	318 w/mk
Aluminum	239 w/mk
Iron	52-73 w/mk
Steel	15 w/mk



A. Experimental set up

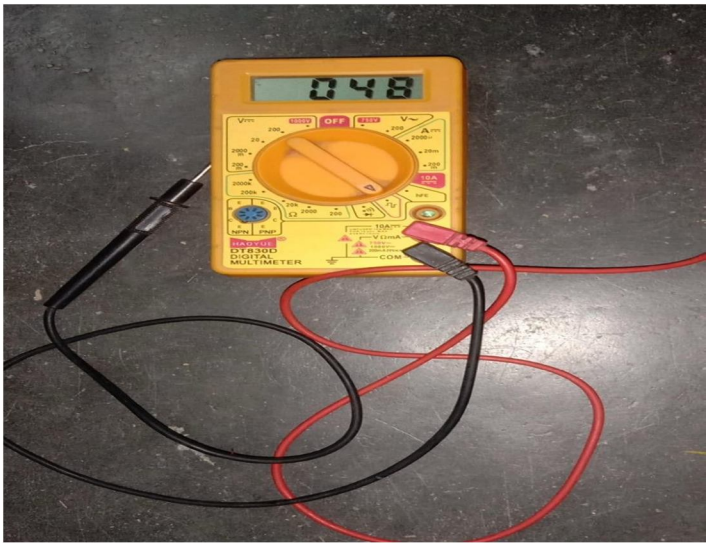


1. Mechanism of Solar Panel

2. Photograph of PV panel in different set up

B. Instrumentation

1) Multimeter: A multimeter is a measuring device that can measure multiple electrical properties. A multimeter can measure voltage, resistance and current, in which case can beused as a voltmeter, ammeter and ohmmeter. Some feature the measurements of additional properties such as temperature and capacitance. It can be used in both AC andDC system.



3. Digital multimeter

2) *Digital Temperature Gun:* Digital Temperature Gun is a device used to measure the temperature. Infrared thermometers commonly referred to as temperature guns or non-contact thermometers are portable instruments used to measure temperatures precisely by analyzing the intensity of heat radiation without making direct physical contact with the object.

4. Digital temperature gun

3) *Solarimeter:* An instrument used to measure the combined direct and diffused sun insolation or radiation is called a solarimeter. The solarimeter uses heat absorption to measure the energy produced by solar radiation. Now a day Pyranometers are also used to measure solar irradiation.

5. Digital solarimeter

Solar charge controller:- Solar charge controllers control the flow of electricity from solar panels to batteries. As the namesuggests, a solar charge controller is a component of a solar panel system that controls the charging of a battery. It gives data about current and voltage coming from solar panel. It charged the battery at proper rate and to the proper level.

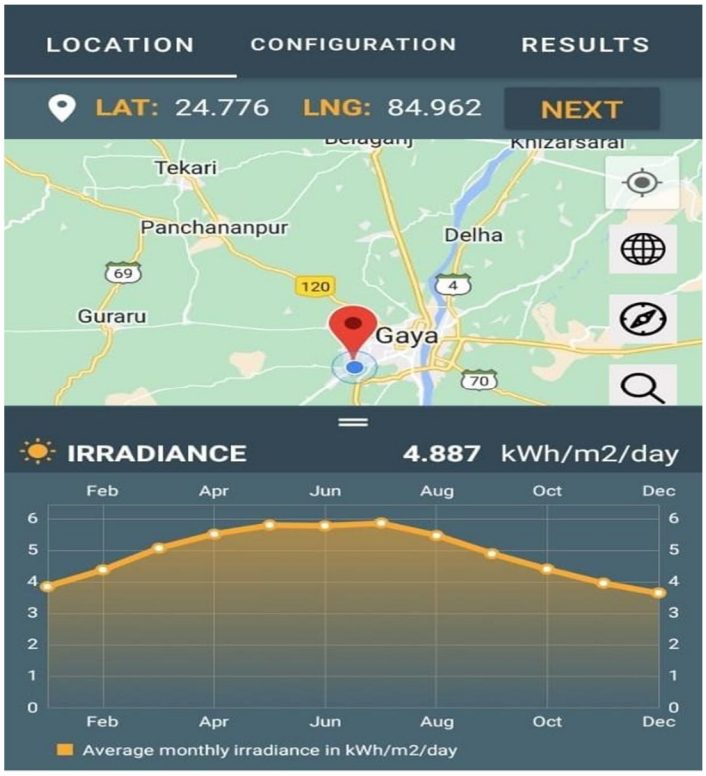
6. Solar charge controller

C. Experimental Procedure

This study give suggestions regarding the transfer of heat coming from the sun to the solar panel has to be minimised by cooling method which was discussed in literature review. Different cooling methodare used to decrease the surface temperature of solar panel like Natural cooling, forced cooling, air cooling & also discussed about soil mitigation technique.

Apart from various cooling method, another type of method is introduce for maximum heat dissipation from the solar panel is to install aluminium or copper panel or stand in place of iron or steel stand which has higher thermal conductivity, so it will give permanent cooling which help in increasing the efficiency of solar panel.

This experiment is done on my house roof location LAT24.776° & LNG 84.962° where average irradiance of 4.887kwh/m²/day which is sufficient to install a solar panel.



7. Graph showing solar irradiation

IV. EXPERIMENTS & OBSERVATIONS

A. Data Collection

The study began with innovations to access green electricity from the solar power generation system. Conventional powergeneration source has affecting environment due to burning of coal and fossil fuel, so the research focus on non-conventional power generation source like solar, wind, tidal and biomass energy. Among these solar technology is most developing than other source due to availability and clean energy.

Assumption taken for the installation of solar panel:Sun light available in a day = 6-7 hour/day

Solar panel rating:- peak power(Pmax)= 166.95 watt

Peak voltage (Vmpp) = 18.13 watt Open circuit voltage (Voc)= 22.9

voltPeak current (Impp)= 9.20 amp Short circuit current (Isc)= 9.74 ampModel -2021

Dimensions =153cmx72cmx3.5cm

This output is generated under following condition:-

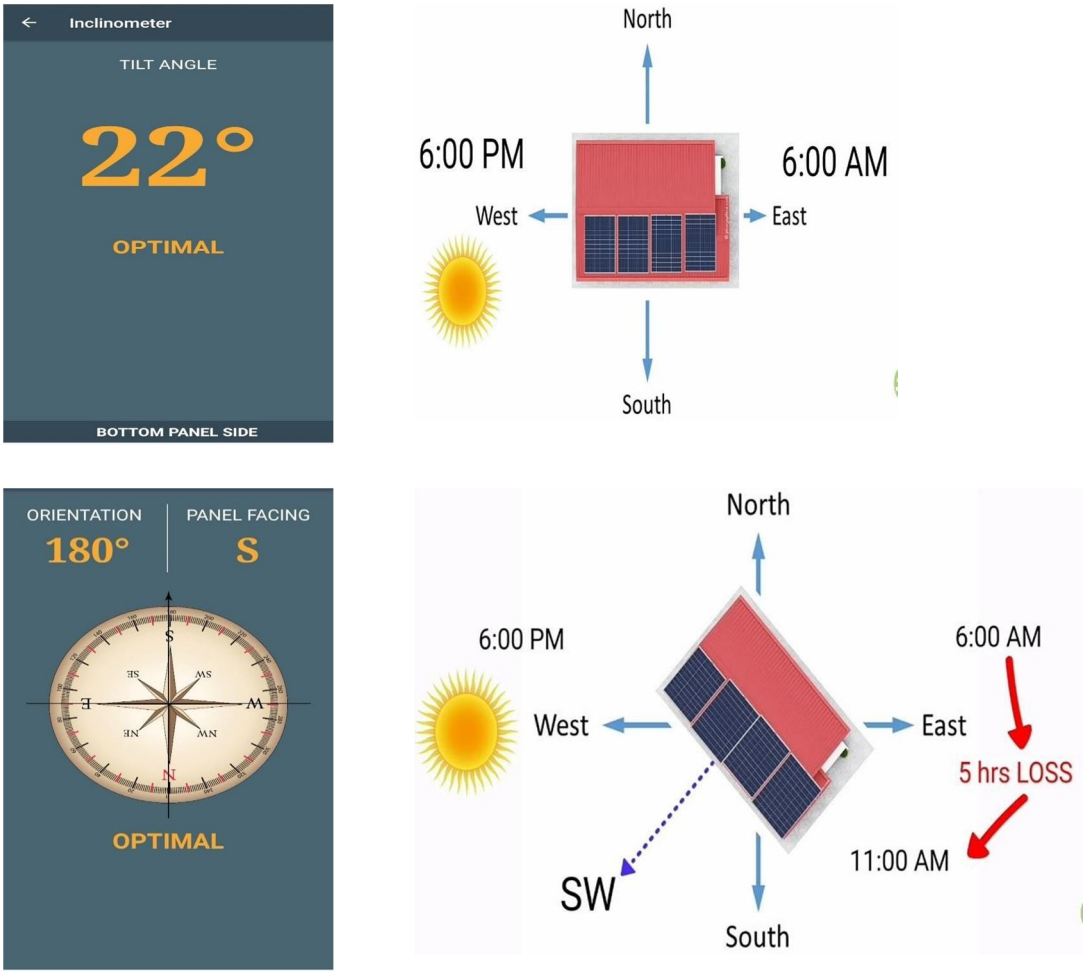
At STC, irradiance = 1000 w/m²

PV panel temp = 25°c

AM=1.5 where (AM means air mass value)

B. Mounting Structure of Solar Panel for Increasing Efficiency

Panel should be installed on metal frame having a aluminium frame in rear side that are generally 28-30° tilt but for my location optimal angle is 22° with horizontal in southdirection. The structure are made to allow for easy replacement panel in accordance with site requirements aswell as future modification and maintenance.



8. Optimal condition for installation of solar panel

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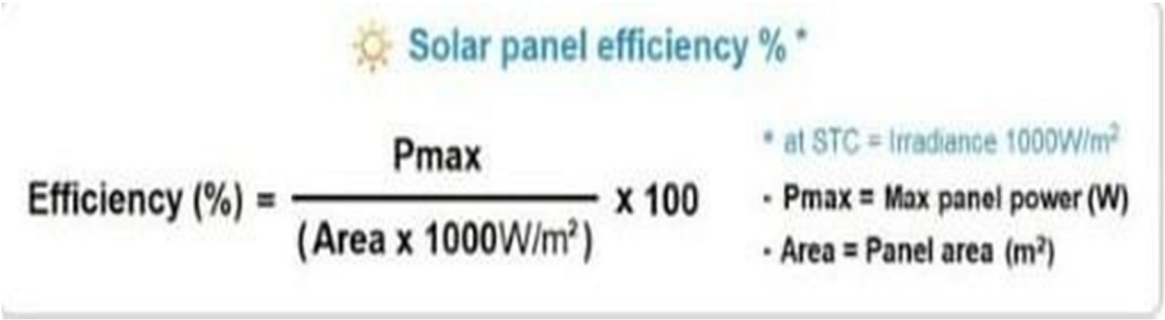
C. Panel Efficiency

Solar panel efficiency is measured under standard test condition (STC) based on a cell temperature of 25°c solarirradiance (G) of 1000 w/m² and Air Mass of 1.5. The efficiency (%) of panel is effectively calculated by dividing themaximum power rating or Pmax at STC by total panel area measured in square meters.



Comparison of efficiency with different generation of solarpanels

Generation	Types of Panel	Panel efficiency (%)	uses
First	Monocrystalline type	14-17.5	Used in conventional surroundings
	Polycrystalline type	12-14	
Second	Thin film solar cells	16-17	Used in smaller power systems
	Amorphous silicon	4-8	
Third	Nanocrystal	7-8	Best suited for areas with normal irradiation
	Polymer	3-10	

Under the optical discernment day by day from the first generation solar panels, the monocrystalline solar panel gives a better performance compared to polycrystalline solar panelbecause the structure is uniform and because it is highly pure. Mostly crystalline solar cells absorb 90% of irradiance ranging from 400 to 1200 nm, but the conversion efficiency isup to 18% only while the rest are converted into heat.

After installation of solar panel, the data is collected throughout the day and results are analyzed. These data are collected two day in a month during April to July. Average data of these month are shown in the table in both the condition without aluminium plate in rear side as well as withaluminium plate in rear side to observe the change in efficiency of solar panel.

Time	current	voltage	Panel surface temperature	Solar radiation (G) (w/m²)	
	(Amp)	(V)	(°c)	Direct radiation	Diffuse radiation
08:00AM	3.37	10.9	38.3	617	284
10:00 AM	4.67	11.3	44	710	489
12:00 PM	5.02	11.6	48.7	905	587
02:00 PM	4.87	11.2	46	847	479
04:00 PM	3.07	9.06	36	847	479
AVERAGE VALUE	4.148	10.426			

1. Average Data Collection of PV panel with iron plate in April 2023

As per the information given on solar panel we first find itsmaximum efficiency,
Given data:- peak current =9.20 amp
Peak voltage =18.13volt Dimension =153cmx72cmx3.5cm
So, efficiency = (9.20x18.13/153x72x1000)100%
=15.14%

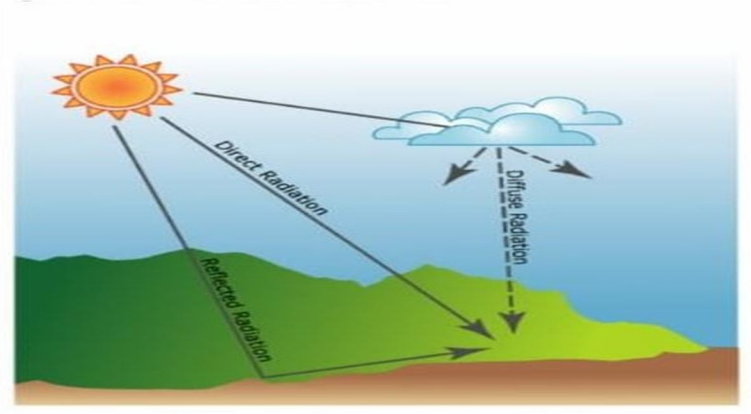
Solar panel efficiency % *

$$\text{Efficiency (\%)} = \frac{\text{Pmax}}{(\text{Area} \times 1000 \text{W/m}^2)} \times 100$$

* at STC = Irradiance 1000W/m²
- Pmax = Max panel power (W)
- Area = Panel area (m²)

This efficiency is obtained under STC condition but in real liferesult varies from given data

Now we find original efficiency under my observation,Given data average current= 4.148amp
Average voltage=10.426 voltDimension =153cmx72cm
So, efficiency = (4.148x10.426/153x72x1000)100%
=3.953%

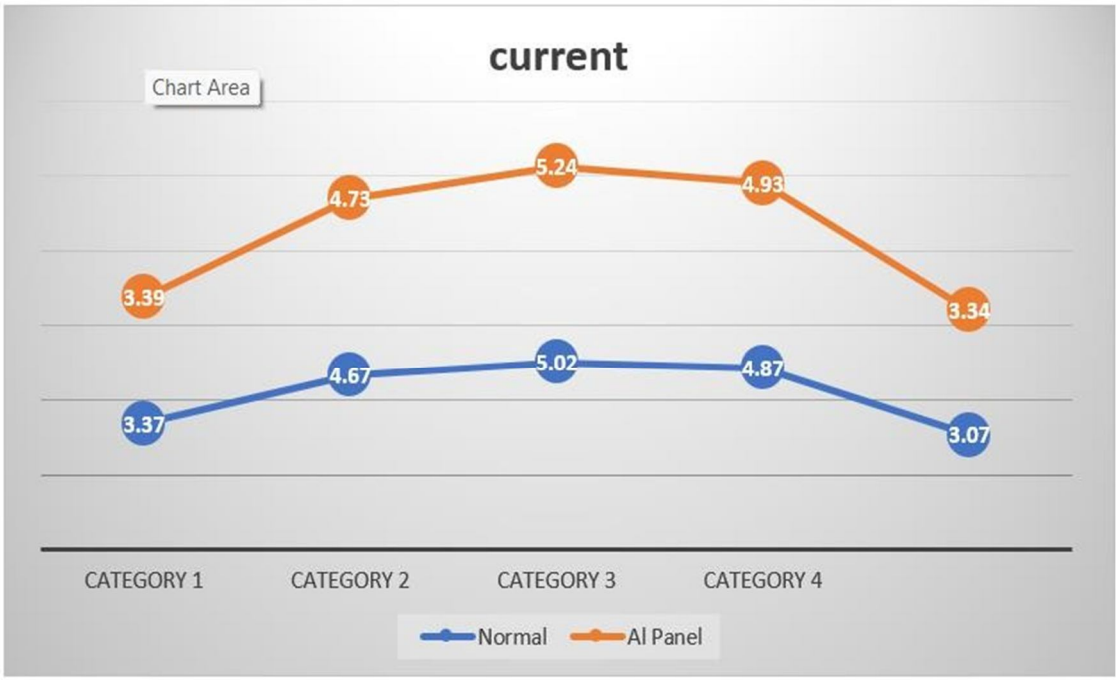


9. Radiation coming to solar panel in these way

Time	current	voltage	Panel surfacetemperature	Solar radiation (G) (w/m²)	
	(Amp)	(V)	(°c)	Direct radiation	Diffuse radiation
08:00AM	3.39	11.3	34.2	617	284
10:00 AM	4.73	11.7	39	710	489
12:00 PM	5.24	12.2	44.1	905	587
02:00 PM	4.93	11.5	43.8	847	479
04:00 PM	3.34	9.26	34	847	479
AVERAGE VALUE	5.1556	11.192			

2. Average data collection of PV panel with rear side aluminum plate in April 2023

Now we find original efficiency under my observation when aluminum plate is installed in backside of panel which help in heat dissipation as result surface temperature decreases, which gives better efficiency
Given data average current= 5.1556 ampAverage voltage=11.192 volt Dimension =153cmx72cm
So, efficiency = (5.1556x11.192/153x72x1000)100%
=5.237%
Net increase in efficiency after installation on aluminumpanel is
= (5.237-3.953) % =1.284%
Due to installation of aluminum panel which as very high thermal conductivity as compare to iron heat dissipation rateincreases that why surface temperature of panel is maintain at lower value due to uniform heat dissipation.



Graph showing current value

Time	current	voltage	Panel surface temperature	Solar radiation (G) (w/m²)	
	(Amp)	(V)	(°c)	Direct radiation	Diffuse radiation
08:00AM	3.37	11.5	36.7	639	296
10:00 AM	5.02	11.9	41	822	521
12:00 PM	5.04	12.1	50.9	927	556
02:00 PM	5.01	11.9	50.6	925	589
04:00 PM	3.87	10.02	43	789	437
AVERAGE VALUE	4.243	11.484			

3. Average Data Collection of PV panel with iron plate in May 2023

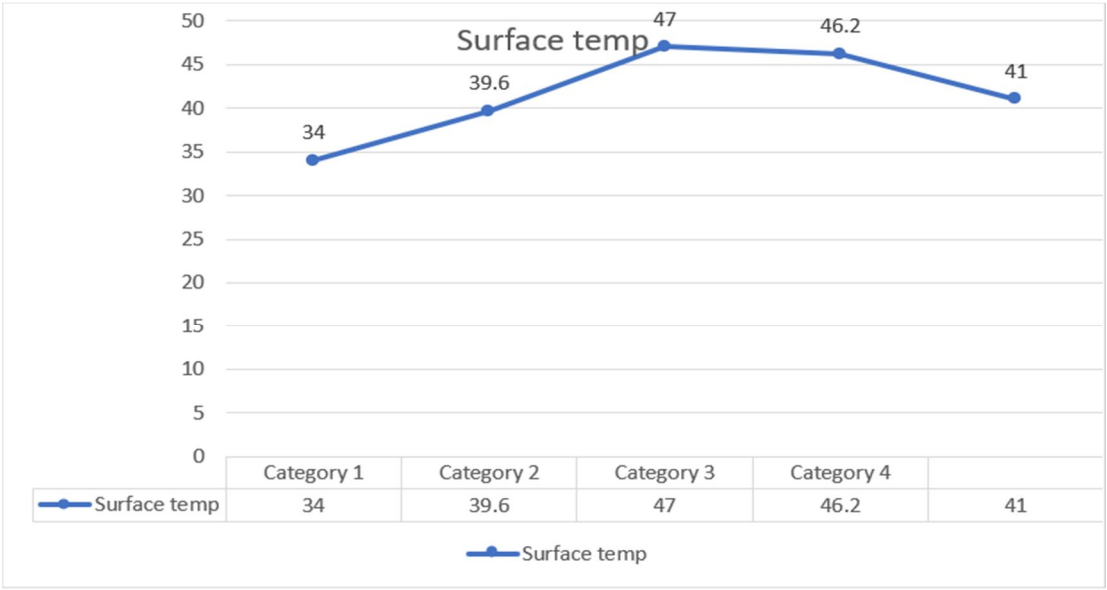
Now we find original efficiency under my observation,Given data average current= 4.462amp
Average voltage=11.484 voltDimension =153cmx72cm
So, efficiency = (4.462x11.484/153x72x1000)100%
=04.65%

Time	current	voltage	Panel surface temperature	Solar radiation (G) (w/m²)	
	(Amp)	(V)	(°c)	Direct radiation	Diffuse radiation
08:00AM	3.46	11.89	34	639	296
10:00 AM	5.53	13.07	39.6	822	521
12:00 PM	5.80	14.20	47	927	556
02:00 PM	5.21	13.01	46.2	925	589
04:00 PM	4.26	11.32	41	789	437
AVERAGE VALUE	4.852	12.698			

4. Average Data Collection of PV panel with Aluminum plate in May 2023

Now we find original efficiency under my observation,Given data average current= 4.852 amp
Average voltage=12.698 voltDimension =153cmx72cm
So, efficiency = (4.852x12.698/153x72x1000)100%
=05.613%
Net increase in efficiency after installation on aluminumpanel is = (5.613 - 4.2435) =1.37%
Due to installation of aluminum panel which has very highthermal conductivity as compare to iron, heat dissipation rate increases.

Graph showing current value of May 2023

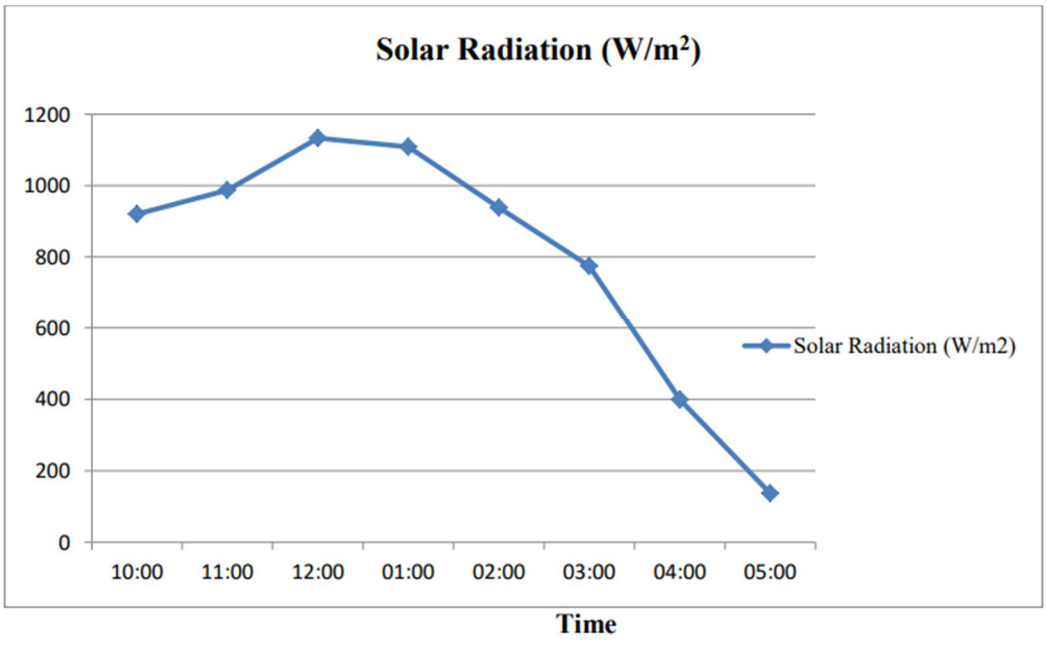


Panel surface temperature (°c)

Time	current	voltage	Panel surface temperature	Solar radiation (G) (w/m²)	
	(Amp)	(V)	(°c)	Direct radiation	Diffuse radiation
08:00AM	3.21	10.6	36.2	521	194
10:00 AM	5.04	11.6	43	729	396
12:00 PM	5.08	12.2	53.5	823	407
02:00 PM	5.07	12.3	54	826	413
04:00 PM	3.26	9.69	39	678	439
AVERAGE VALUE	4.404	11.278			

5. Average data collection of PV panel with iron plate in June 2023

Now we find original efficiency under my observation,Given data average current= 4.404 amp
Average voltage=11.278 voltDimension =153cmx72cm
So, efficiency = (4.404x11.278/153x72x1000)100%
=04.48%
After observation it is seen that reason for lower efficiency isthe surface temperature of solar panel which crosses 50°c during proper sunlight that why most of sunlight energy is converted in heat due to this its efficiency decreases so different method is used to decrease the surface temperature in such a way that is economical as well as no extra electricity is consumed in cooling the surface of solar panel.

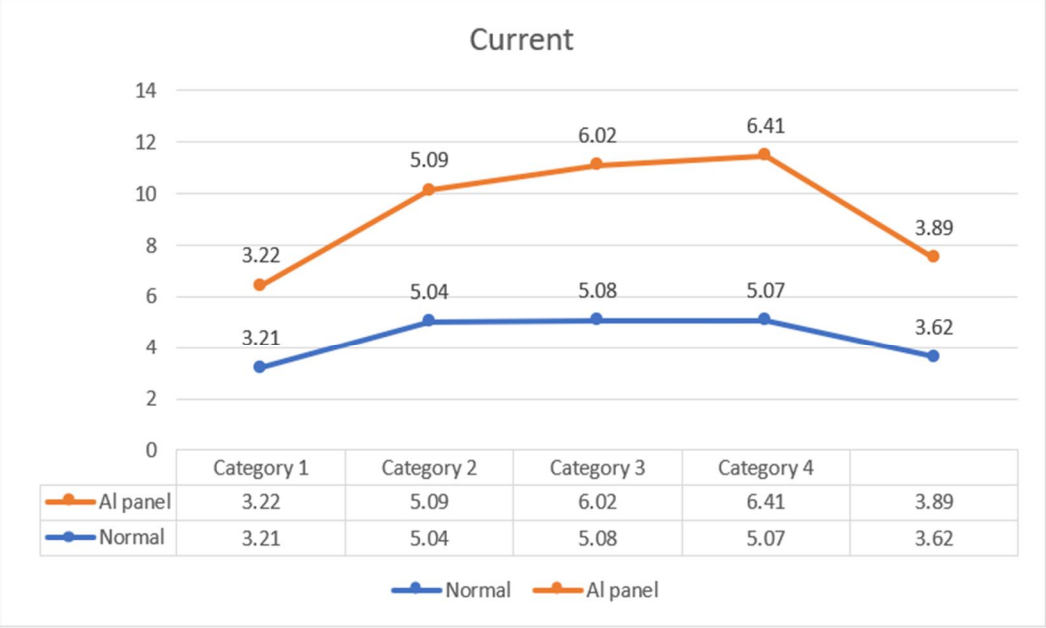


Time vs Solar Radiation June 2023

Time	current	voltage	Panel surface temperature	Solar radiation (G) (w/m²)	
	(Amp)	(V)	(°c)	Direct radiation	Diffuse radiation
08:00AM	3.22	10.6	36.2	521	194
10:00 AM	5.09	11.6	43	729	396
12:00 PM	6.02	12.2	53.5	823	407
02:00 PM	6.41	12.3	54	826	413
04:00 PM	3.89	9.69	39	678	439
AVERAGE VALUE	4.926	11.908			

6. Average data collection of PV panel with Aluminum plate in June 2023

Now we find original efficiency under my observation,Given data average current= 4.926 amp
Average voltage=11.908 voltDimension =153cmx72cm
So, efficiency = (4.926x11.908/153x72x1000)100%
=05.34%
Net increase in efficiency after installation on aluminumpanel is = (5.34 - 4.48) =0.90%
Due to installation of aluminum panel which has very highthermal conductivity as compare to iron, heat dissipation rate increases.



Graph showing current value of June 2023

Time	current	voltage	Panel surface temperature	Solar radiation (G) (w/m²)	
	(Amp)	(V)	(°c)	Direct radiation	Diffuse radiation
08:00AM	2.98	9.6	35.7	508	187
10:00 AM	3.28	10.9	42	711	363
12:00 PM	4.98	11.7	51.6	792	379
02:00 PM	4.87	11.6	50.8	803	371
04:00 PM	3.17	10.6	40.6	654	417
AVERAGE VALUE	3.856	10.88			

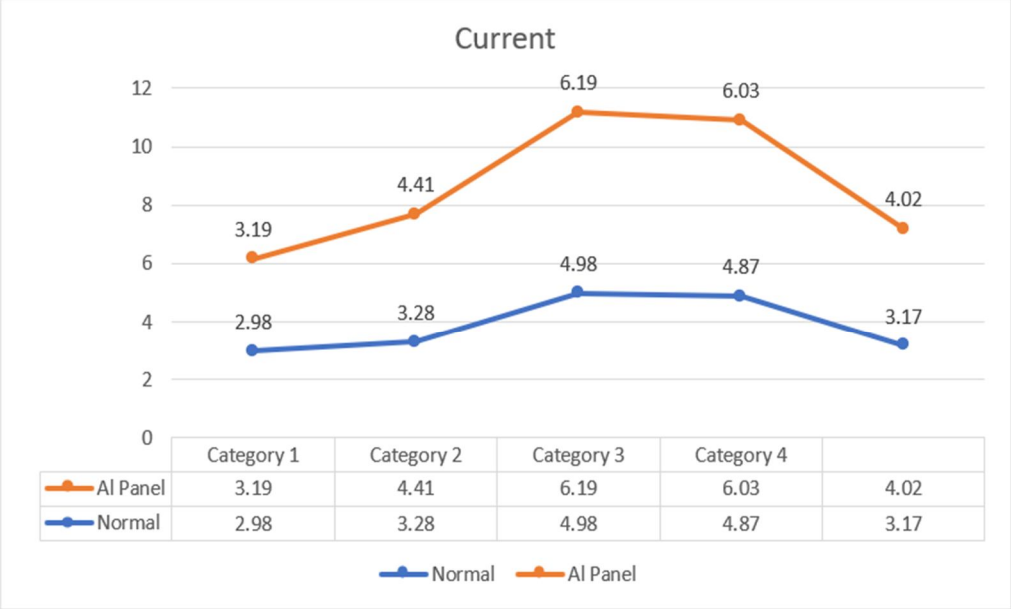
7. Average data collection of PV panel with iron plate in July 2023

Now we find original efficiency under my observation,Given data average current= 3.856 amp
Average voltage=10.88 voltDimension =153cmx72cm
So, efficiency = (3.856X10.88/153x72x1000)100%
=3.8083%
A higher concentration mirror is installed above the PV solar panel results in high irradiation energy which gives high inputto solar panel but also it increases the solar panel heat due towhich again efficiency decreases, so working on maintaining the surface temperature of panel to optimum value is main target in achieving desired output.

Time	current	voltage	Panel surface temperature	Solar radiation (G) (w/m²)	
	(Amp)	(V)	(°c)	Direct radiation	Diffuse radiation
08:00AM	3.19	10.2	33	508	187
10:00 AM	4.41	11.9	39	711	363
12:00 PM	6.19	12.9	46.8	792	379
02:00 PM	6.03	11.82	46.2	803	371
04:00 PM	4.02	10.86	37.3	654	417
AVERAGE VALUE	4.768	11.531			

8. Average data collection of PV panel with Aluminum plate in July 2023

Now we find original efficiency under my observation,Given data average current= 4.768 amp
Average voltage=11.531 voltDimension =153cmx72cm
So, efficiency = (4.768x11.531/153x72x1000)100%
=04.9897%
Net increase in efficiency after installation on aluminumpanel is = (4.9897 – 3.8083) =1.1814%



Graph showing current value of July 2023

V. DATA ANALYSIS AND RESULTS

For the installation of solar panel, first we have to check the location,solar irradiance, space etc. There is availability of proper sun light from sunrise to sunset without any disturbance like shadow, dust etc. An off grid solar system is advice to installed for low consumption of electricity or personal needs. There are several experiment has been done to increase the efficiency of solar panel but in every experiments there is need of some improvements eitherthey are not economical or it need some electrical appliances like DCmotor which require electrical energy to run it which decreases the net output. Water cooling system gives good efficiency but it again require DC pump which run electricity to sprinkle water on solar panel.

After reading lots of research paper, it is advised to install solar panel with aluminum panel in rear side which has high thermal conductivity gives proper cooling to solar panel by dissipating maximum amount of heat through surface convection and it is permanent solution which does not require any maintenance and also not require any electrical energy hence it gives better efficiency.The project has a very strong scope as conventional electrical energy rate is increasing and it is environment friendly.

VI. CONCLUSION

In this research, the performance of an off – grid solarsystem having Aluminum panel is installed in rear side of panel. Themain objective of this study is to provide a best design that gives better efficiency as compare to pervious research study on this topic which is also economical as well as environment friendly. In this system design, efficiency of solar panel increases by 1-2% in all the observation table of experiments. In order to read the performance of solar panel with my set up voltage, current, surface temperature and solar irradiance are continuously monitored. These above data helps to read and improvethe efficiency of solar panel. This set up does not require any extra surface area to install the aluminum panel.

Hence, for any PV solar panel installation, this method can bereferred to give good efficiency and it is permanent solution, economical and environment friendly.

VII. FUTURE SCOPE TO INCREASE THE EFFICIENCY OF SOLAR PANEL

Various methods were discussed earlier to increase the efficiency ofthe solar panel:-

To enhance the more efficiency further, some of the research gapswere identified to carryout needful research.

1) Materials such as copper is to be used in the back side of solar panel for better heat dissipation or uniformly at higher rate as it has very high thermal conductivity.

2) Condenser heat exchanger is to be installed made up of copperhaving liquid refrigerant as water is used in back side of panel to cool the solar panel.

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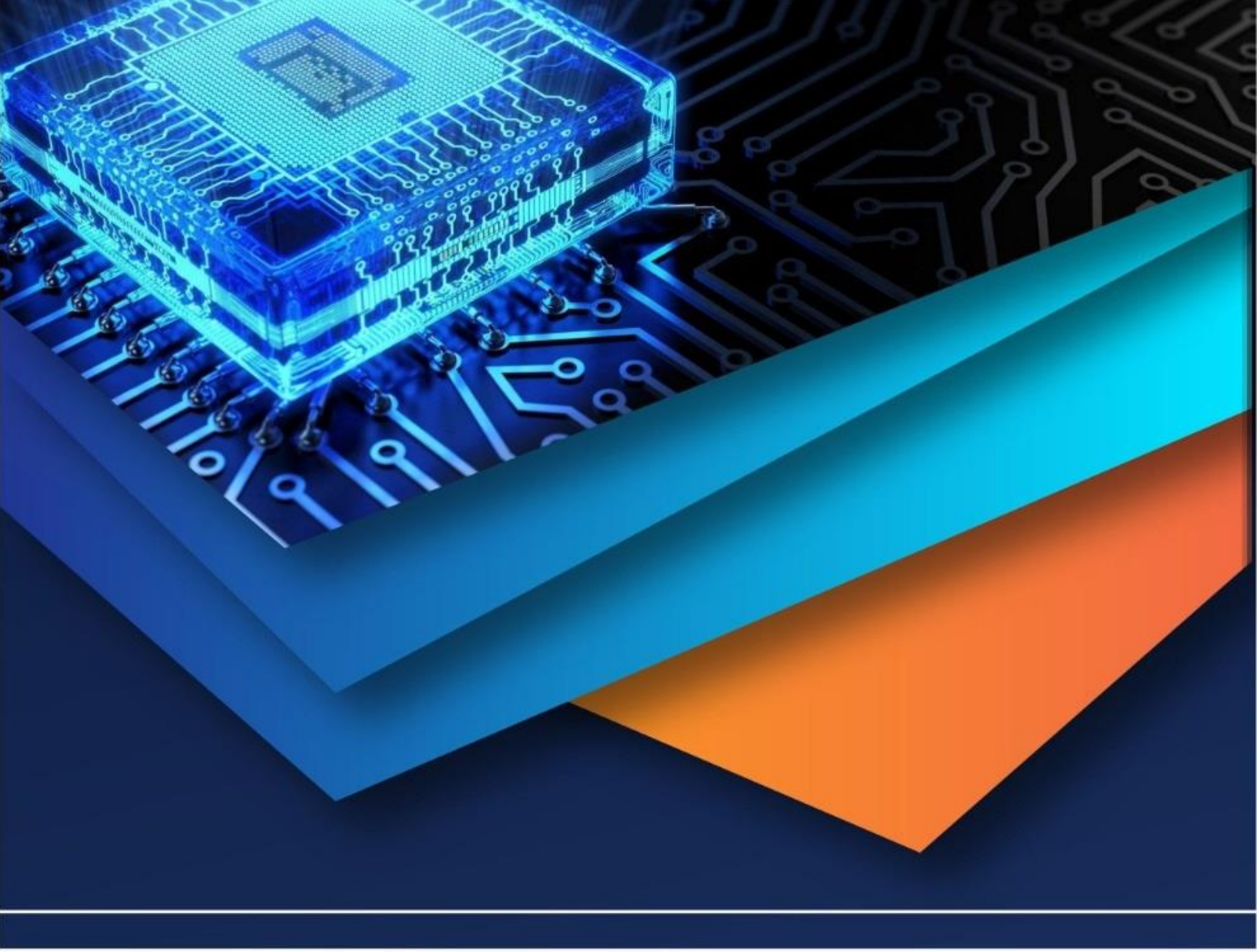

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