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Analysis of the changes in the performance of Solar Module with the Increase in the Temperature

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Abstract: Photovoltaic's are the devices can produce electricity. To study the real behaviour of these devices, an authentication model is required. In this article, MATLAB double diode model is developed using the device physics of solar cell. The Simulink model is analysed at different operation conditions. For this analysis Kyocera data sheet is taken having two modules KD330GX-LFB and KD25GX-LFB contains 80 cells. The above two modules are studied at the temperatures 10^0C, 20^0C and 30^0C. The results are illustrating that as the temperature increases the performance of the model decreases.
Keywords: Data sheet, temperature, MATLAB, simulation, efficiency.

I. INTRODUCTION

Solar energy is the wide range of renewable energy resource. A huge amount of energy is reaching to the earth every day, but a very little amount of energy is utilizing for the mankind. In olden days. Solar energy is utilized for domestic purpose after industrial revolution solar energy is using to produce power. The photovoltaic effect is the phenomena used to produce electrical energy from the solar energy(1). An amount of solar energy i.e. 0.8% of the total energy is using for the power production(2-3). In solar power generation, high cost of solar modules and instability are the limiting factors to use solar power widely. To clear understand the system, numerical modelling of the photovoltaic is becoming a major valuable tool to study the outdoor behaviour of solar cells. Many scientists have been developed the MATLAB models which is an authenticate the real system.

From literature, Longatt. Et. Al(4) developed the circuit based simulation work using the MATLAB, Later Tsai et al developed various MATLAB models(5). Kumari and Babu also developed a MATLAB model to extract the parameters using the I-V equation. In this work a double diode MATLAB model is developed using fundamental equations.

The required resistance parameters are extracted using the newton-rapshon method. To validate the developed Simulink model MATLAB results are compared with an experimental data sheet. Got good coincidence with the practical values. This work mainly focussed on the influence of operating temperature on the performance of the model.

A. Working of a Photovoltaic Cell

Solar cell works on the principal of photovoltaic effect. Most of the solar cells are made with silicon. There are various types of silicon materials are available in the market those are mono crystalline silicon, poly crystalline materials, amorphous silicon.

When sunlight falls on the semi conducting material , The photons from the incident radiation pulls out the electrons from their respective places, leaving a vacant place called as holes. The produced electrons and holes will move toward opposite contacts.

The photovoltaic effect is the combination of four steps those are carrier generation, carrier dissociation, carrier transport, collection. In some photo voltaic materials in place of electrons and holes , excitons will produce and later separates into electrons and holes. Below diagram explains the movement of electrons and holes from the conduction and valence band.

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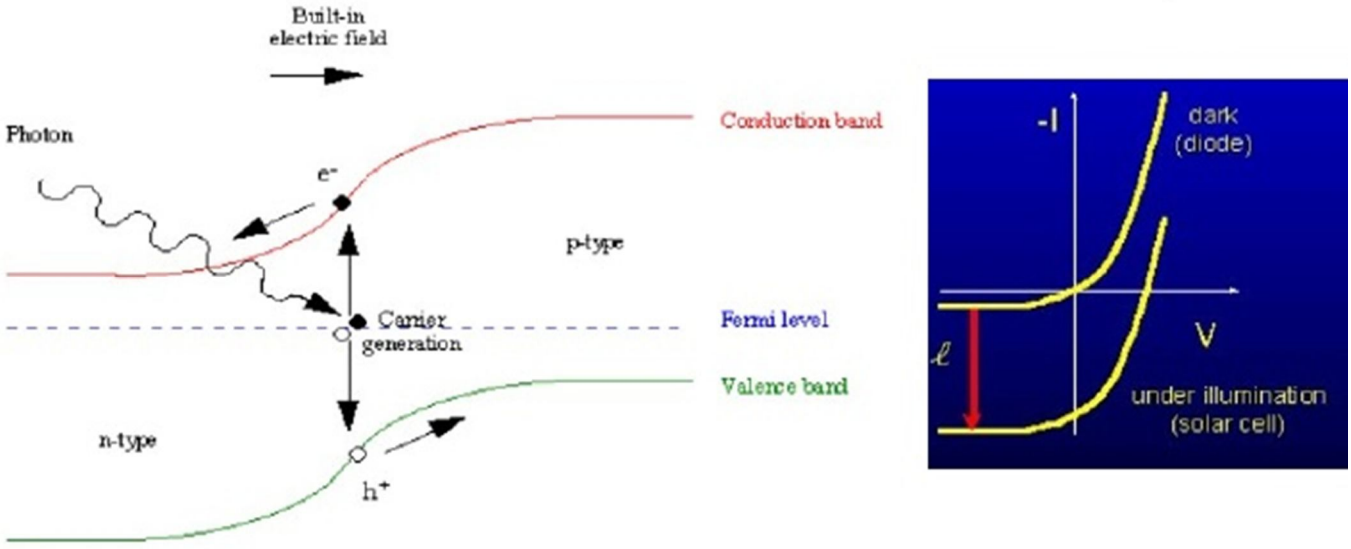

Fig:1 Representation of photovoltaic effect

B. Mathematical Modelling of a Solar Cell

Modelling is the understanding of the real system using simulation tool. In this work MATLAB/Simulink is used for the simulation of photovoltaic module. Mathematical model is developed using the equations of solar cell, which are convertible into the codes for the process of simulation. This type of mathematical models are using from the long back. The commonly used model to predict the performance of the solar cell are the single diode and double diode models having the special features individually(6-13).

The equivalent circuit of double diode solar cell is having a current source, two P-N Junction diodes, series resistance and the parallel resistance(14). In single diode model one diode is present to represent the recombination of charges, but the recombination at the depletion region is also considerable this can be identified using a second diode. Previous investigations are proving that the Double diode model is accurate at the low operating conditions. The series resistance and parallel resistances are added in the circuit. To get best performance series resistance should low and the parallel resistance should high.

C. The Characteristic I-V equation of a PV Cell

To describe the parameters of a solar cell, the equation used is as follows. Simulink model of double diode particularly values of the input parameters are taken from the KYOCERA KD 330 GX-LFB, data sheet(15). The series and shunt resistances are approximated using the newton-rapshon method.

$$I = I_{PV} - I_{O1}\left[exp\left(\frac{V+IR_S}{a}\right)-1\right] - I_{O2}\left[exp\left(\frac{V+IR_S}{a}\right)-1\right] - \frac{V+IR_S}{R_P}.$$

I_{PV} = Photo current
I_o = Saturation current
R_S = Series resistance
R_P = Parallel resistance
A= Ideality factor
I= Current

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D. Influence of Temperature on KD 330GX-LFB SOLAR Module

Kyocera, KD330GX-LFB is analysed at the constant irradiation and varying temperature. Below graphs are indicating the changes in the photovoltaic parameters of the solar module at fixed 1000W/m^2, and at the varying temperatures 10^0 C, 20^0 C, 30^0 C. The changes are indicating that as the temperature changes the performance of the device decreases. Increase in the temperature leads to the increase in the band gap of the material. So, requires more energy to cross the barrier. Hence the efficiency of the device decreases(16). When we observe the photovoltaic parameters. Short circuit current(I_{SC}) is almost constant. The major changes are observed in the V_{OC}, P_{MAX} as those are decreasing, proving the non-linear nature of solar module.

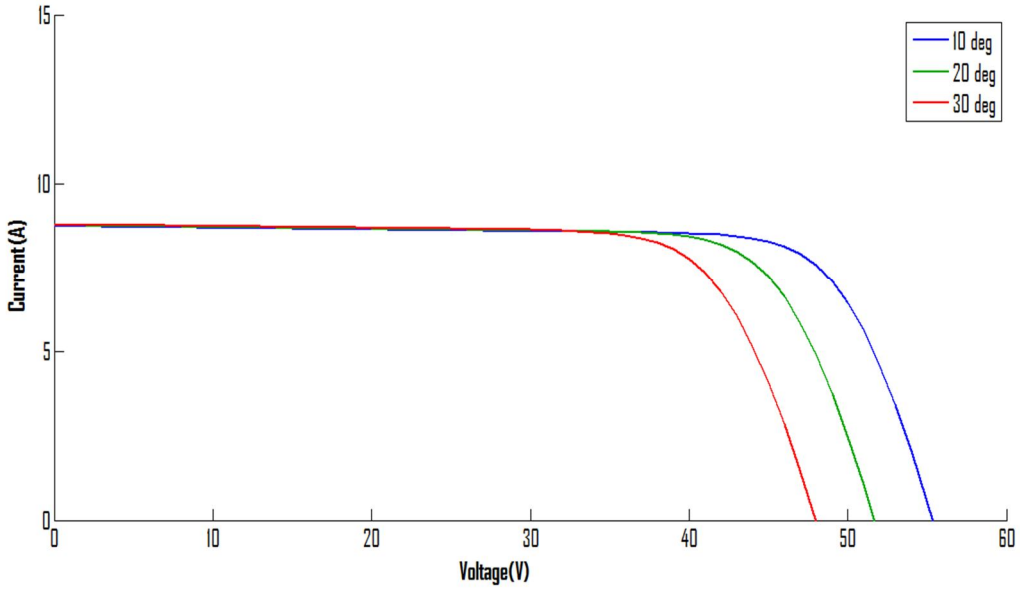

Fig-2: I-V Curve for KD330GX-LFB at different temperatures(10^0 C, 20^0 C, 30^0 C).

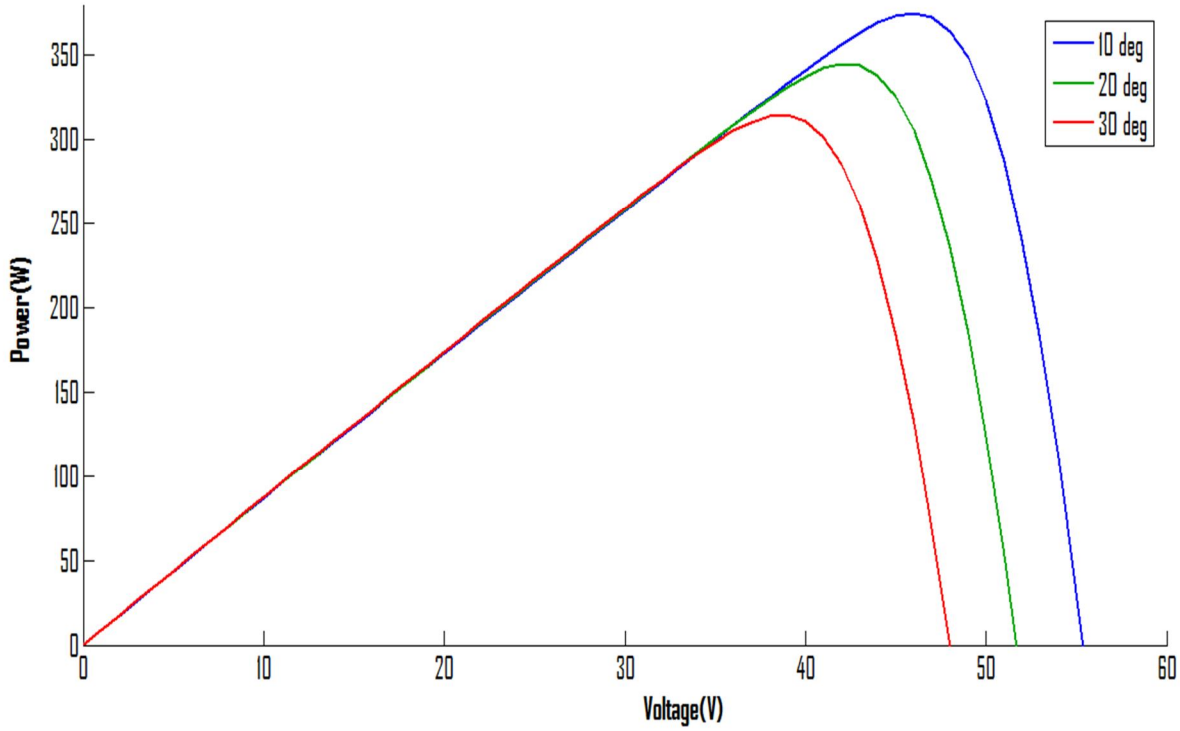

Fig-3: P-V Curve for KD330GX-LFB at different temperatures 10^0 C, 20^0 C, 30^0 C.

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E. Influence Of Temperature On Kd 325gx-Lfb Solar Module

The developed mathematical model can be used for any type of solar module. Similarly, here the MATLAB/Simulink model is applied for the KYOCERA KD325GX-LFB solar module to analyse the changes in the performance at different temperatures.

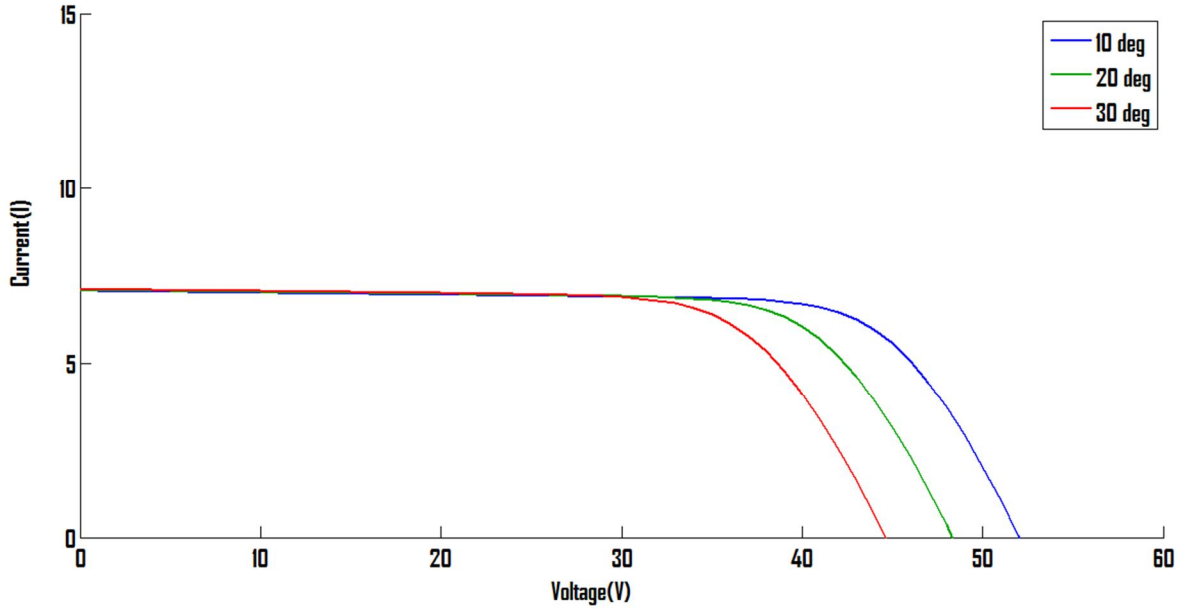

Fig-4: I-V curve for KD325GX-LFB at different temperature(10^0 C, 20^0 C, 30^0 C)

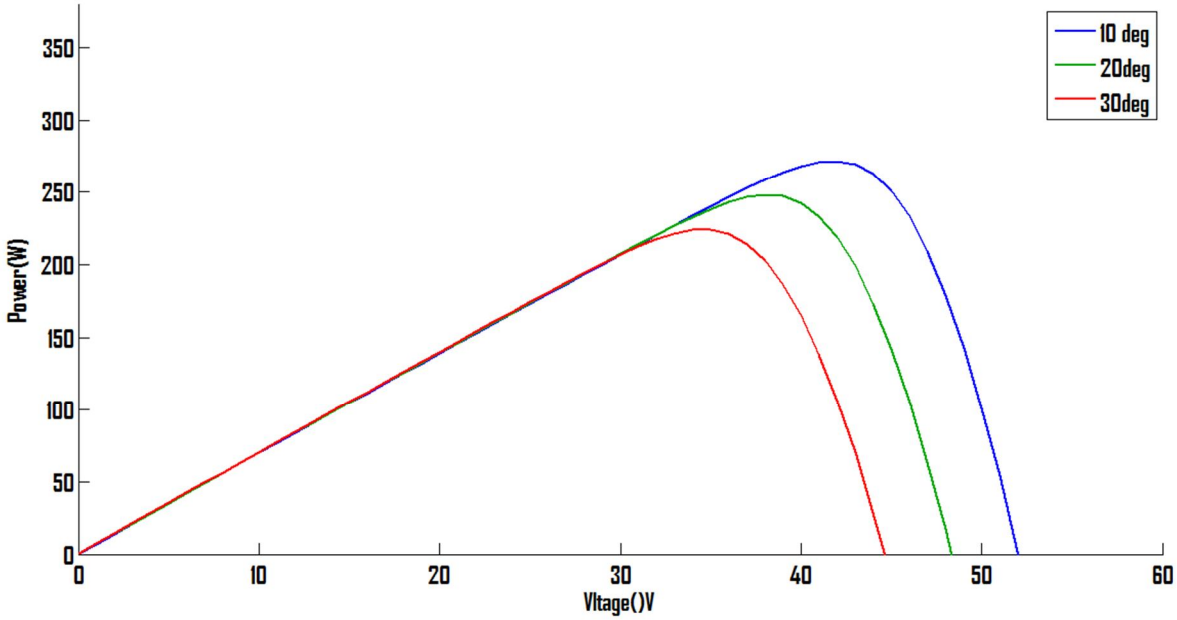

FIG-5: P-V CURVE FOR KD325GX-LFB AT DIFFERENT TEMPERATURES 10^0 C, 20^0 C, 30^0 C.

Same as in the previous case the results are illustrating that as the temperature increases the performance drops. The increase in the temperature is showing the negative impact on the efficiency of the model. Particularly the open circuit voltage is more decreased than the short circuit current because the open circuit voltage is the function of band gap of the material. Temperature increase varies the band gap of material. With the decrease in the open circuit voltage maximum power also decreases, representing the drop

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in the performance. Hence at low temperatures the performance is good than at high temperatures. Below graphs clearly illustrating the changes in I-V and P-V curves of Kyocera KD325GX-LFB solar module.

II. CONCLUSION

The developed, Simulink model is applied for the KYOCERA practical solar modles to analyze the changes in the performance of the models. To understand the effect of temperature on the performance of the model, temperature is varied from 10^0 C, 20^0 C, 30^0 C at the fixed irradiance of 1000W/m^2 for both modules. Following conclusions have been taken out from the above analysis.

A. As the temperature increases open circuit voltage decreases and short circuit current(I_{SC}) remains constant.

B. Maximum output power drops at higher temperature because less number of charges are present.

Hence the temperature increase is showing the negative impact on the performance of both the module.

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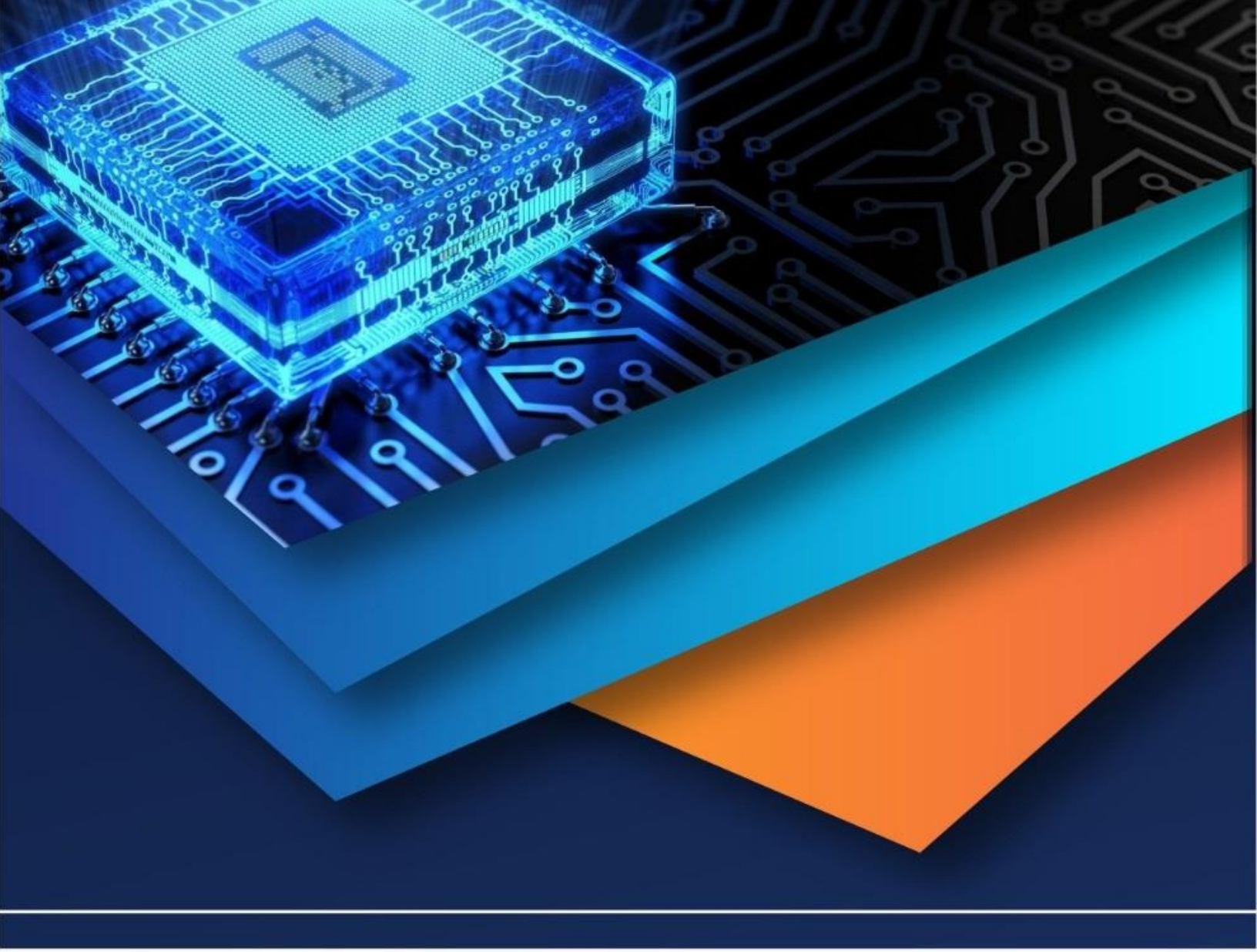

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