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A Hybrid Implementation of New Power Converter for Hybrid Wind Solar Energy Conversion System

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***Abstract:** Wind power involves converting wind energy into electricity by using wind turbines. A wind turbine is composed of 3 propellers-like blades called a* **rotor.** *The rotor is attached to a tall* **tower.** *The tower looks like a very tall pole. On average wind towers are about 20m high. The reason why the tower is so tall is because winds are stronger higher from the ground. As the power demand increases, power failure also increases. So, renewable energy sources can be used to provide constant loads. A new converter topology for hybrid wind/photovoltaic energy system is proposed. Hybridizing solar and wind power sources provide a realistic form of power generation. The topology uses a fusion of Cuk and SEPIC converters. This configuration allows the two sources to supply the load separately or simultaneously depending on the availability of the energy sources. Simulation is carried out in MATLAB/ SIMULINK software and the results of the Cuk converter, SEPIC converter and the hybridized converter are presented.*
***Index Terms:**Renewable energy, Cuk converter, SEPIC converter ,VSI inverter.*

I. INTRODUCTION

Recent developments and trends in the electric power consumption indicate an increasing use of renewable energy. Virtually all regions of the world have renewable resources of one type or another. By this point of view studies on renewable energies focuses more and more attention. Solar energy and wind energy are the two renewable energy sources most common in use. Wind energy has become the least expensive renewable energy technology in existence and has peaked the interest of scientists and educators over the world. Photovoltaic cells convert the energy from sunlight into DC electricity. PVs offer added advantages over other renewable energy sources in that they give off no noise and require practically no maintenance. Hybridizing solar and wind power sources provide a realistic form of power generation.

In this paper, a new converter topology for hybridizing the wind and solar energy sources has been proposed. In this topology, both wind and solar energy sources are incorporated together using a combination of Cuk and SEPIC converters, so that if one of them is unavailable, then the other source can compensate for it. The Cuk-SEPIC fused converters have the capability to eliminate the HF current harmonics in the wind generator. This eliminates the need of passive input filters in the system. These converters can support step up and step down operations for each renewable energy sources. They can also support individual and simultaneous operations. Solar energy source is the input to the Cuk converter and wind energy source is the input to the SEPIC converter. The average output voltage produced by the system will be the sum of the inputs of these two systems. All these advantages of the proposed hybrid system make it highly efficient and reliable.

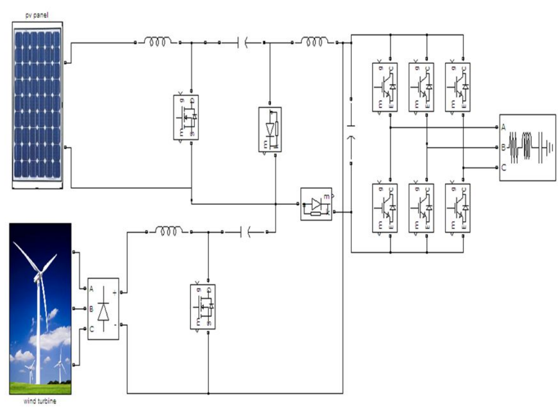

Figure 1: Block Diagram of Hybrid System

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

II. DC – DC CONVERTERS

DC-DC converters can be used as switching mode regulators to convert an unregulated dc voltage to a regulated dc output voltage. The regulation is normally achieved by PWM at a fixed frequency and the switching device is generally BJT, MOSFET or IGBT.

A. Cuk Converter

The Cuk converter is a type of DC-DC converter that has an output voltage magnitude that is either greater than or less than the input voltage magnitudeIt has the capability for both step up and step down operation. The output polarity of the converter is negative with respect to the common terminal. This converter always works in the continuous conduction mode. The Ćuk converter operates via capacitive energy transfer. When M1 is turned on, the diode D1 is reverse biased, the current in both L1 and L2 increases, and the power is delivered to the load. When M1 is turned off, D1 becomes forward biased and the capacitor C1 is recharged [10]. The voltage conversion ratio MCUK of the Cuk converter is given by:

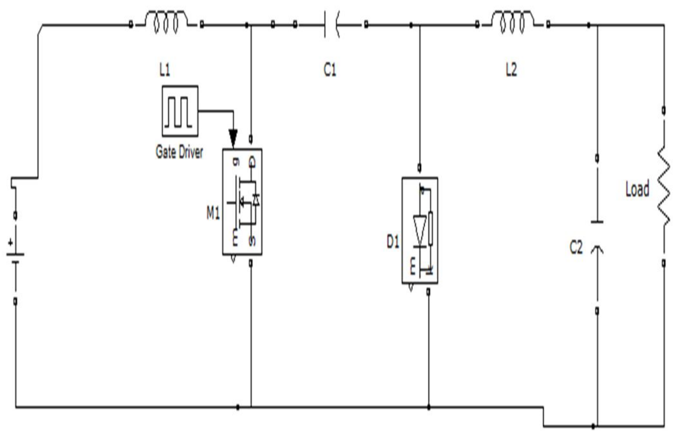

Figure 2.1 CUK converter

III. SEPIC CONVERTER

Single-ended primary-inductor converter (SEPIC) is a type of DC-DC converter allowing the voltage at its output to be greater than, less than, or equal to that at its input. It is similar to a buck boost converter. It has the capability for both step up and step down operation. The output polarity of the converter is positive with respect to the common terminal

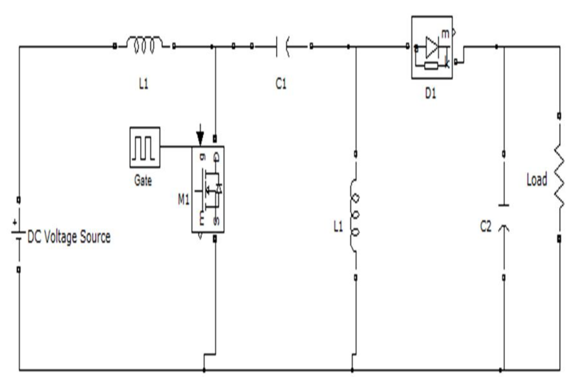

Figure 2.2 SEPIC converter

The capacitor C1 blocks any DC current path between the input and the output. The anode of the diode D1 is connected to a defined potential. When the switch M1 is turned on, the input voltage, Vin appears across the inductor L1 and the current IL1 increases. Energy is also stored in the inductor L2 as soon as the voltage across the capacitor C1 appears across L2. The diode D1 is reverse biased during this period. But when M1 turns off, D1 conducts. The energy stored in L1and L2 is delivered to the output, and C1 is recharged by L1 for the next period. The voltage conversion ratio MSEPIC of the SEPIC converter is given by

Volume 4 Issue III, March 2016
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IV. PROPOSED HYBRID SYSTEM

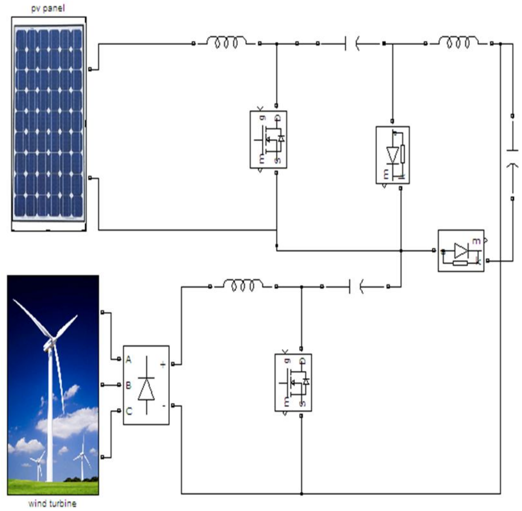

Figure 3. hybrid system

A system diagram of the proposed rectifier stage of a hybrid energy system is shown in Figure 3, where one of the inputs is connected to the output of the PV array and the other input connected to the output of a generator. The fusion of the two converters is achieved by reconfiguring the two existing diodes from each converter and the shared utilization of the Cuk output inductor by the SEPIC converter. This configuration allows each converter to operate normally individually in the event that one source is unavailable. Figure 3.1 illustrates the case when only the wind source is available. In this case, *D*1 turns off and *D*2 turns on; the proposed output voltage relationship is given by (1). On the other hand, if only the PV source is available, Figure 3.2 then *D*2 turns off and *D*1 will always be on and the circuit becomes a Cuk converter as shown The input to output voltage relationship is given by (2). In both cases, both converters have step-up/down capability, which provide more design flexibility in the system if duty ratio control is utilized to perform MPPT control.

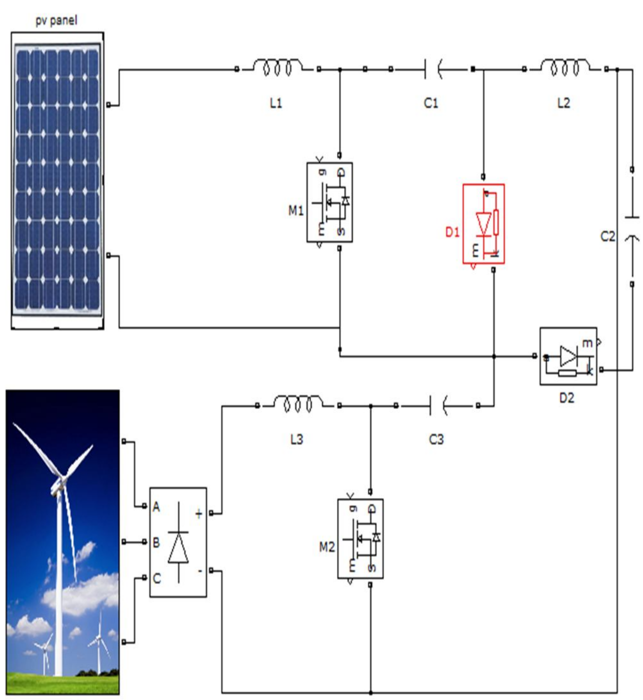

Figure 3.1 only wind source (SEPIC)

Volume 4 Issue III, March 2016
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

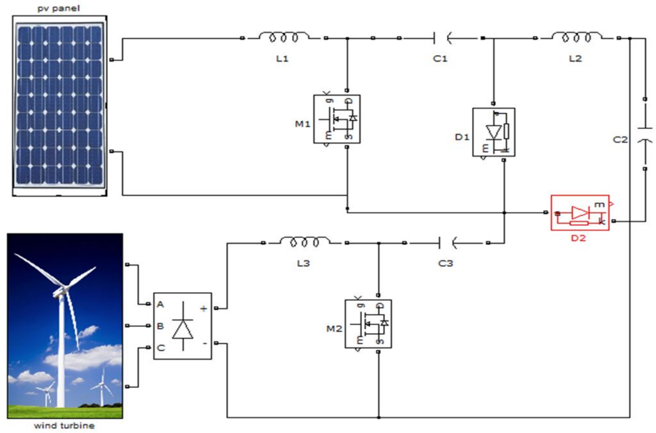

Figure 3.2 only solar (CUK)

$$\frac{V_{dc}}{V_w} = \frac{d_2}{1-d_2} \qquad (1)$$

$$\frac{V_{dc}}{V_{pv}} = \frac{d_1}{1-d_1} \qquad (2)$$

Solving the equations gives the output DC bus voltage Vdc as.

$$V_{dc} = \left(\frac{d_1}{1-d_1}\right)V_{pv} + \left(\frac{d_2}{1-d_2}\right)V_w$$

It is observed that Vdc is simply the sum of the two inputs of the Cuk and SEPIC converter. Vdc can be controlled by d1 and d2 individually or simultaneously.

V. MODELING OF PV PANEL

A photovoltaic cell is comprised of a P-N junction semiconductor material such as silicon that produces currents via the photovoltaic effect. When light energy strikes the solar cell, electrons are knocked loose from the atoms in the semiconductor material. If electrical conductors are attached to the positive and negative sides, forming an electrical circuit, the electrons can be captured in the form of an electric current. This electricity can then be used to power a load. Due to the low voltage generated in a PV cell (around 0.5V), several PV cells are connected in series (for high voltage) and in parallel (for high current) to form a PV module for desired output.

A. PV Cell Characteristics

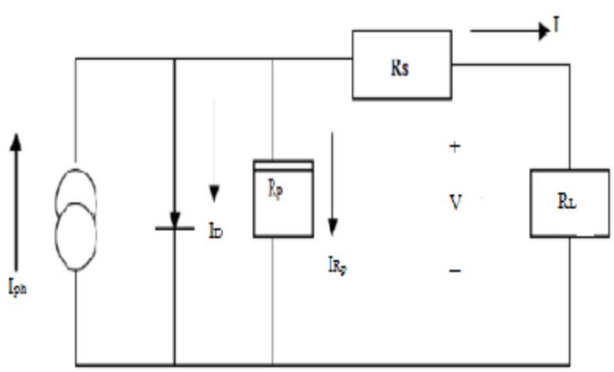

Figure 4.1 PV Cell Equivalent Circuits

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A PV cell can be represented by a current source connected in parallel with a diode, since it generates current when it is illuminated and acts as a diode when it is not. The equivalent circuit model also includes a shunt and series internal resistance. Rs is the intrinsic series resistance. Whose value is very small. Rp is the equivalent shunt resistance which has a very high value.
The current – voltage characteristic equation of a PV cell is given by.

$$I = n_p I_{ph} - n_p I_{rs} \left(\exp\left(\frac{qv}{KTAn}\right) - 1 \right) I$$

VI. MODELING OF WIND TURBINE

The wind turbine is the first and foremost element of wind power systems. Wind turbines capture the power from the wind by means of aerodynamically designed blades and convert it to rotating mechanical power . The number of blades is normally three. This mechanical power is delivered to the rotor of an electric generator where this energy is converted to electrical energy.Electric generator used may be an induction generator or synchronous generator.
The mechanical power that is generated by the wind is given by:

$$p_w = \frac{\rho}{2} c_p.(\lambda, \theta) A_r V_w^3$$

Where
ρ - air density
A - rotor swept area
$Cp (\lambda, \beta)$ - power coefficient function,
λ - tip speed ratio
β - pitch angle
v w -wind speed.
The wind turbine model is connected to a squirrel cage asynchronous generator. The mechanical energy obtained from the wind turbine is fed to the generator, which convert it to the electrical energy.

VII. SIMULATION MODELS

PV array, Wind turbine, and the proposed hybrid system ismodelled using MATLAB/ SIMULINK software.

A. Simulink Model Of PV Array

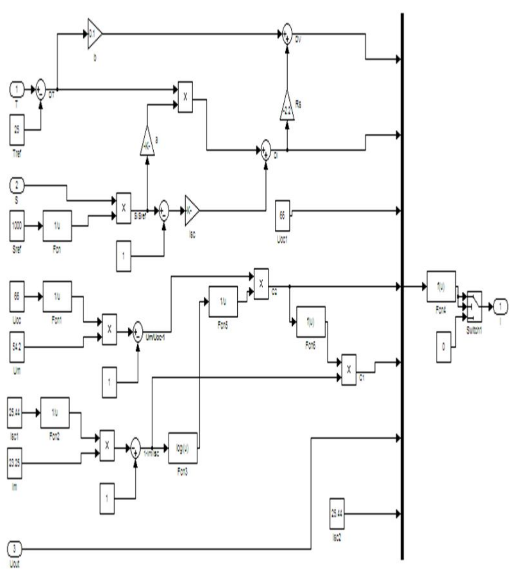

Figure 6.1 Simulink model of PV array

Volume 4 Issue III, March 2016
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

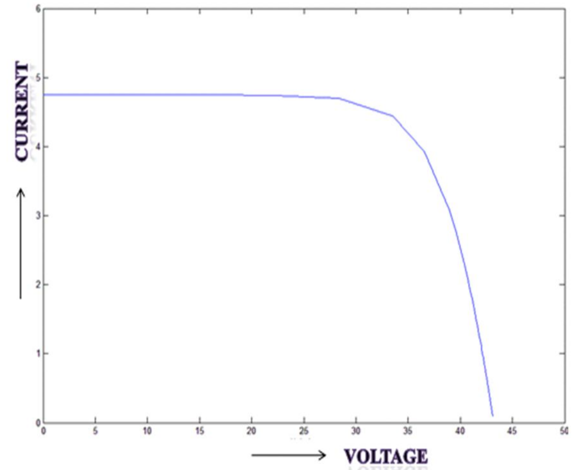

Figure 6.1a I-V curve characteristics

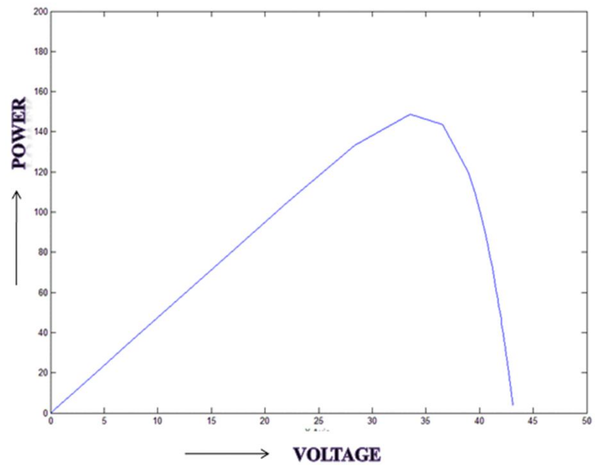

Figure 6.1b PV curve characteristics

B. Simulink Model of Wind Turbine

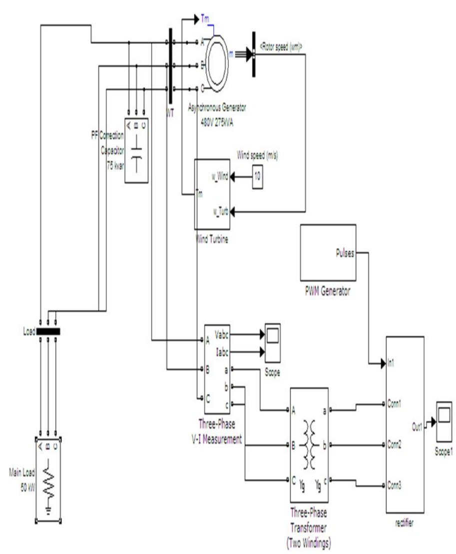

Figure 6.2 Simulink model of wind turbine

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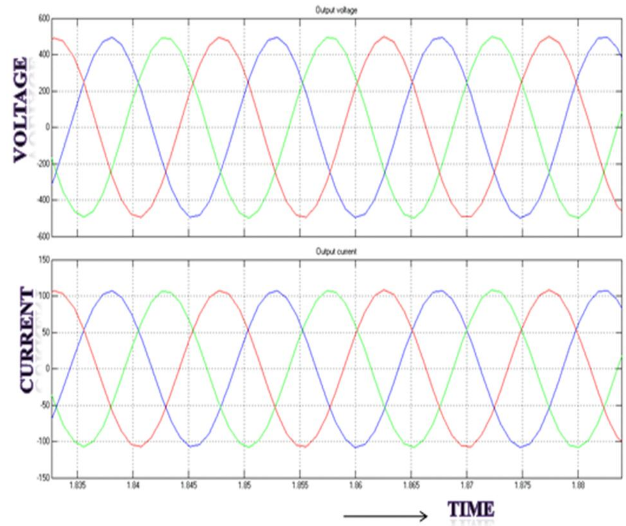

Figure 6.2a output waveform of wind turbine

C. Simulink Model of Proposed Hybrid System

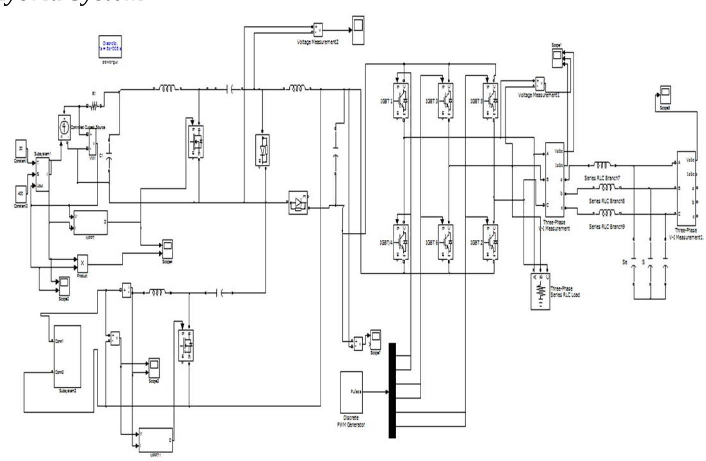

Figure 6.3.Simulink Model of Proposed Hybrid Converter

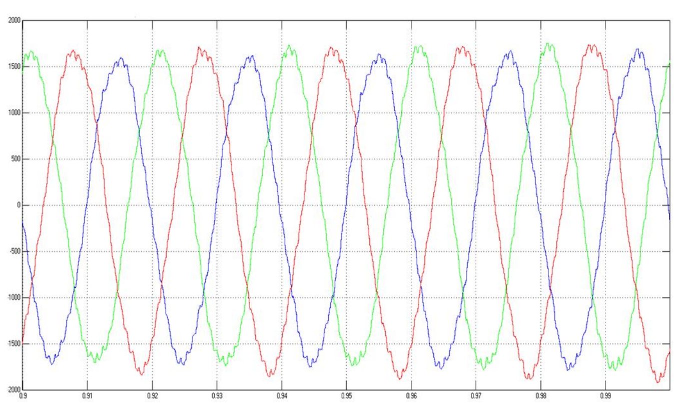

Figure 6.3a output waveform.

VIII. CONCLUSION

Renewable energy sources also called non-conventional type of energy are continuously replenished by natural processes. Hybrid systems are the right solution for a clean energy production. Hybridizing solar and wind power sources provide a realistic form of power generation. Here, a hybrid wind and solar energy system with a converter topology is proposed which makes use of Cuk and SEPIC converters in the design. This converter design overcomes the drawbacks of the earlier proposed converters. This topology allows the two sources to supply the load separately or simultaneously depending on the availability of the energy sources. The output voltage obtained from the hybrid system is the sum of the inputs of the Cuk and SEPIC converters. This system has lower operating cost and finds applications in remote area power generation, constant speed and variable speed energy conversion systems and rural electrification. MATLAB/ SIMULINK software is used to model the PV panel, wind turbine, DC-DC converters and the proposed hybrid system.

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BIOGRAPHY

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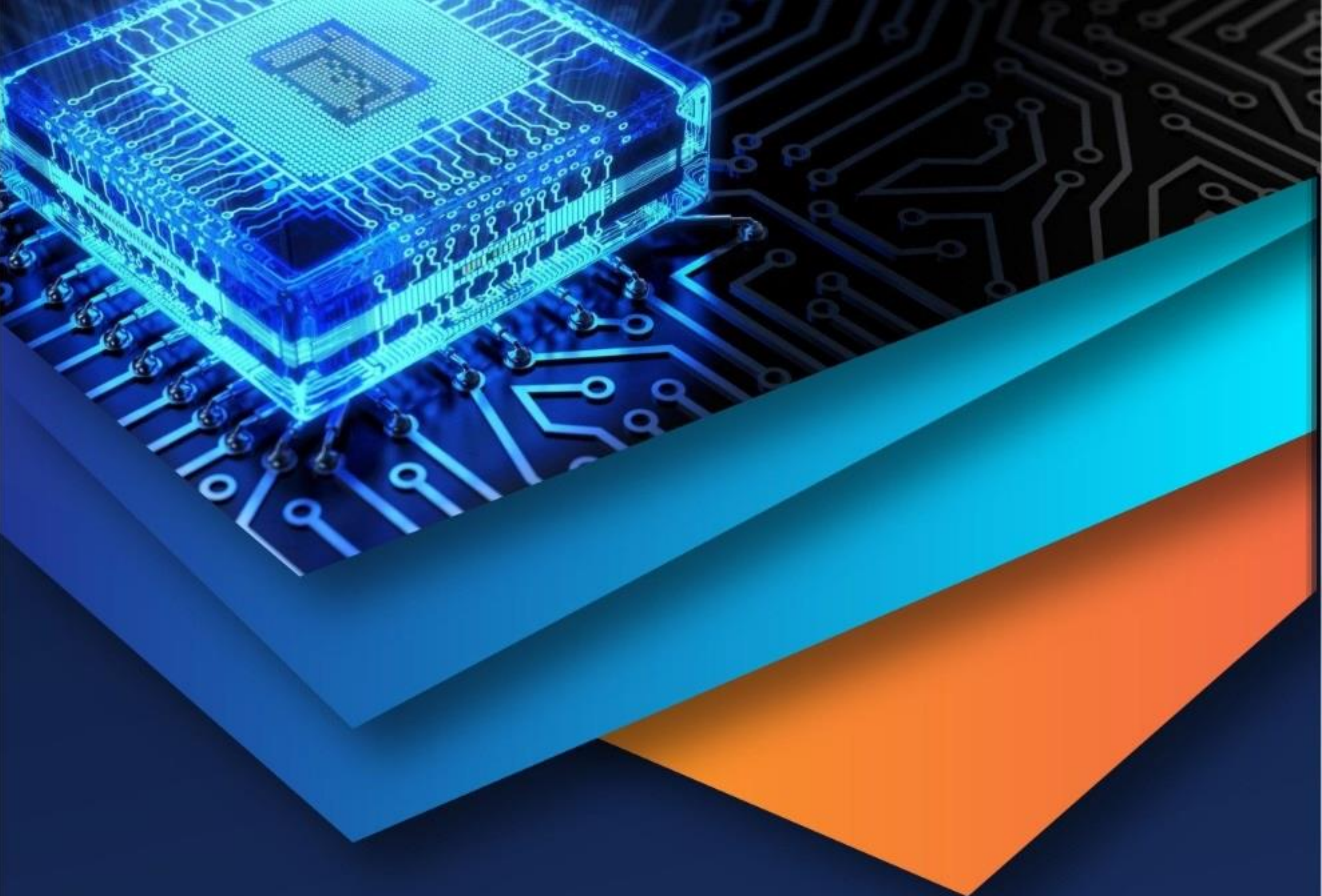

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