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A Hybrid Active Power Filters for Reactive Power Compensation Using Hybrid Renewable Energy

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Abstract: In this paper a new reference generation technique to in Hybrid Renewable Energy (solar photovoltaic (PV), Wind energy and Fuel cell) power to the grid is proposed. The power electronics converters are widely use to mitigate the current harmonics, reactive power compensation, improve the load power factor and to regulate the load voltage. This converter requires a dc link voltage support that can be provided by any of the renewable source of energy like solar, wind etc. which act as a voltage source and also inject the active power generated by the source. It is shown in this paper that the Hybrid active power filter is used to compensate the reactive power, reduce harmonics in the source current and also injects the active power from the Hybrid Renewable energy source into the grid. The varying nature of power due to change in solar radiation and temperature of injected power, wind speed variations can be accounted for with the online computation of the reference power available. The simulation studies are carried out for single-phase application using power system simulator MATLAB. Thus we get the better power factor and good voltage or power stability when the non-linear loads are applied to the system. Major thing in this paper is to compensating the Reactive power in the transmission lines for 24 hrs by using a Hybrid Renewable Energy sources in the case of emergency we can also use a Fuel cell.

Keywords: Hybrid renewable energy, Photovoltaic cell, Fuel well, Wind Energy, Transmission line, reactive power compensation, power factor

1. INTRODUCTION

Electrical power plays a vital role in our day today life, power is the most wanted source for each and every devices. We are using more number of power electronic devices and non-linear loads, which degrades the quality of power. In order to maintain the quality of power in standard level, we need compensating devices.

FACTS devices are mainly used for reactive power compensation. FACTS a device not only compensate the reactive power and also reduces negative impacts of the load by improve the stability of the power system. Flexible AC transmission system (FACTS) controllers either extend the power transfer capability of existing transmission corridors or

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enhance the stability and security margins for given power-transmission limits, and also for compensating a compensating

device needs some external power source by which we can vary the Reactive power by absorbing or generating it. So it is necessary to have an external source in each transmission lines so it need of power source for compensating. So in this project, we are giving a supply to Hybrid Active Power Filters from the Hybrid Renewable Energy (Solar energy, Wind energy and Fuel cell energy etc.) by which can compensate the Reactive power in the transmission lines. In this project we are improving the power factor and reducing the current ripple when the non-linear loads are operating. The losses in transmission and distribution system degrade the quality of power. By compensating these losses we can able to deliver good quality of power to the system.

Hybrid Active Power Filters are connected to a power system is capable for reactive power compensation, increase transient stability, voltage control, stability improvement, power quality improvement, power conditioning, fault clearance, flicker mitigation etc. Interconnection of renewable and distributed generation and storages. The main aim of this project is to design the Hybrid Active Power filters for compensating reactive power, and improve the power factor while operating of Non-linear loads. Whenever the Non-linear load is applied to the system then the current and power of source supply is varied according to the non-linear characteristics. The Hybrid active power filters model can be constructed by the compensating technique which includes PI controller, buck-boost converter and PWM Inverter with coupling transformer. The existing system which does not uses the any optimizing technique and renewable energy for the compensating devices for reactive power compensation.

2. RELATED WORK

In [1] the current source converter based STATCOM model and control is discussed in this paper. STATCOM is conventionally realized by a voltage-source converter; however, being a current injection device, its performance can be improved when realized by a current-source- converter (CSC) that can generate a controllable current directly at its output terminals. In this paper, a STATCOM based on the current-source converter topology is proposed. The nonlinear model of the current-source converter, which is the source of the difficulties in the controller design, has been modified to a linear model through a novel modeling technique. The proposed modeling technique is not based on the linearization of a set of nonlinear equations around an operating point. Instead, the power balance equation and a nonlinear input transformation are used to derive a linear model independent of the operating point. This model acts as the basis for the design of a decoupled state-feedback controller.

In [2] described about the STATCOM with a self-oscillating bidirectional dc–dc converter for interfacing battery energy storage in a stand-alone induction generator system. The self-oscillation mode is based on relay feedback control with hysteresis. To reduce the output current ripple, an LC filter is connected between the half bridge of this DC–DC converter and the energy storage system.

The other side of bidirectional converter is coupled with a voltage-source converter. The proposed control allows that the previous electronic converters, with an additional resistive dump load, compensate all disturbances in a self-excited induction generator due to three-phase four-wire loads and an improvement of system efficiency.

In [3] described the uncontrollable resource and the nature of distributed wind induction generators, integrating a large-scale wind-farm into a power system poses challenges, particularly in a weak power system. In the paper, the impact of static synchronous compensator (STATCOM) to facilitate the integration of a large wind farm (WF) into a weak power system is studied. First, an actual weak power system with two nearby large WFs is introduced. Based on the field SCADA data analysis, the power quality issues are highlighted and a centralized STATCOM is proposed to solve them, particularly the short-term (seconds to minutes) voltage fluctuations. Second, a model of the system, WF, and STATCOM for steady state and

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dynamic impact study is presented, and the model is validated by comparing with the actual field data.

In [4] described the injection of the wind power into an electric grid affects the power quality. The performance of the wind turbine and thereby power quality are determined on the basis of measurements and the norms followed according to the guideline specified in International Electro-technical Commission standard, IEC-61400. The influence of the wind turbine in the grid system concerning the power quality measurements are-the active power, reactive power, variation of voltage, flicker, harmonics, and electrical behavior of switching operation and these are measured according to national/international guidelines. The paper study demonstrates the power quality problem due to installation of wind turbine with the grid. In this proposed scheme STATIC Compensator (STATCOM) is connected at a point of common coupling with a battery energy storage system (BESS) to mitigate the power quality issues.

3. PROPOSED ALGORITHM

The proposed method shows the advancements or modifications made on the existing system. The block diagram and the components will be explained in this chapter along with the working principle and operation of the Hybrid Active Power filters using Hybrid Renewable Energy. The block diagram of the proposed system shows the connection of various components and consists of the AC source which is obtained by the synchronous generator, voltage measurement blocks, the Hybrid Active Power Filters are used for reactive power compensation and the Non-linear load.

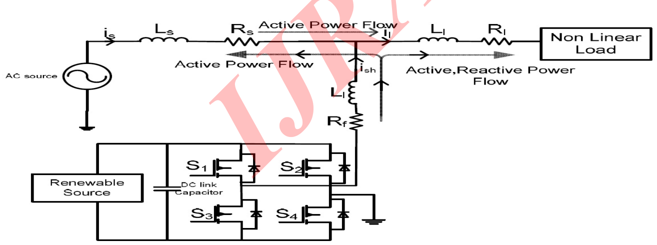

Fig. 1 Single phase Shunt converter integrated with Hybrid Renewable Energy Source

4. REACTIVE POWER

Reactive power flow in an alternating-current transmission system is to support the transfer of real power over the network. In alternating current circuits, energy is stored temporarily in inductive and capacitive elements, which can result in the periodic reversal of the direction of energy flow. The portion of power flow remaining, after being averaged over a complete AC waveform, is the real power; that is, energy that can be used to do work. On the other hand, the portion of power flow that is temporarily stored in the form of magnetic or electric fields, due to inductive and capacitive network elements, and then returned to source, is known as reactive power. AC connected devices that store energy in the form of a magnetic field include devices called inductors, which consist of a large coil of wire. When a voltage is initially placed across the coil, a magnetic field builds up, and it takes a period of time for the current to reach full value. This causes the current to lag behind the voltage in phase; hence, these devices are said to absorb reactive power.

A capacitor is an AC device that stores energy in the form of an electric field. When current is driven through the capacitor, it takes a period of time for a charge to build up to produce the full voltage difference. On an AC network, the voltage across a capacitor is constantly changing – the capacitor will oppose this change, causing the voltage to lag behind the current. In other words, the current leads the voltage in phase; hence, these devices are said to generate reactive power. Energy stored in capacitive or inductive elements of the network give rise to reactive power flow. Reactive power flow strongly influences the voltage levels across the network.

Voltage levels and reactive power flow must be carefully controlled to allow a power system to be operated within acceptable limits.

In an inductive circuit, we know the instantaneous active power to be:

$$P = V_{max} I_{max} \cos\omega t \cos(\omega t - \theta) \quad \text{---------- (1)}$$

The Instantaneous Reactive power is given by:

$$Q = \frac{V_{max} I_{max}}{2} \sin\theta \sin 2\omega t \quad \text{----------- (2)}$$

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P = Instantaneous active power
Q = Instantaneous reactive power
Vmax = Peak value of voltage
Imax = Peak value of current
ω = Angular Velocity
t = Time period
θ = Angle by which the current lags voltage in phase

The reactive power should be balanced in the system to maintain the voltage profile constant. This is reactive power compensation and it is done by the FACTS devices.

4.1 Need for reactive power compensation.

The main reason for reactive power compensation in a system is:

1) The voltage regulation;

2) Increased system stability;

3) Better utilization of machines connected to the system;

4) Reducing losses associated with the system; and

5) To prevent voltage collapse as well as voltage sag.

The impedance of transmission lines and the need for lagging VAR by most machines in a generating system results in the consumption of reactive power, thus affecting the stability limits of the system as well as transmission lines. Unnecessary voltage drops lead to increased losses which needs to be supplied by the source and in turn leading to outages in the line due to increased stress on the system to carry this imaginary power. Thus we can infer that the compensation of reactive power not only mitigates all these effects but also helps in better transient response to faults and disturbances. In recent times there has been an increased focus on the techniques used for the compensation and with better devices included in the technology, the compensation is made more effective. It is very much required that the lines be relieved of the obligation to carry the reactive power, which is better provided near the generators or the loads. Shunt compensation can be installed near the load, in a distribution substation or transmission substation.

4.2 Reactive power compensation

In a linear circuit, the reactive power is defined as the ac component of the instantaneous power, with a frequency equal to 100 / 120 Hz in a 50 or 60 Hz system. The reactive power generated by the ac power source is stored in a capacitor or a reactor during a quarter of a cycle, and in the next quarter cycle is sent back to the power source. In other words, the reactive power oscillates between the ac source and the capacitor or reactor, and also between them, at a frequency equals to two times the rated value (50 or 60 Hz). For this reason it can be compensated using VAR generators, avoiding its circulation between the load (inductive or capacitive) and the source, and therefore improving voltage stability of the power system. Reactive power compensation can be implemented with VAR generators connected in parallel or in series.

4.3 Reactive Power Compensation by Hybrid Active Power filters

Hybrid Active Power Filter is one of the compensating device which is a connected by means of shunt connection. It is the better compensation device available because it makes compensation with the possibility of power exchange absorption and injection and the four quadrant operation.

HYBRID POWER FILTERS FOR HARMONIC COMPENSATION

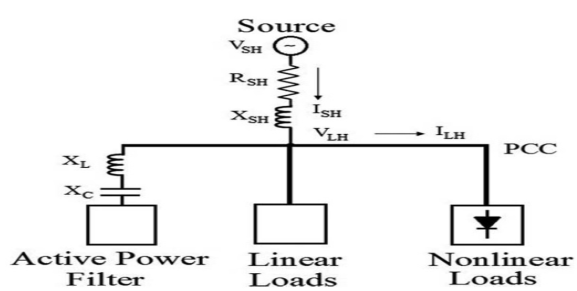

Fig. 2 Basic System Configuration of Hybrid Compensation

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Fig. 2 shows the system configuration of the hybrid compensation required for harmonic suppression and reactive power compensation for an industrial power system. The hybrid active power filter is based on a three-phase voltage-source power converter, using insulated gate bipolar transistor (IGBT) switches connected in parallel with the utility grid, and a set of tuned filters or simply a single tuned filter according to the system requirements [17]. The tuned filter is used to decrease the capacity of the power converter, which enables the active power filter to be used in a high-power situation [18]. The voltage-source converter is usually used rather than the current-source converter because it has higher efficiency, lower cost, and is smaller in size than the current converter. Moreover, [8] clarifies that the IGBT module is more suitable for the voltage-source converter because a freewheeling diode is connected in anti-parallel with each IGBT. This means that the IGBT does not need to provide the capability of reverse blocking in itself, thus bringing more flexibility to the device design with a compromise among conducting and switching losses and short-circuit capability than with reverse-blocking IGBT.

5. SIMULATION RESULT

Simulink is developed by MathWorks and is a commercial tool for modelling, simulating and analysing multi domain dynamic systems. It offers tight integration with the rest of the MATLAB environment and can either drive MATLAB or be scripted from it. Simulink is widely used in control theory and digital signal processing for multi domain simulation and Model-Based Design.

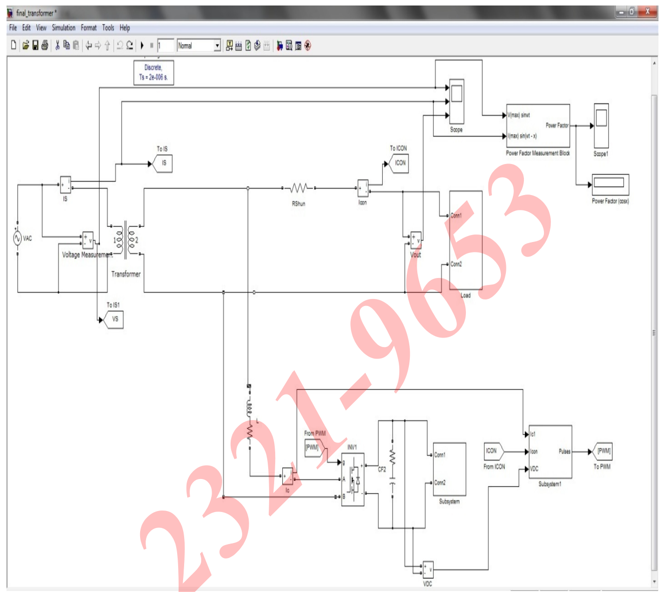

Fig.3 Overall Implementation

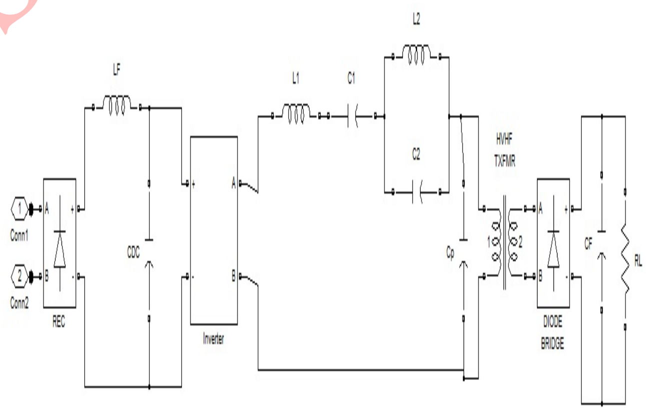

Figure 4. Matlab Implementation of Non-linear load

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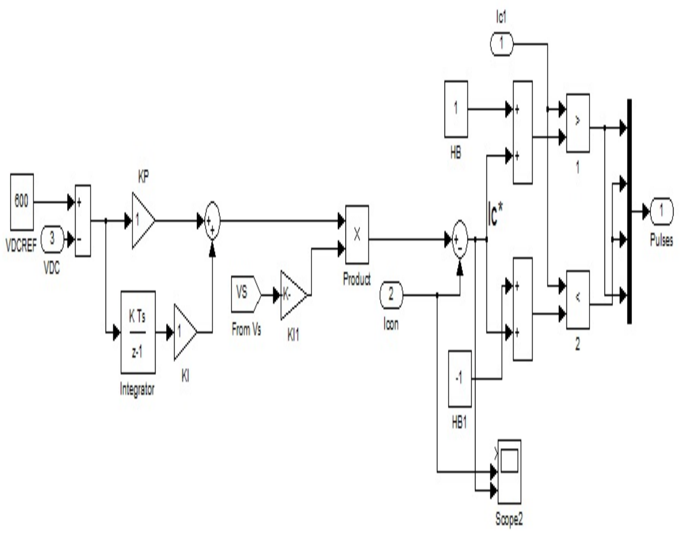

Figure 5 MATLAB implementation for a gate drive pulse controller

Fig.7 Load p.f. without HAPF

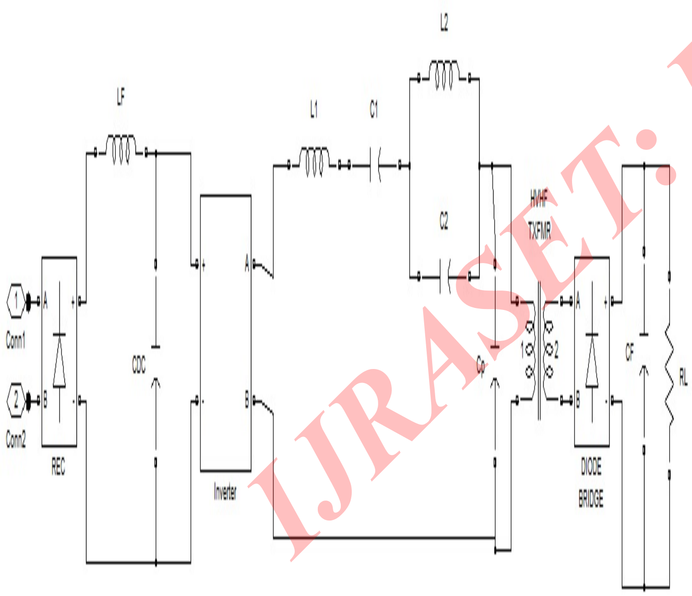

Fig 6. Matlab implementation of Excitation system

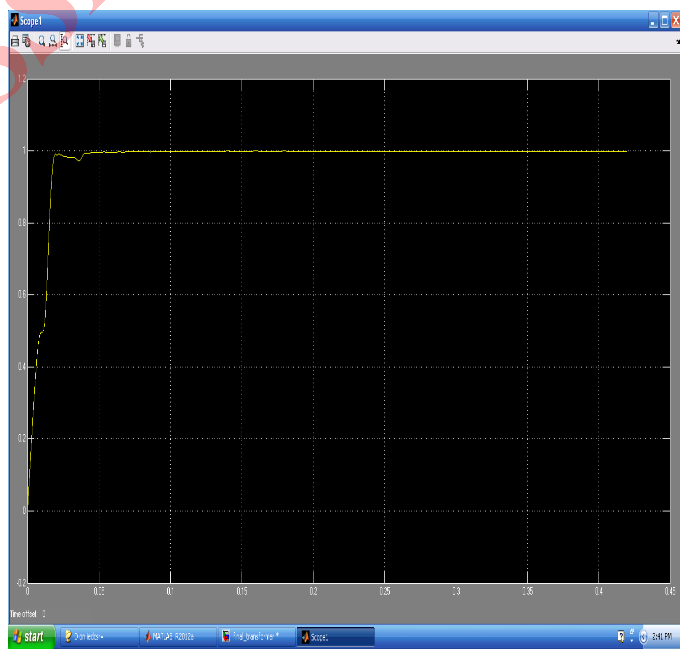

Fig. 8 Load p.f. with HAPF

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6. CONCLUSION

A novel concept of compensation using Hybrid Active power filters using Hybrid Renewable Energy has been proposed and validated through MATLAB/Simulink simulations. A power flow model of HAPF is constructed along with its controllers, can be used for reactive power compensation in transmission lines, stability of power system under various load conditions.

The bus system shows improved plots and thus we can conclude that the addition of a hybrid renewable energy to the hybrid active power filters for improving the power factor and reducing the current ripple factor.

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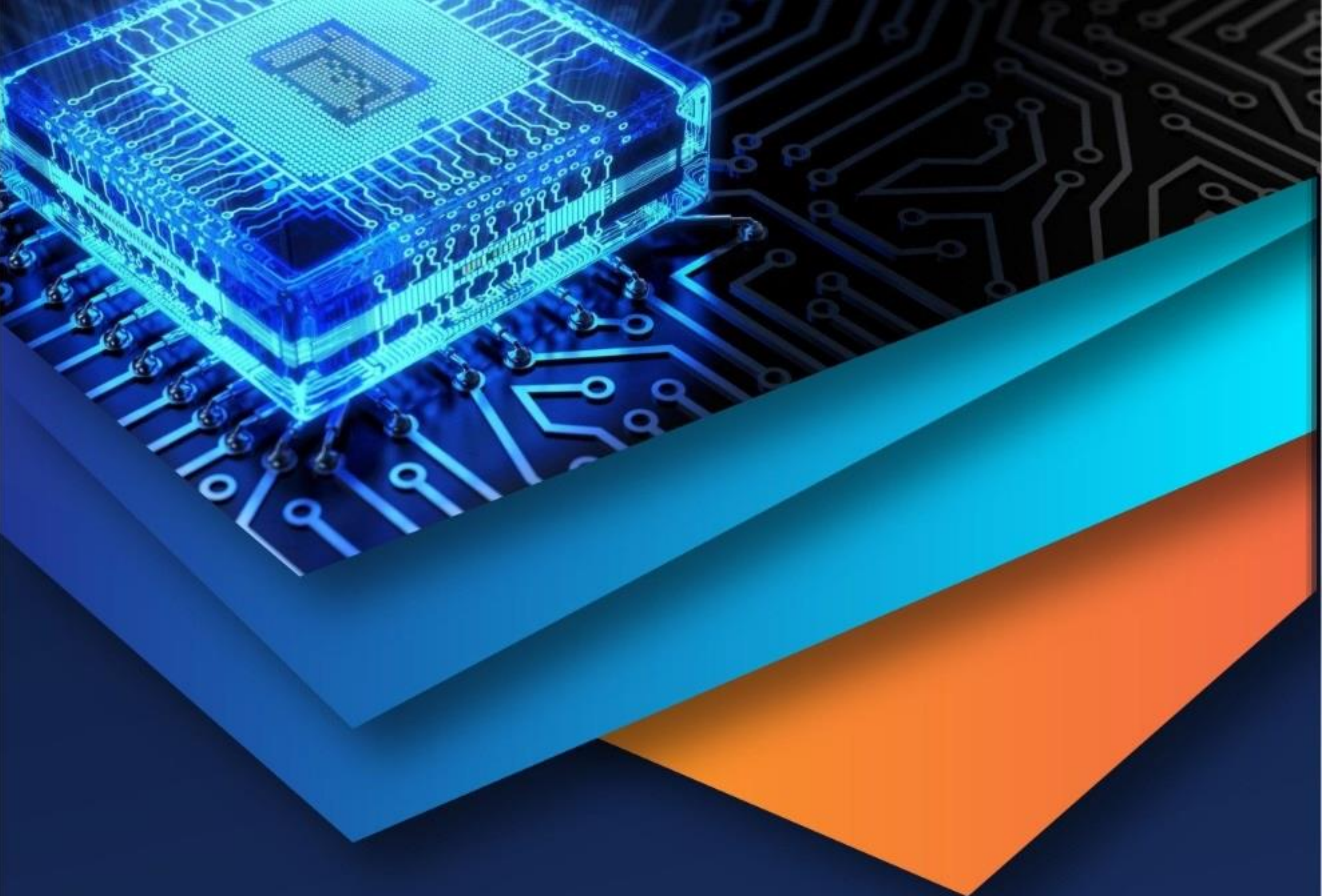

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