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Simulation and Investigation of Total Harmonic Distortion of Unified Power-Quality Conditioner for Power-Quality Improvement

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Abstract: This paper proposes a novel reference signal generation method for the unified power quality conditioner (UPQC) Adopted to compensate current and voltage-quality problems of sensitive loads. It consists of a shunt and series converter having a common dc link. The shunt converter eliminates current harmonics originating from the nonlinear load side and the series Converter mitigates voltage sag/swell originating from the supply Side. The Total Harmonic Distortion was focused in load side and. The proposed UPQC achieves superior capability of mitigating the effects of voltage sag/swell and suppressing the load current harmonics under distorted supply conditions. The MATLAB Simulink model was developed and analyzed.
Index terms: Shunt Converter, Series Converter, Unified Power Quality Conditioner (UPQC), Total Harmonics Distortions (THD), Non –Linear Loads

I. INTRODUCTION

Power quality has become an issue of mounting concern in the electric power industry. Power quality problems encompass a wide range of deviations in supply voltage and frequency that result in failure or disoperation of equipment [1].

With increasing applications of nonlinear and electronically switched devices in distribution systems and industries, power quality problems such as harmonics, flicker and imbalance have become serious concerns.

Lightning strikes on transmission lines, switching of capacitor banks and various network faults can also power quality problems such as transients, voltage sag, voltage swell and interruption.

To overcome and to mitigate this power quality problems voltage source converter, series converter and shunt converter are used. One modern and promising solution is the use of Unified Power Quality Conditioner [2].

This paper main objective is to compensate current and voltage-quality problems of sensitive loads using Unified Power Quality Conditioner and to mitigate voltage swell and voltage sag originating from supply side by using voltage source converter. . This is resulting in increasing harmonic levels on the power system.

Moreover, the presence of non-linear loads in the power system causes disturbances in the voltage waveform. Any power problem manifested in voltage, current or frequency deviations that results in failure or disoperation of customer equipment is termed as a power quality problem [3].

However, it is actually the quality of voltage that is addressed generally. The power supply system has control only over the quality of the voltage; it has no control over the currents that particular loads might draw. Therefore power quality generally refers to maintaining the supply voltage within certain limits.

AC power systems are designed to operate at a sinusoidal voltage of a given frequency and magnitude[4]. Any significant deviation in the waveform magnitude, frequency or purity is a potential power quality problem. The common power quality problems include a) Harmonics b) Flicker c) Voltage swell d) Voltage sags e) Interruptions f) Transients and Voltage imbalance. In the paper mainly focused in THD and reduced in Non liner load side.

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II. BLOCK DIAGRAM OF UPQC

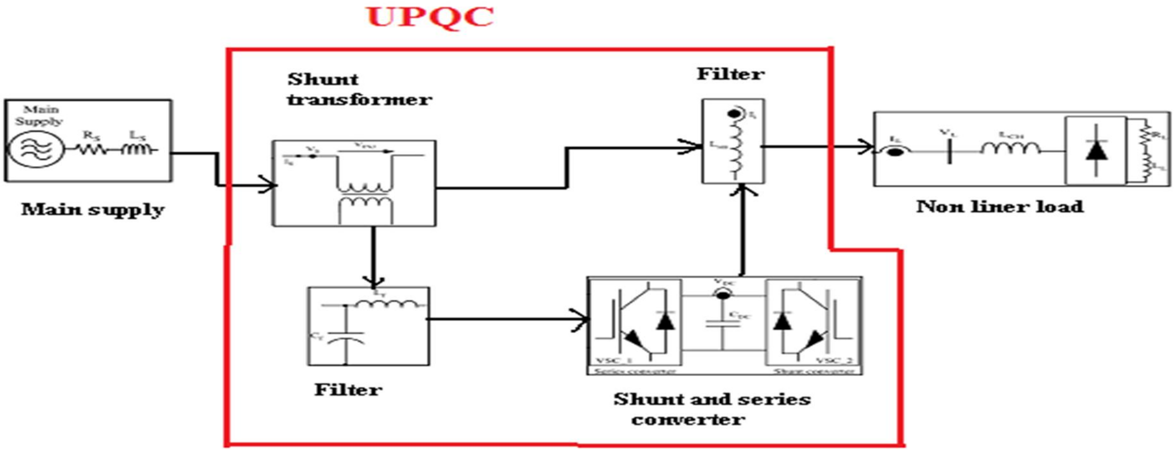

Figure No: 01 Block Diagram of UPQC

These two converters are connected back to back through a common energy storage dc capacitor. Series converter (Vsc_1) is connected through transformers between the supply and point of common coupling (PCC). Shunt converter (Vsc_2) is connected in parallel with point of common coupling through the transformers. Voltage source converter (Vsc_1) operates as voltage source while voltage source converter (Vsc_2) operates as current source [5].

The power circuit of (Vsc_1) consists of three single phase H-bridge voltage source PWM inverters. H-bridge inverters are controlled independently. The main objective of (Vsc_1) is to mitigate voltage sag and voltage swell originating from supply side. The ac filter inductor and capacitor are connected in each phase to prevent the flow of harmonic currents generated due to switching. The transformers connected at the output of each H-bridge inverter provide isolation modify voltage and current levels and prevent the dc capacitor from being shorted due to the operation of various switches [6].

The power circuit of Voltage Source Converter 2 consists of a three phase voltage source PWM inverter is supplied from dc capacitor. (Vsc_2) is directly connected through a boost inductor which can boost up the common dc link voltage to the desired value [7-9]. The objectives of are to regulate the dc link voltage between both converters and to suppress the load current harmonics. The switching devices in (Vsc_1) and (Vsc_2) are Insulated Gate Bipolar Transistors (IGBTs) with antiparallel diodes DC capacitor provides the common dc link voltage to (Vsc_1) and (Vsc_2).

Ideally once charged the dc link voltage should not fall of its charge ,but due to finite switching losses of the inverters-inductor and capacitor some power is consumed and the charge of the dc link voltage needs to be maintained in a closed loop control, through the (Vsc_2). A three phase uncontrolled diode-bridge rectifier with resistive and inductive load is used to produce inductive current. The ac reactor is placed before the rectifier to enhance the load impedance.

III. OPERATION MODES OF UPQC

The shunt and series compensations (Vsc_1) off and (Vsc_2) on: when the peak voltage (Pc) is within its operation limits, (Vsc_1) is closed and (Vsc_2) works as the current source. During this operation of UPQC, two lower IGBTs of each phase H-bridge inverter of (Vsc_2) remain turned on while the two upper IGBTs turned off ,forming a short circuit across the secondary(inverter side) winding of the series transformer through filter inductor(L_f) .Thus, there is no need to use bypass switches the across across transformers. (Vsc_2) suppresses the load current harmonics and regulates dc-link voltage during this mode of operation.

(Vsc_1) on and (Vsc_2) on: When the PCC voltage is outside its operating range; both (Vsc_1) and (Vsc_2) are open. (Vsc_2) starts to mitigate sag/swell using the energy stored in V_{dc} and (Vsc_2) continue to suppress the load current harmonics and to regulate dc-link voltage.

IV. SIMULATION DIAGRAM

A UPFC consists of an advanced shunt and series compensator with a common dc link .power control is achieved by adding the series voltage V_{in} to Vs. Thus giving the line voltage V_L with two converter UPFC can supply be supplied through shunt converter. In a more general UPFC with bidirectional power flow .it would be necessary to have two shunt converters one at the sending end and one at the receiving end. In paper to maintain the power quality and stability of the system. UPFC system used for PI controller in both converter and to control the Total harmonics Distortion.

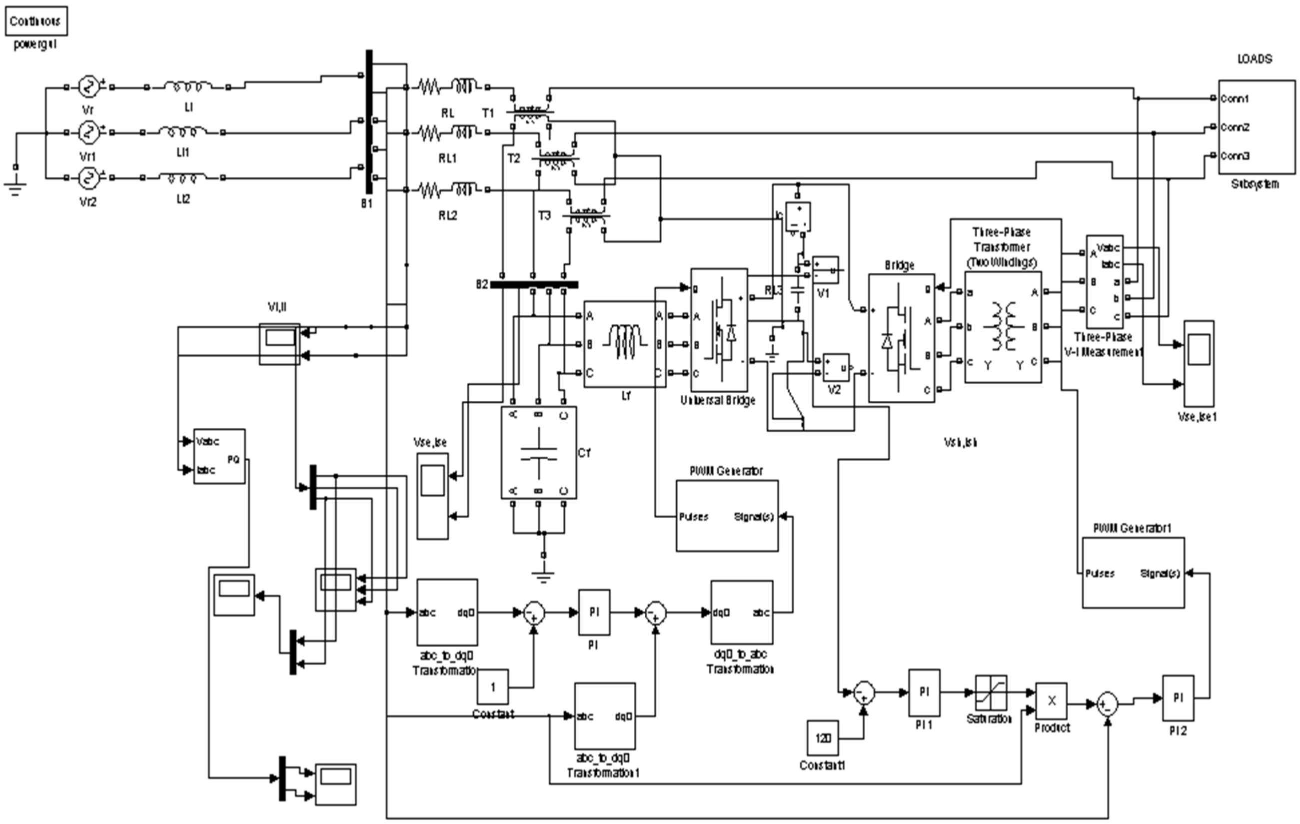

Figure No : 02 Simulation diagram of UPQC

Power systems are designed to operate at frequencies of 50 or 60Hz. However, certain types of loads produce currents and voltages with frequencies that are integer multiples of the 50 or 60 Hz fundamental frequency. These higher frequencies are a form of electrical pollution known as power system harmonics. These loads use diodes, silicon-controlled rectifiers (SCRs), power transistors, and other electronic switches to chop waveforms to control power or to convert 50/60Hz AC to DC. Due to tremendous advantages in efficiency and controllability, power electronic loads are proliferating and can be found at all power levels – from low voltage appliances to high voltage converters. Hence, power systems harmonics are once again an important problem.

Power electronic loads control the flow of power by drawing currents only during certain intervals of the 50/60Hz period. Thus, the current drawn by the load is no longer sinusoidal and appears chopped or flattened. The non-sinusoidal current can interact with system impedance to give rise to voltage distortion and, in some cases, resonance. In a 'stiff' power system, where the available fault current is high (thus the system impedance is low), the voltage distortion is usually small and does not present a power quality problem.

However, in a weak system, where the system impedance is high, voltage distortion can be high and may cause problems. Unlike transient events such as lightning that last for a few microseconds, or voltage sags that last from a few milliseconds to several cycles, harmonics are steady-state periodic phenomena that produce continuous distortion of voltage and current waveforms. These periodic non sinusoidal waveforms are described in terms of their harmonics, whose magnitudes and phase angles are computed using Fourier analysis. The analysis permits a periodic distorted waveform to be decomposed into an infinite series containing dc, fundamental frequency (e.g. 60Hz), second harmonic (e.g. 120Hz), third harmonic (e.g. 180Hz), and so on. The individual harmonics add up to reproduce the original waveform. The highest harmonic of interest in power systems is usually the 25th multiple, which is in the low audible range. Positive and negative half cycles of power systems voltages and currents tend to have identical wave shapes so that their Fourier series contain only odd harmonics. A DC term is usually not present. The most common measure of distortion is total harmonic distortion, THD. THD applies to both current and voltage and is defined as the rms value of

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harmonics divided by the rms value of the fundamental, and then multiplied by 100%. THD of current varies from a few percent to more than 100%. THD of voltage is usually less than 5%. Voltage THDs below 5% are widely considered to be acceptable, but values above 10% are definitely unacceptable and will cause problems for sensitive equipment and loads. It is not generally known that power factor is closely linked to harmonics. The traditional displacement power factor is the cosine of the relative phase angle between fundamental voltage and current. However, true power factor is average power divided by the product of rms voltage and rms current. Harmonics increase rms voltage and, especially, rms current. Table 1 shows the theoretical maximum true power factor of a distorting load as a function of current THD. The table assumes the optimum case, i.e., the displacement power factor is 1.0

S.no	Current THD	Maximum True Power factor
1.	0.19%	0.98
2.	50%	0.89
3.	100%	0.71

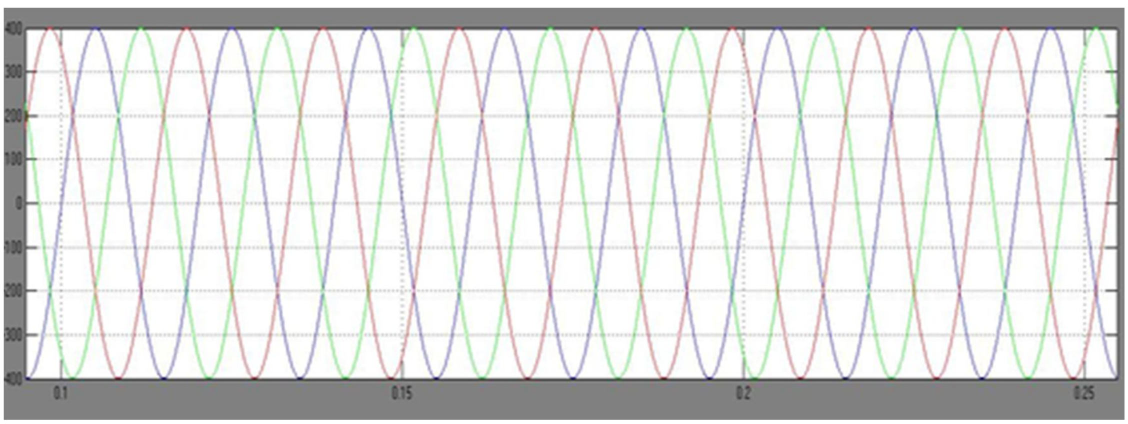

Figure No: 04 UPQC Output voltage

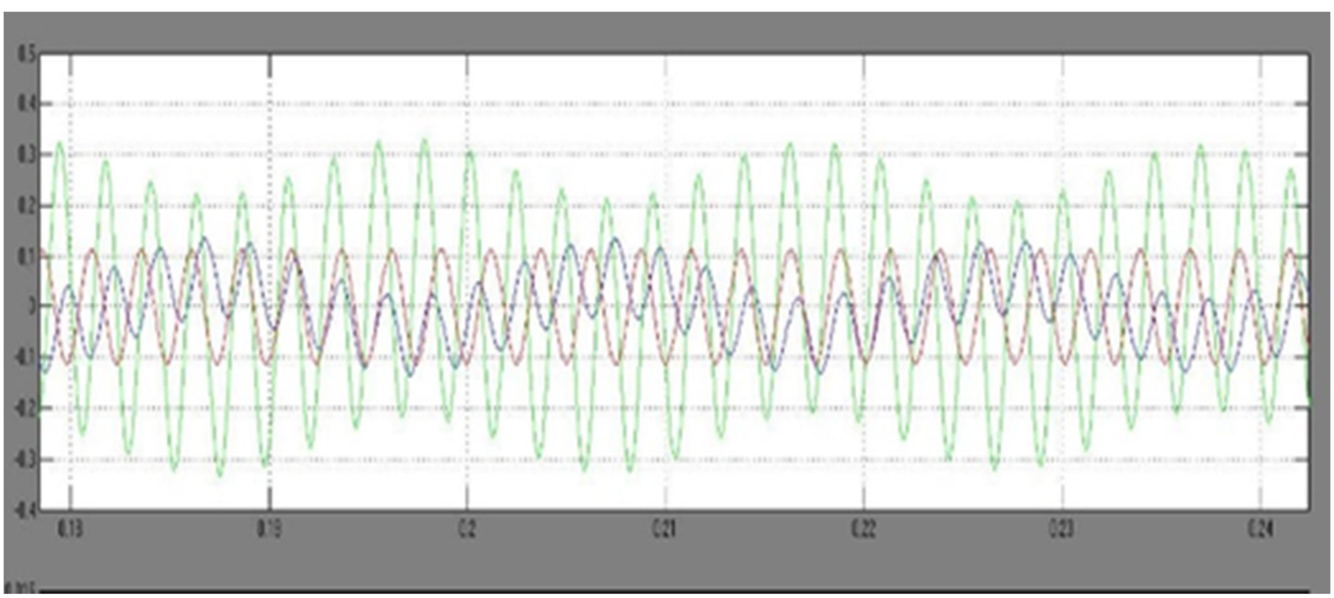

Figure No: 04 UPQC Output voltage before compensation of distribution voltage

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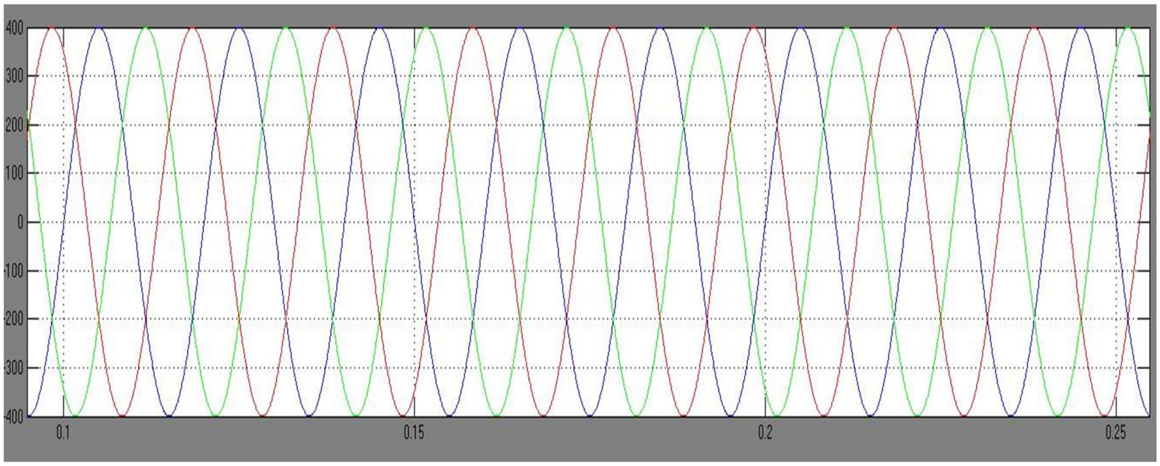

Figure No: 04 UPQC Output voltage after compensation of distribution voltage

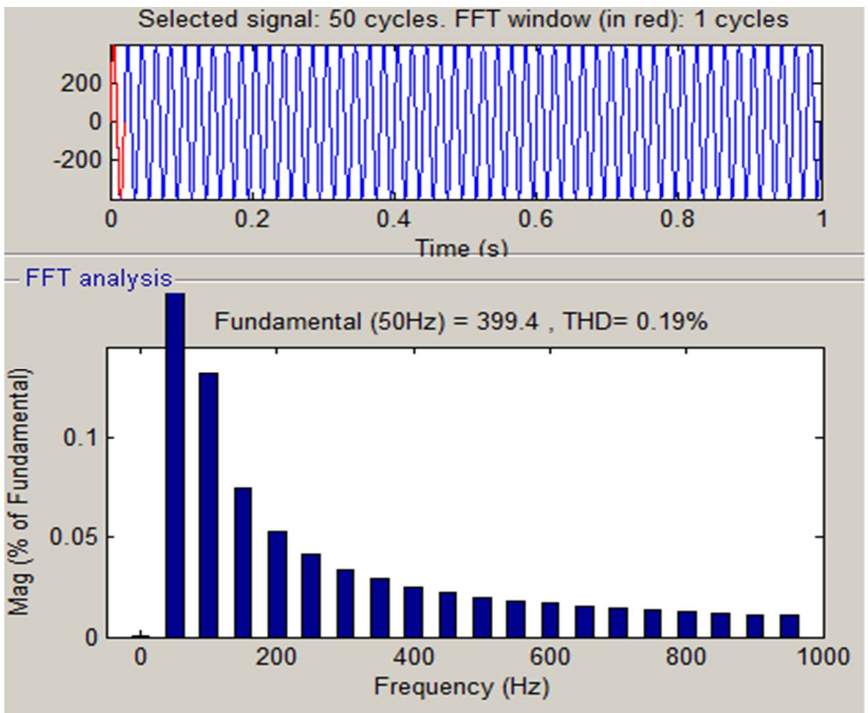

Figure No :05 Total Harmonics Distortions (P.F=0.98)

In power quality improvement capability of the UPQC system is tested through case studies of MATLAB.A three phase diode bridge rectifier is used as a harmonics distortion (THD) of 0.19%.The (Vsc_1) and (Vsc_2) is able to compensate up to 30% voltage sag of the nominal voltage .The performance of (Vsc_1) and (Vsc_1) from the point of view of sag/swell detection speed, sag compensation, and harmonics suppression capabilities are investigated.

V. CONCLUSION

The novel controller for the unified power quality conditioner is introduced analyzed by controlling voltage source converter (Vsc_1) and (Vsc_2) The nonlinear adaptive filter algorithms DC –link voltage with a PI controller .This paper presents an effective and fast voltage sag/swell detection method for unbalanced faults .the performance of the proposed UPQC and controller for PQ improvement is tested through the case studies simulation. This paper mainly focused reduced in total harmonics distractions (THD) and power qualities improve.

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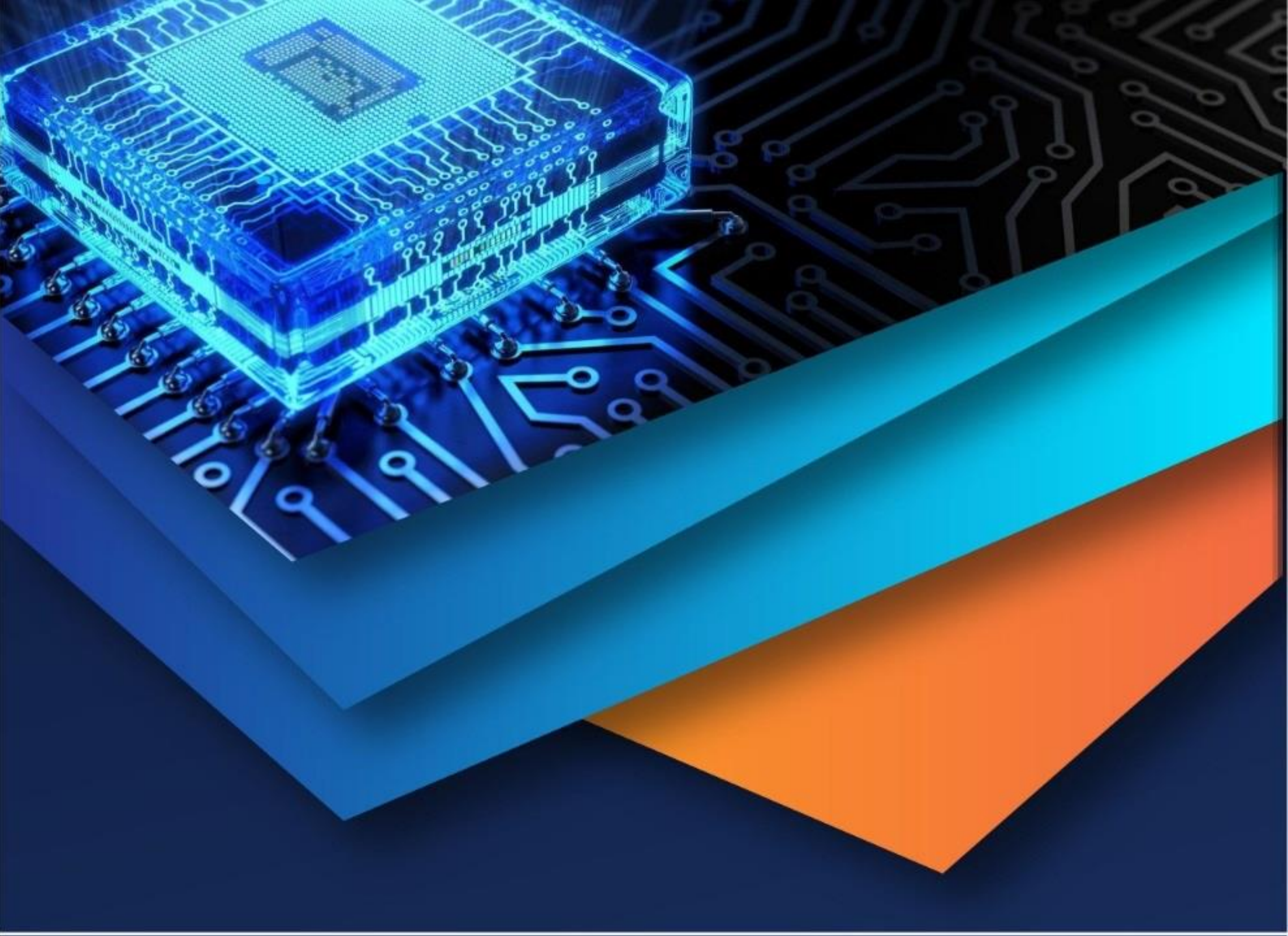

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