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Enhancement of Power Quality in Distribution System Using D-STATCOM

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Abstract: Sensitive loads are greatly affected by power-quality (PQ) disturbances in the system. Power quality problems such as voltage sag and harmonic distortion along with reliability issues are some major concern and in this work the voltage distortion & reactive power issues are considered. Inverters based on Voltage Source Converters (VSC) are widely used as a basic component in custom power devices. These controllers produce voltage harmonics due to switching operation of power electronic converters. The proposed controller supplements the voltage-sag compensation control of the statcom. It does not require phase-locked loop and independently controls the magnitude and phase angle of the injected voltage for each phase.

The proposed scheme have the following advantages such as limit the fault current , interrupt the fault current within two cycles, interrupt the fault current during arching fault and low dc link voltage. The circuit will be simulated using MATLAB.

Index Terms:Voltage Source Converters (VSC), power-quality (PQ),STATCOM..

I. INTRODUCTION

The ongoing expansion and growth of the electric utility industry continuously introduce changes to a once predictable business. Electricity is increasingly being considered and handled as a commodity. Thus transmission systems are being pushed closer to their stability and thermal limits with the focus on the quality of power delivered.In the evolving utility environment, financial and market forces will continue to demand a more optimal and profitable operation of the power system with respect to generation, transmission and distribution. Advanced technologies are paramount for the reliable and secure operation of power systems. To achieve both operational reliability and financial profitability it is clear that more efficient utilization and control of the existing transmission system infrastructure is required.

Improved utilization of the existing power system is provided through the application of advanced control technologies. Power electronics based equipment or Flexible AC Transmission systems (FACTS) provide proven technical solutions to address these new operating challenges being presented today. FACTS technologies allow for improved transmission system operation with minimal infrastructure investment, environmental impact and implementation time compared to the construction of new transmission lines. FACTS technologies provide advanced solutions as cost effective alternative to new transmission line construction. FACTS provide the needed corrections of transmission functions in order to efficiently utilize existing transmission systems and therefore, minimize the gap between the stability and the thermal level.

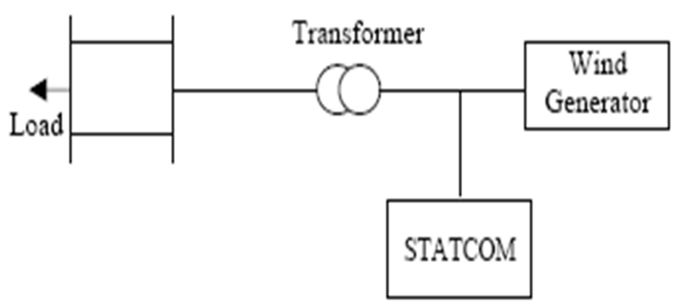

Figure 1: Voltage Fluctuation Mitigation with STATCOM

II. TRADITIONAL SOURCE INVERTERS

Traditional source inverters are Voltage Source Inverter and Current Source Inverter. The input of Voltage Source Inverter is a stiff dc voltage supply, which can be a battery or a controlled rectifier both single phase and three phase voltage source inverter are used

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in industry. The switching device can be a conventional MOSFET, Thyristor, or a power transistor. Voltage source inverter is one which the dc source has small or negligible impedance. In other words a voltage source inverter has stiff dc source voltage at its input terminals. A current-fed inverter or current source inverter is fed with adjustable current source. In current source inverter output current waves are not affected by the load.

A. Voltage Source Inverter

When the power requirement is high, three phase inverters are used. When three single-phase inverters are connected in parallel, we can get the three-phase inverter. The gating signals for the three phase inverters have a phase difference of 120^o. These inverters take their dc supply from a battery or from a rectifier and can be called as six-step bridge inverter. Figure.2.2 shows the three phase inverter using six MOSFET's and with diodes. A large capacitor is connected at the input terminals tends to make the input dc voltage constant. This capacitor also suppresses the harmonics fed back to the source. Therefore the Voltage Source Inverter is only buck (step down) inverter operation for DC to AC power conversion or boost (step-up) operation for AC to DC power conversion.

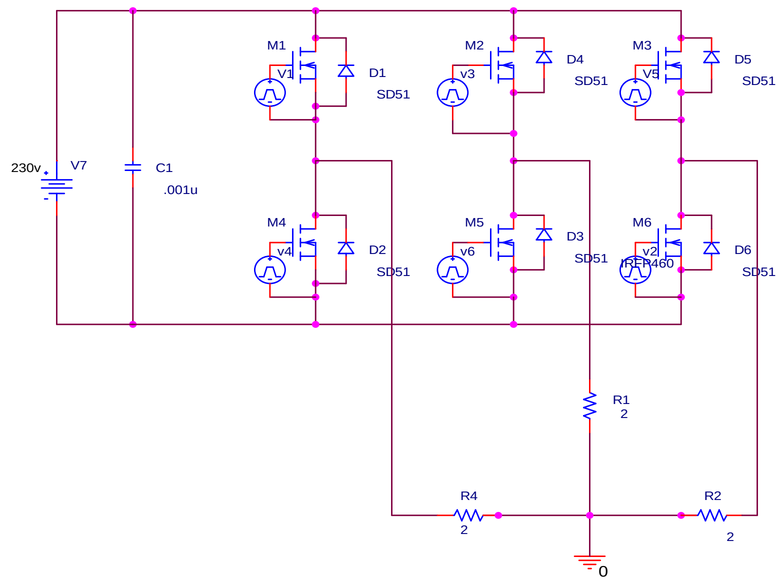

Figure.2 Voltage Source Inverter

For applications where over drive is desirable and the available dc voltage is limited, an additional dc-dc boost converter is needed to obtain a desired ac output. The additional power converter stage increases system cost and lowers efficiency. The upper and lower devices of each phase leg cannot be gate on simultaneously either by purpose or by EMI noise. Otherwise a shoot through problem by Electromagnetic interference noise's misgating–on is major killer to the inverter reliability. Dead time to block both upper and lower devices has to provide in the Voltage Source Inverter which causes the waveform distortion, etc. An output LC filters needed for providing a sinusoidal voltage compared with Current Source Inverter which causes additional power loss and control complexity.

III. OPERATION

A. Modes of Operation

Three phase inverters are normally used for high power applications. Three single-phase half or full bridge inverters can be connected in parallel to form the configuration of a three phase inverter. The gating signals of single phase inverters should be advanced or delayed by 120^o with respect to each other in order to obtain three phase balanced voltages. The three phase output can be obtained from a configuration of six switches and six diodes. Two types of control signals can be applied to the switches: 180^oconduction or 120^oconduction.

1) 180° Conduction: Each switch conducts for 180°. Three switches remain on at any instant of time. When switch 1 is switched on, terminal 'a' is connected to the positive terminal of the dc input voltage. When switch 4 is switched on, terminal 'a' is connected to the negative terminal of the dc source. There are six modes of operation in a cycle and the duration of each mode is 60°. The switches are numbered in the sequence of gating the switches 123, 234, 345, 456, 561, 612. The gating signals are shifted from each

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other by 60° to obtain three phase balanced voltages.

2) 120° Conduction: Each switch conducts for 120°. Only two switches remain on at any instant of time. The conduction sequence of switches is 61, 12, 23, 34, 45, 56, and 61. There are three modes of operation in a half cycle and the equivalent circuits for wye connected load are shown in Figure. 3.

During mode 1 for $0 \le \omega t \le \pi/3$ switches 1 and 6 conducts.

$$Van = Vs/2 \qquad Vbn = -Vs/2 \qquad Vcn = 0$$

During mode 2 for $\pi/3 \le \omega t \le 2\pi/3$, switches 1 and 2 conduct.

$$Van = Vs/2 \qquad Vbn = 0 \quad Vcn = -Vs/2$$

During mode 3 for $2\pi/3 \le \omega t \le 3\pi/3$, switches 2 and 3 conduct.

$$Van = 0 \quad Vbn = Vs/2 \qquad Vcn = -Vs/2$$

The line to neutral voltages can be expressed in Fourier series as given in equations 2.1 to 2.3.

$$Van = n{=}1, 3, 5 \ldots \Sigma \infty\ 2Vs/n\pi \cos n\pi/6 \sin n(\omega t + \pi/6) \qquad \ldots 2.1$$

$$Vbn = n{=}1, 3, 5 \ldots \Sigma \infty\ 2Vs/n\pi \cos n\pi/6 \sin n(\omega t - \pi/2) \qquad \ldots 2.2$$

$$Vcn = n{=}1, 3, 5 \ldots \Sigma \infty\ 2Vs/n\pi \cos n\pi/6 \sin n(\omega t - 7\pi/6) \qquad \ldots 2.3$$

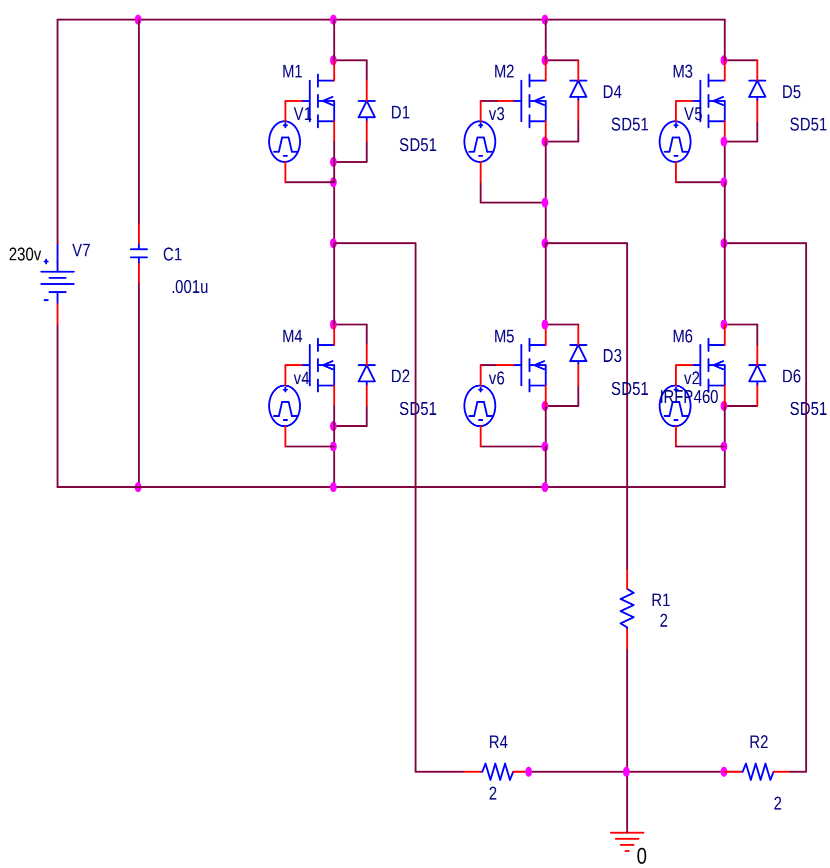

Figure.3 Voltage source Inverter

The a to b line voltage is Vab =√ 3 Van with a phase advance of 30°. There is a delay of π/6 between the turning off switch 1 and turning on of switch 4. Thus there should be no short circuit of the dc supply through one upper and lower switch. At any time, two load terminals are connected to the dc supply and the third one remains open. The potential of this open terminal will depend on the load characteristics and would be unpredictable. Since one switch conducts for 120°, the switches are less utilized as compared to that of 180° conduction for the load condition. The control of output voltage is done using pulse width modulation. The commonly used techniques are Single pulse width modulation.

Multiple pulse width modulation.
Sinusoidal pulse width modulation.
Modified sinusoidal pulse width modulation.
Phase displacement control.

3) Pulse Width Modulation Technique: The control of output voltage is done using pulse width modulation. The commonly used techniques are

Single pulse width modulation.
Multiple pulse width modulation.
Sinusoidal pulse width modulation.
Modified sinusoidal pulse width modulation**.**
Phase displacement control.

Pulse-width modulation (**PWM**) is a very efficient way of providing intermediate amounts of electrical power between fully on and fully off. A simple power switch with a typical power source provides full power only when switched on. PWM is a comparatively recent technique, made practical by modern electronic power switches.

IV. SIMULATION MODELS

A. Case-1 STATCOM

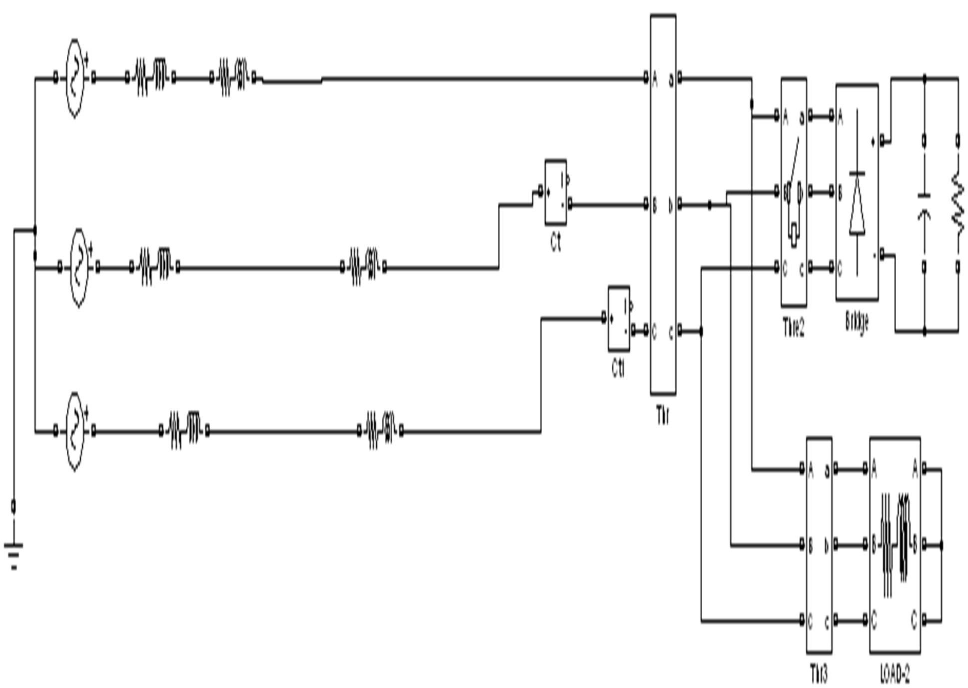

Figure.4 Circuit diagram

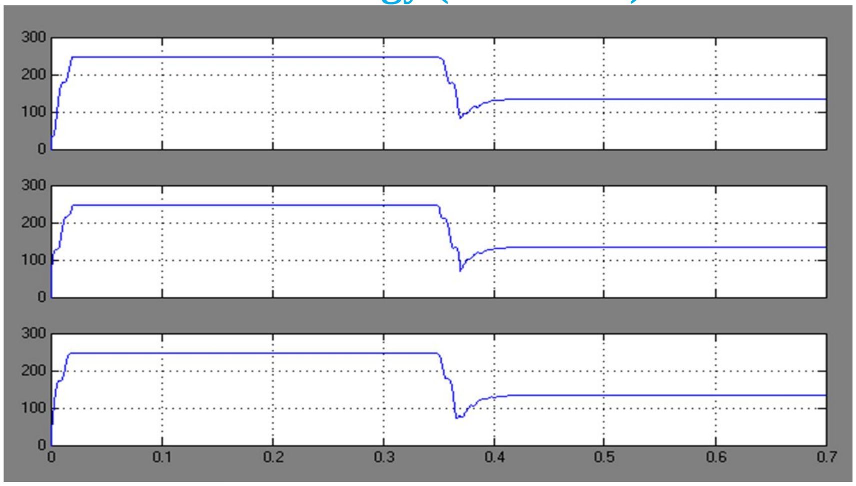

Figure.5 Three phase load voltage (RMS)

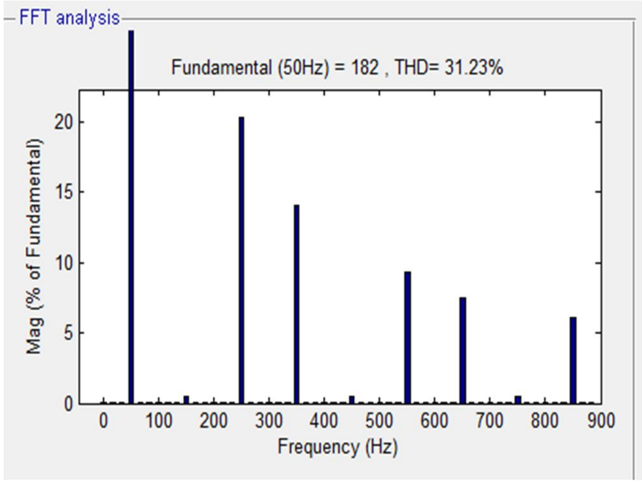

Figure.6 FFT analysis

B. Case-2 D-STATCOM

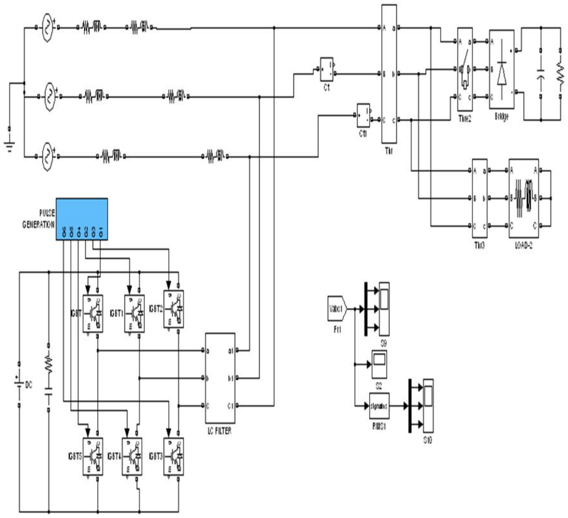

Figure.7 Circuit diagram with D- STATCOM

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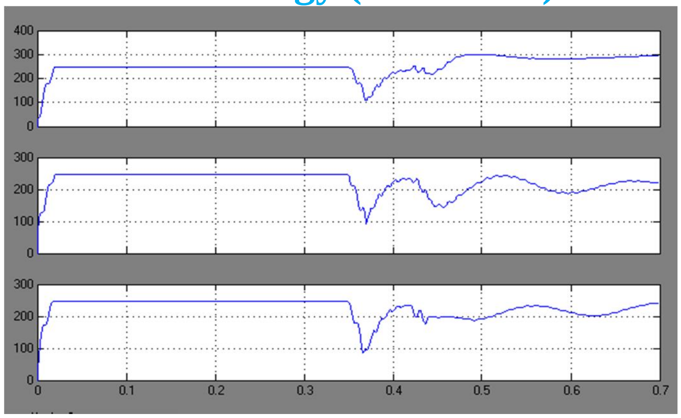

Figure.8 Three phase load voltage (RMS**)**

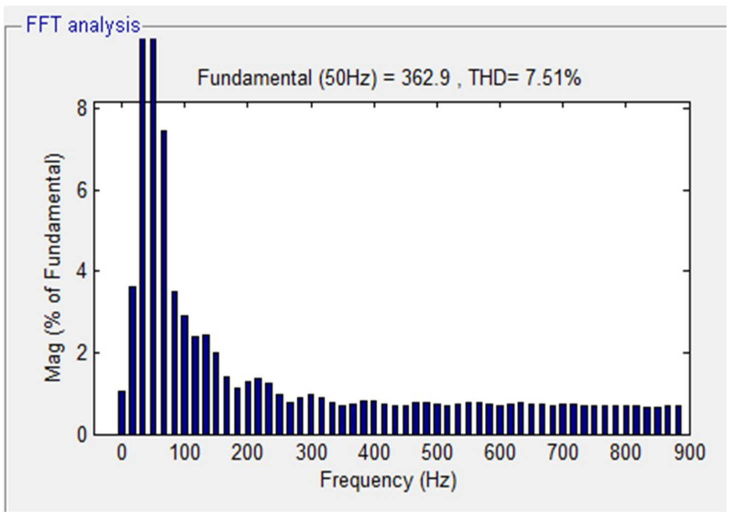

Figure.9 FFT analysis

C. Case-3 Three Phase Fault Rectification Using D-STATCOM

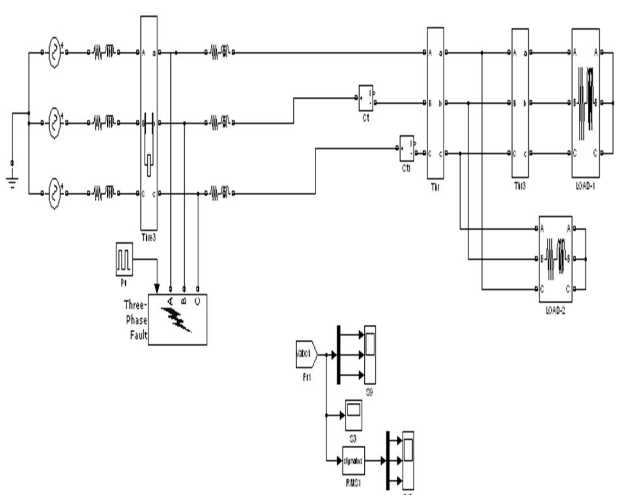
Figure.10 Circuit diagram

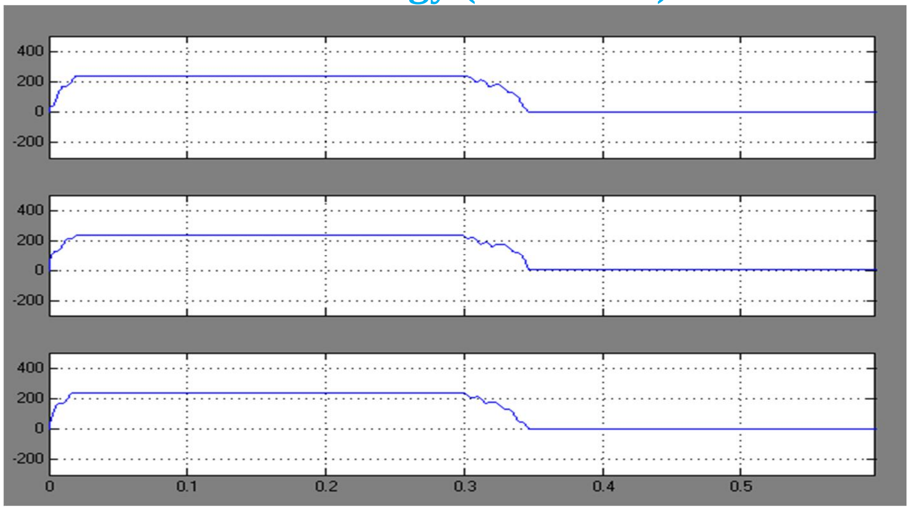

Figure.11 Three phase load voltage (RMS)

PARAMETER	WITH d- STATCOM
VOLTAGE PEAK	340
VOLTGAE RMS	240
%THD	0.84

V. CONCLUSION

This paper introduces an auxiliary control mechanism to enable the DVR to interrupt downstream fault currents in a radial distribution feeder. This control function is an addition to the voltage-sag compensation control of the DVR. The performance of the proposed controller, under different fault scenarios, including arcing fault conditions, is investigated based on time-domain simulation studies in the PSCAD/EMTDC environment. The study results conclude that.The proposed multi loop control system provides a desirable transient response and steady-state performance and effectively damps the potential resonant oscillations caused by the DVR LC harmonic filter. The proposed control system detects and effectively interrupts the various downstream fault currents within two cycles (of 50 Hz). The proposed fault current interruption strategy limits the DVR dc-link voltage rise caused by active power absorption, to less than 15% and enables the DVR to restore the PCC voltage without interruption; in addition, it interrupts the downstream fault currents even under low dc-link voltage conditions. The proposed control system also performs satisfactorily under downstream arcing fault conditions.

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BIOGRAPHY

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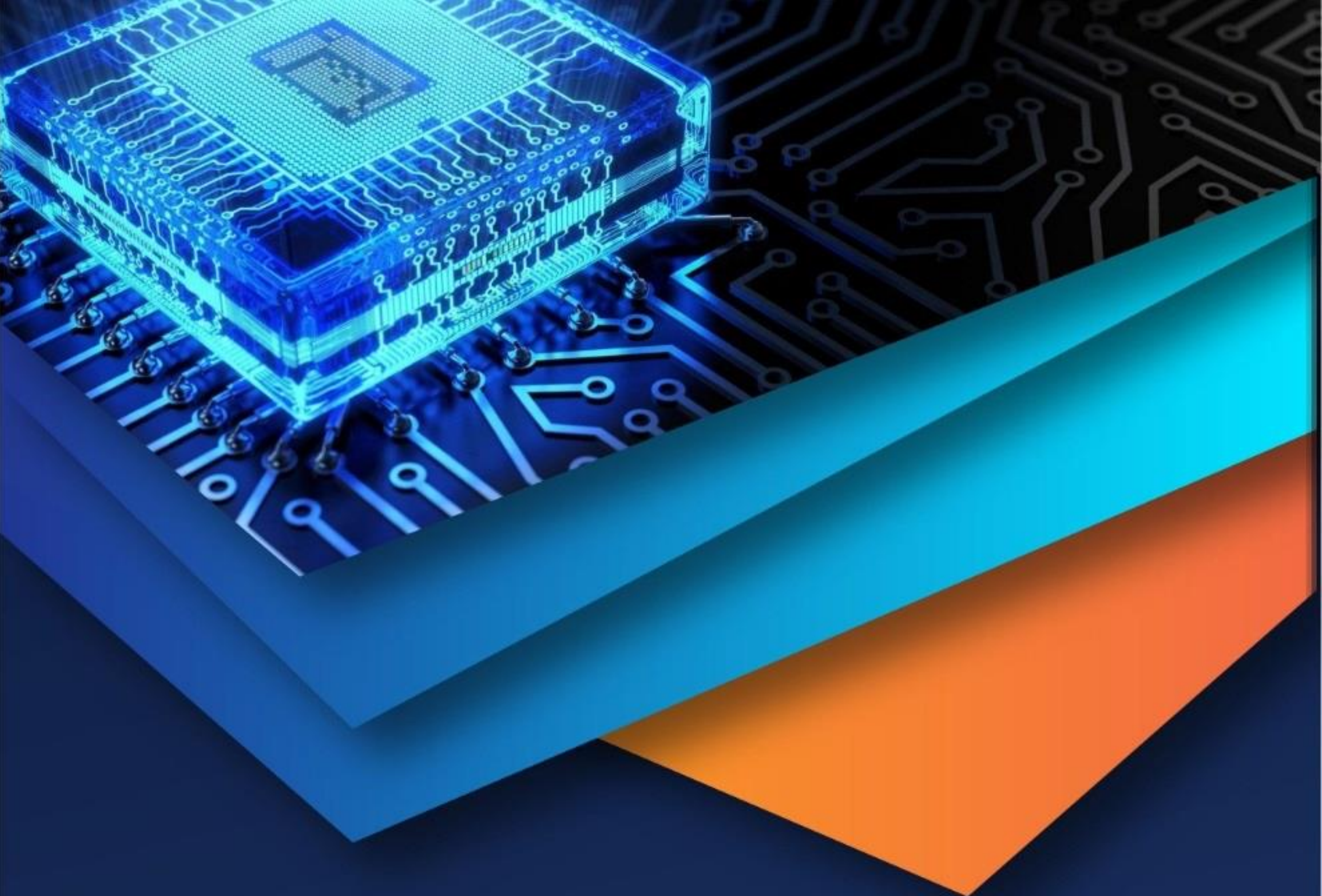

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