iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 2 **Issue:** Issue- III **Month of publication:** November 2014

DOI:

www.ijraset.com

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

The HAAR Wavelet Multi-Resolution Analysis of MIMO-OFDM in Wireless Channel

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***Abstract* — MIMO-OFDM system has a capability of transmitting high speed data-rates to the end user without limiting the channel capacity and with no ISI (Inter Symbol Interference) and ICI (Inter Carrier Interference). MIMO-OFDM system implements with the Wavelets have effective MRA (Multi Resolution Analysis) capabilities to extract the optimum response of the signal. The Wavelets (otherwise called enactment of ripple) based multi-user MIMO OFDM systems has a lot of advantages over the FFT based OFDM, Wavelet based OFDM system does not require a need for cyclic prefix and it has optimal resolution and flexibility. Wavelets are the waves that lost for a finite duration of time. The HAAR Wavelet in MIMO-OFDM system has MRA of dual idea of Fourier analysis. HAAR in the MIMO-OFDM system cut up the waves into smaller parts of the waves with different resolution analysis to obtain smooth function and to converts them into linear combination of effectively discontinuous functions, HAAR wavelets has a capability of obtaining the smoother function by using of the localization technique , MRA, dual band processing and effective closure implementation techniques. HAAR Wavelet suitably existed in the arena of wireless communication scheme, it works suitably on third generation partnership projects (3GPP) networks. The DWT implemented by using of a HAAR transform multi carrier scheme has a benefit of taking the less than the consequence of taking multiple antennas and the creation of simulation, examination will predict easily. The DWT based OFDM compares the efficiency performance with the FFT based OFDM on establishing the bit error rate (BER) presentation to the transmit ability by BPSK also QPSK as a modulation technique in additive white Gaussian noise channel (AWGN).**

***Keywords*—MIMO-OFDM, DWT, MRA, Filter banks, Dual Modulation**

I. INTRODUCTION

The number of increased users in the wireless mobile communication system is needed to provide a high QOS (Quality of Service) and to provide High-data-rates. High-data-rates can be achieved by increasing the Spectrum efficiency. The goal of the any communication network is to be implemented to provide a high data rates and service would be high speed internet access, video communication videophones etc. The barrier of any communication system is the transmission losses of the propagation signal from transmitter to the receiver end in number of different paths said to be multipath propagation of signal.

The multipath propagation of signals will undergone to various types of Fading which leads to change of the transmitted signal with respect to its phase, amplitude, frequency leads to decay of signal strength at receiver side. The multipath propagation loss occurs in both Time domains as well as in the Frequency domain.

The invention of Orthogonal Frequency Division Multiplexing (OFDM) becomes a popular technique for effective transmission mitigate of the signal in multipath. OFDM in a wireless communication channels transmits very extraordinary speed of data rates without limiting the channel capacity in an allocated Frequency. The OFDM has a number of advantages such as reduction of Impulse Response over the channel, high Spectral efficiency and robustness against the Inter Symbol Interference (ISI), Inter Carrier Interference(ICI). The MIMO (Multiple-input Multiple-output) wireless technology [1], gives the improved Spectral efficiency due to its Spatial Multiplexing gain and the reliability of link due to the antenna diversity gain. In the MIMO (Multiple-input Multiple-output) system the multiple antennas are deployed at both transmitter side as well as the receiver side of wireless system, has generated considerable interest in recent years [2], [3].

The OFDM implemented with the basis of Fast Fourier Transform (FFT) used to Multiplexing the signal together at the input side and also decode the signal at receiver side to regain the original signal. Adding the cyclic prefix to the transmitted signal causes the reduction of Spectral efficiency. The FFT based MIMO-OFDM uses the Narrowband analysis produces the high side lobes in Rectangular window which enhance it sensitivity to ICI and Narrow-band interference [4].

The alternative method for FFT based MIMO-OFDM is the Discrete Wavelet Transform based MIMO-OFDM system. The DWT consist of a Low Pass Filter (LPF) as well as High Pass Filter (HPF) functional as a Quadrature Mirror Filter (QMF) technique and the capability to regenerate the original signal as well as producing orthogonal properties. In the DWT based

OFDM system the sub-band coding is done by using of sub-signals of Low pass and High pass Frequencies. The Wavelets in the wireless communication system has a lot of advantages, by way of channel characterization, Interference modification, cognitive radio in addition interacting [7], and flexibility and to produce the optimal resolution.

II. OVERVIEW

A. MIMO system

In order to increased demand of the wireless system it is necessitate to establish the efficient use of radio spectrum, which is done by placing of the Modulation Carriers closely as possible as without occurring of the Inter Symbol Interference (ISI) and capability of carrying ability of many bits.

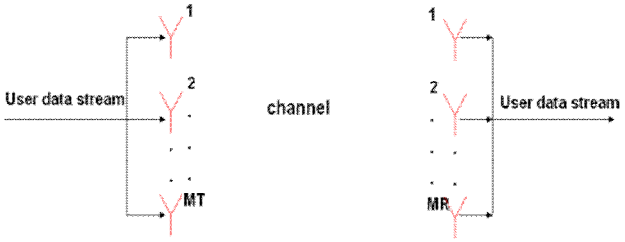


Fig 1. Block diagram of MIMO system

The MIMO (Multiple-input Multiple-output) communication system is implementation of array of antennas at the transmission and at the receiver side in Wireless Communication System. MIMO systems have a capability of transmitting the high speed Data-Rates to the end users without limiting the available channel capacity and with no interference to the signal. The MIMO systems are invented in the middle of 1980 by Jack Winters and Jack Saltzs of Bell Laboratories. The MIMO systems provide the enhanced system performance under the same transmission capability of Single-input Single-output system.

B. FFT based MIMO-OFDM systems

The MIMO-OFDM is implements with the FFT have advantages of easy computational capabilities and easy implementation. The Fourier Transform analysis is used to obtain the Frequency Spectrum of the signals. FFT Transform algorithm is used to find the Discrete Fourier Transformation function in a faster way with reduced complexity. The FFT algorithm converts the input data stream into N parallel data stream after Modulation technique performed to the input sequence.

For a given finite data stream which can be represent as

X[n], n=0 to N-1

The corresponding output sequence of FFT is represented as

$$X(K) = \sum_{n=0}^{N-1} x(n) e^{-j\pi\left(\frac{2n}{N}\right)n} \qquad K = 0 \text{ to } N-1 \qquad (1)$$

And the IFFT i.e. Discrete Domain sequence is

$$X(n) = \frac{1}{N} \sum_{k=0}^{N-1} X(K) e^{j\pi\left(\frac{2n}{N}\right)} \qquad n = 0 \text{ to } N-1 \qquad (2)$$

The FFT based MIMO-OFDM system perform the three types of operations of pre coding, spatial multiplexing, and diversity coding. Pre-coding technique can be used to improve the gain of received signal and to reduce the effect of multipath fading. Spatial multiplexing is used to split the higher data rates into lower data rates and to transmitting to the corresponding antennas. In the FFT system the cyclic prefix is added to the transmitted sequence before it is transmitting to evade the inter symbol interference (ISI), inter carrier interference (ICI) and the inverse FFT operation is performed at the receiver side to construct the original input signal as illustrated in bellow diagram.

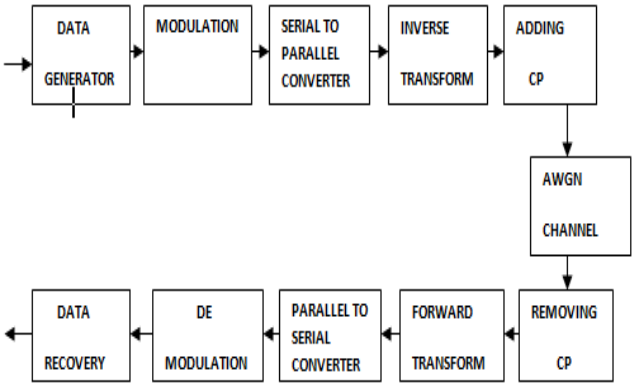


Fig2. Block diagram representation of FFT with cyclic prefixes.

III. REALATED WORK

A. *WAVELET based MIMO-OFDM system*

The Fourier Transform analysis is used to obtain the Frequency Spectrum of the signals and analysis of Fourier Transforms can be analyzed by using Sine waves because of its many useful properties. Sine waves are most analytic and smoothest possible periodic functions and also has a capability to express power to many other waveforms, integration and differentiation of Sine wave resultant to gives the Sine wave with same frequency but the biggest drawback of Sine wave that do not lost forever i.e. no signal in the world that can lost forever leads to change of the signal in FFT Fourier analysis. The alternative for this is implementation of Wavelets with the waves that lost for finite time's, they cut up the signal into many number of small signals that lost for a finite time interval and Wavelet transform produce a multi-resolution disintegration of continuous time signal into different frequencies with different times [5]. the data rates in the wavelet transforms are spitted into smaller data rates and the data rates are sampled into upper frequencies as well as lower frequencies.

In the wavelet transform method the upper frequencies superior decide in time and the lesser frequencies are better decided in frequency, the wavelet transform produces high orthogonal properties and to reproduce the original signal. The wavelet transform is calculated independently spitted part of the sub signal [9] the wavelet transform consist of two types i.e. continuous and as well as the discrete ripple transform. The full-band source signal splitting in to the altered frequency bands and to encrypt all spitted bands individually on their spectrum specification are called as sub-band coding method.

The sub-band coding is used to analysis the discrete ripple transformation and it is analyzed, accepted over a succession of filter banks [7]. Wavelets in the MIMO-OFDM has a analysis period as well as synthesis period ,the analysis period measured by sub-band filter of down sampler while synthesis period is measured by sub-band filter of up sampler. The sub-band filter period used through the channel filter exists exact restoration of Quadrature mirror filter [QMF], subsequently the low pass as well as high pass operation is performed on each level of the individual signal bands and double out puts are taken even for the small sequence[9]. The IDWT as a modulator operation performed at the transmitter and DWT as a demodulator perform at the receiver side.

IV. PROPOSED DWT MMO-OFDM SYSTEM DESIGN

MIMO-OFDM is normally implemented using the Fast Fourier Transform (FFT) and Inverse Fast Fourier Transform (IFFT). The FFT uses a rectangular window technique, use of rectangular window produces a high side lobes, that impact of side lobes causes a interference when the impairments are not compensated with each other, for this the use of wavelets packets and as well as the wavelets transforms and use of orthogonal wavelets are implemented. Wavelet transform cut the continuous unction into discontinuous function and to make it smoother and smoother by adding more discontinuous function to achieve the optimum response this idea is opposite to the idea of Fourier Transform. The wavelet transform produces the different resolution subspaces used to decompose the signal[12].

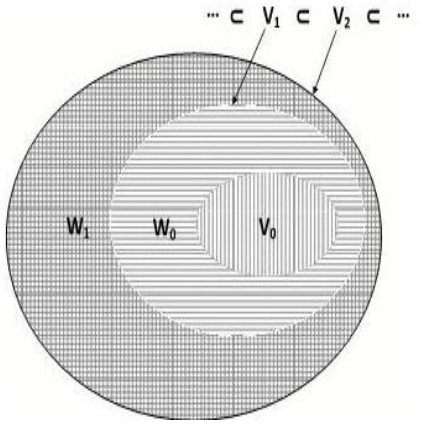


Fig 3. Nested subspaces

The subspaces can be represented as bellow showed from the nested subspaces of the wavelet discontinuous functions

$$...V_{-2} < V_{-1} < V_0 < V_1 <....$$

Decomposition is done by using of the translation and dilation of a wavelet function[10], from the various subspaces the dilated and scaling functions are formulated and to capture the incremental information in between the two consecutive resolution subspaces i.e. $\{\Phi(t)\}$ forms a basis of V_0 . The scaling function and the wavelet function both should satisfy the dilation equation

$$\Phi(t)=\sum ø(2t-n)h(n).$$

if *ø(t)* should be orthogonal to the translated then h[n] should satisfies the orthogonality condition.

$$\sum h[n]h[n-2m]=\delta[m] \text{ and } \sum(-1)^n h(n)=0$$

Given a sequence we find the another sequence g(n) such that the function satisfy the dilation equation.

$$\Psi(t)=\sum \Psi(2t-n)g(n)$$

This function is the wavelet function i.e. function is orthogonal to the wavelet function, the scaling and wavelet function can be used to decompose the signal into different subspaces. *ø(t)* occupies the half the frequency space of *ø(2t)* and similarly for the wavelet fluencies and the corresponding low pass frequency function is h(-n) and high pass frequency function is g(-n) this can be represented using structures shown below.

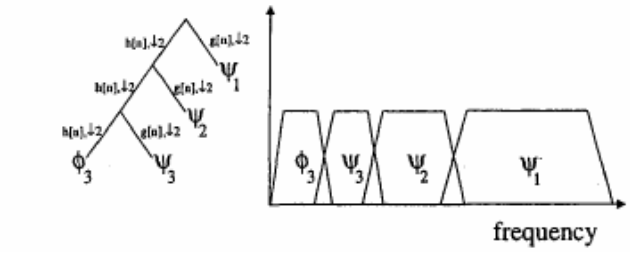


Fig4. The tree structure of the wavelet decomposition

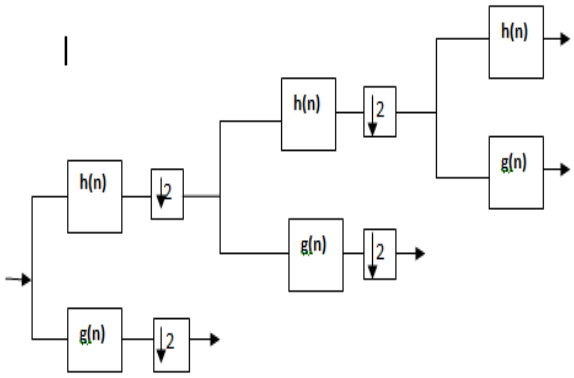
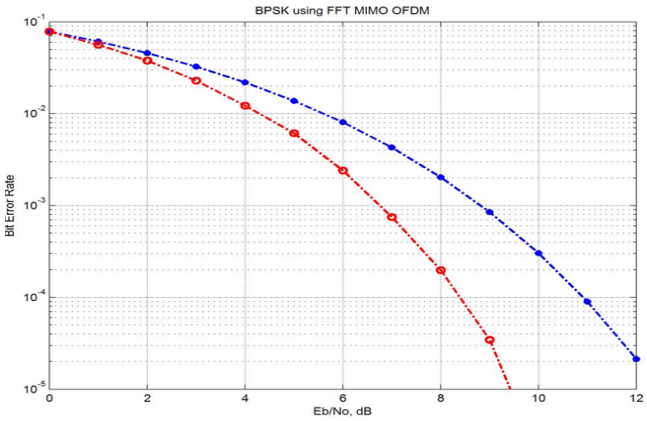
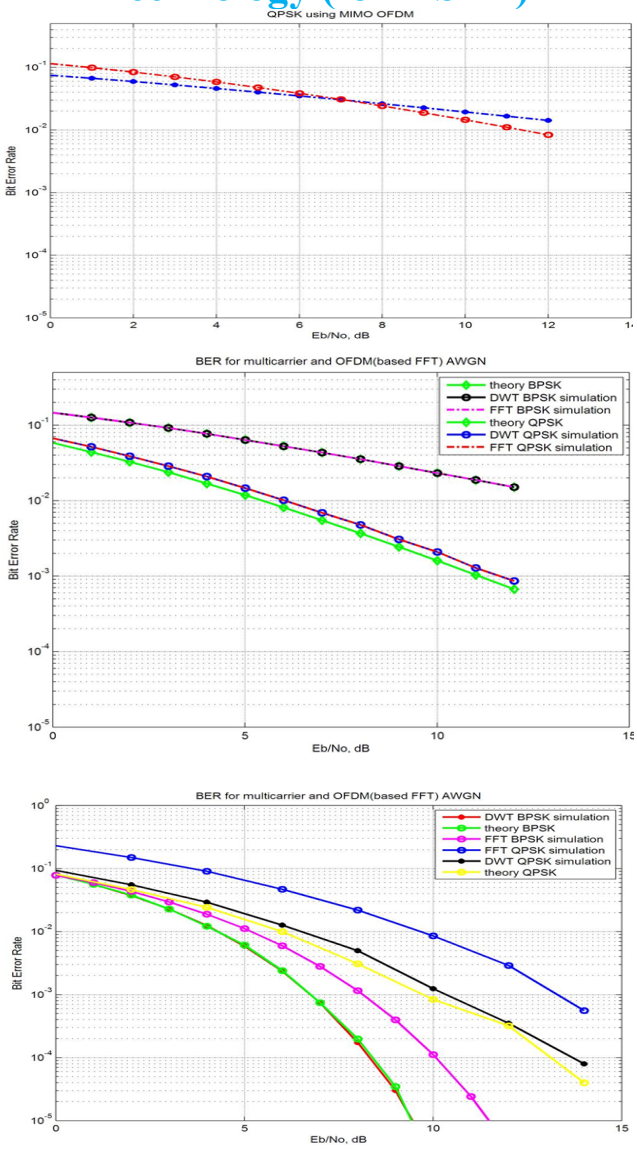


Fig 5. The structure of wavelet decomposition

V. SIMULATION RESULTS USING MATLAB

The figures show the graphical representation of the FFT based MIMO-OFDM and DWT based MIMO-OFDM system. The simulation results plots with bit error rate and to the signal to noise ratio, from the graphical representation for the DWT based MIMO-OFDM has a fewer than the probability bit error rate of the FFT based system. The HAAR wavelet transform is used in it and it possess the superior performance than the other type of transforms.





VI. CONCLUSION

The proposed DWT MIMO-OFDM system has a lot of advantages over the FFT based MIMO-OFDM system. In reality no signal is lost forever it should start somewhere and should end somewhere based on this the Wavelet functions are implemented, wavelets are the small portion of the continuous signal that vanish after duration of finite time. DWT based system constructed with the HAAR mother transform reduces number of multiple antennas than the consequences of required number of antennas, which perfectly suits for the arena of 3GPP network. Unlike the FFT based MIMO-OFDM the DWT based MIMO-OFDM particularly using the HAAR mother wavelet transformation is conceptually simple, provides the great Orthogonal properties and it has a absolute Symmetric property, the DWT based MIMO-OFDM oversample the signal into different resolutions as well as oversamples the signal in both Time domain and as well as in Frequency domain. By using the sub band coding in DWT uses HAAR transformation can reconstruct the samples accurately. The DWT based MIMO-OFDM can be suitable for all applications of the next generation wireless systems and it has a capability of delivering a high speed packet access (HSPA) capabilities.

Wavelets are using in many advanced applications such as Nuclear Engineering, Image Synthesis, Biomedical Engineering, Music's, Fractals, Pure Mathematics, Data Compression, Computer Graphics, Human Vision, Radar, Optics, Astronomy, Acoustics and Seismology etc.

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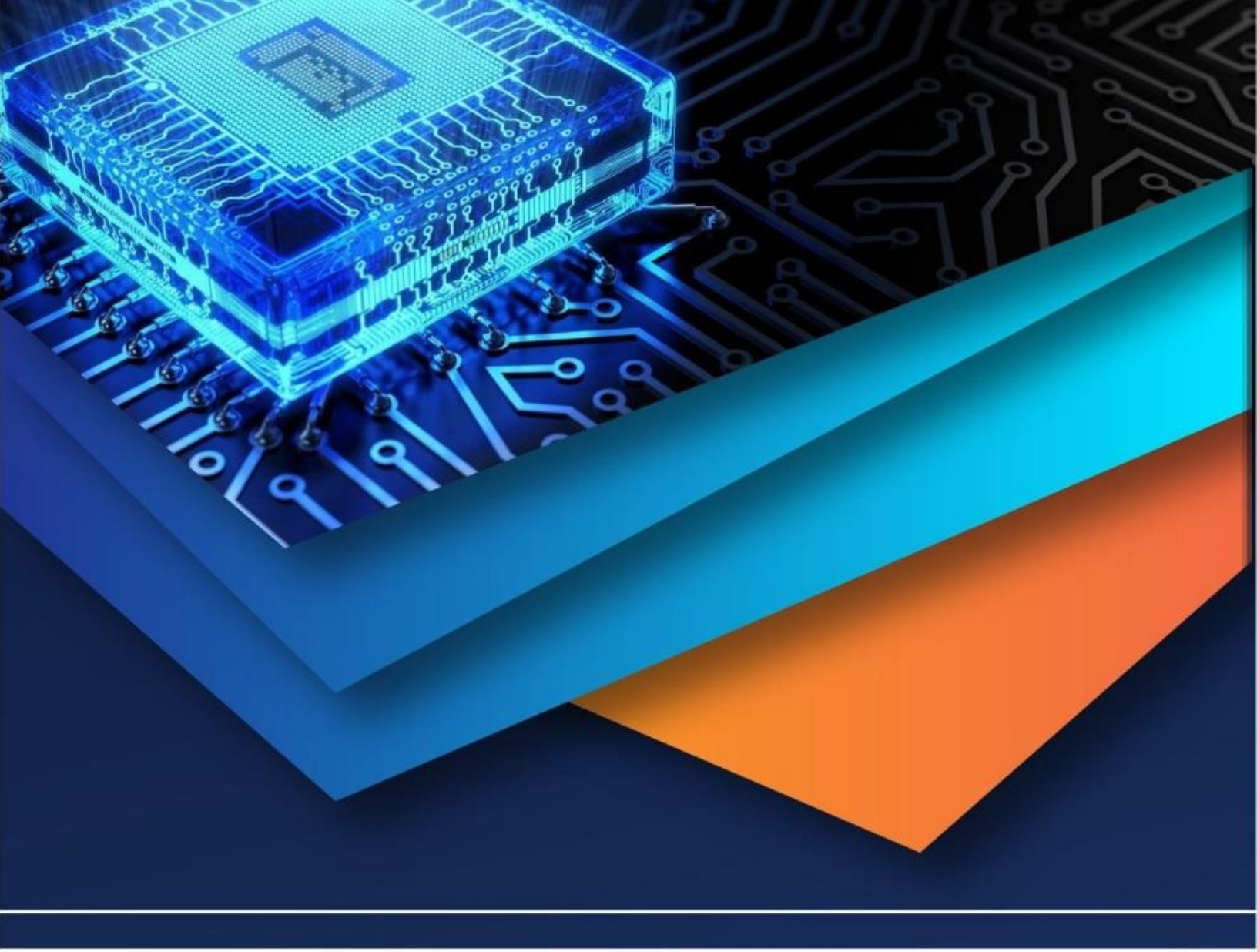

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