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PAPR Reduction in OFDM: A Technological Review

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Abstract: ***Earlier signals were sent in analog domain, but in these days signals are sent in the digital domain. Additionally, single carriers are substituted by multicarrier for the purpose of better transmission. Nowadays multicarrier systems are commonly implemented. Some multi carrier systems are Orthogonal Frequency-division Multiplexing (OFDM), Code-Division Multiple Access (CDMA) and many others. OFDM is one of the best and attractive techniques. Its sub carriers are place orthogonally to each other and are utilized to carry the data from the transmitter to the receiver. In this system, guard band is present which deals with the issue of ISI and noise is lessened by greater number of sub carriers. But the large Peak – to – Average Power Ratio of these signal have some undesirable effects on the system.***
Keywords: Cyclic Prefix, CCDF, Amplitude Clipping & Filtering, SLM, PTS.

I. INTRODUCTION

A simple communication system consists of a transmitter end which send the data and a receiver end at which the data is received. Usually this received data is not the same as the data sent. Several modulation approaches make ensure that the signal sent is safely available at the receiver end. OFDM is one of the best and attractive techniques for multicarrier modulation that is specifically suitable for transmission over wide channel. Here some distinct channels are located orthogonal to each other which are not dependent on one another. This is attained by locating the carrier accurately at nulls in the modulation spectra of each other. In the OFDM system, delay spread is decreased because of increase in symbol duration. Alteration of the channel into numerous closely spaced orthogonal sub–carriers provides its protection to frequency selective fading. As it is evident from the spectral pattern of an OFDM system, sub carrier that is orthogonally places can lead to high spectral efficiency.

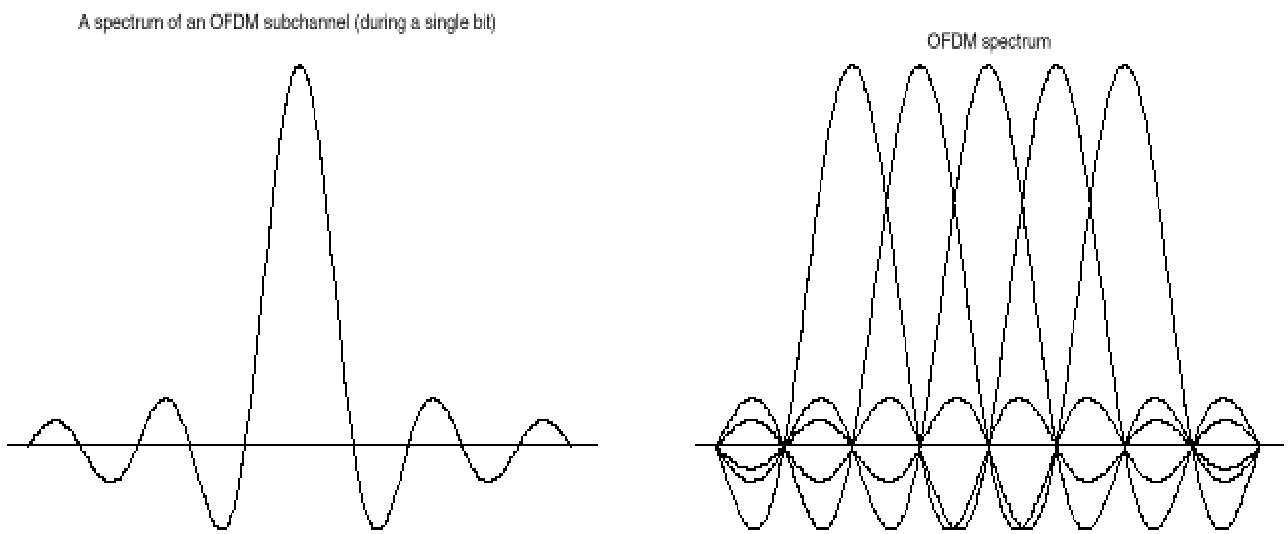

Fig. 1 OFDM Spectrum

The development of OFDM systems can be divided into three parts. This comprises of Frequency Division Multiplexing, Multicarrier Communication and Orthogonal Frequency Division Multiplexing.

A. Frequency Division Multiplexing

In FDM (Frequency division multiplexing), non-overlapping frequency range are assigned to separate signals or to every user of medium. FDM is form of single multiplexing. There is a gap between each channel and this gap makes sure that one channel does not overlap with the signal from an adjacent one. Because of lack of digital filters it was difficult to filter closely packed adjacent channels.

B. Multicarrier Communication

In this communication system, one signal is divided into number of signals in frequency range in order to send higher rate data stream. Each of these signals are individually modulated and transmitted over the channel. At the receiver end, signals are passed from the de-multiplexer in order to get recombined original signal again.

C. OFDM

OFDM systems are highly sensitive to Doppler shifts which affect the carrier frequency offsets, resulting in ICI. In these systems, presence of a large number of sub – carriers with varying amplitude results in a high Peak – to – Average Power Ratio (PAPR) of the system, which in turn hampers the efficiency of the RF amplifier.

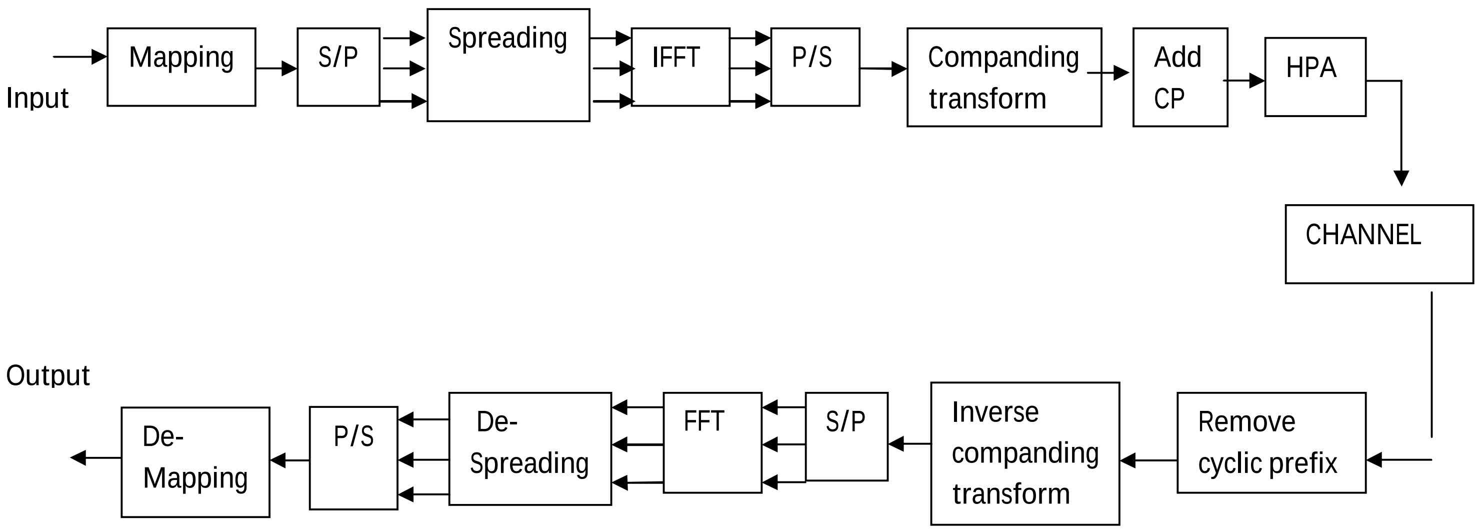

Fig.2 Block Diagram of Baseband OFDM System

D. Modulation And Demodulation Of Ofdm Systems

1) *Modulation:* It is the technique by which the signal wave is transformed in order to send it over the communication channel in order to minimize the effect of noise. This is done in order to ensure that the received data can be demodulated to give back the original data. The high data rate is split into small packets of data and it is attained by modulating the data by a desirable modulation technique (QPSK). In order to avoid ISI we provide a cyclic prefix to the signal.
2) *Companding Transform:* In companded OFDM system the PAPR of OFDM signals is reduced by increasing the average power of signals while keeping the peak unchanged, but this reduction in PAPR may be very limited under certain bit error rate (BER) performance constraint. I.e. Out of band radiation (OBR), filtering in system and even the bandwidth plays a key role in the performance of companded OFDM systems. Companding transforms mitigate the effects of OFDM only under sufficient bandwidth. In band limited case; the OBR value is not satisfied. Thus we filter the OBR parameter. To avoid PAPR regrowth commanding parameters are tightened to compress large amplitude and enhance small amplitude. The opposite process in called inverse companding transforms
3) *Demodulation:* It is the technique by which the original data (or a part of it) is recovered from the modulated signal which is received at the receiver end. In this case, the received data is first made to pass through a low pass filter and the cyclic prefix is removed. Signals are then passed from the de-multiplexer to order get to recombined original signal again. The bit error rate and the SNR are computed by taking into consideration the un- modulated signal data and the data at the receiving end.

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II. RELATED WORK

Agarwal, Deergha [1] proposed PAPR reduction by utilizing companding and precoding approaches for OFDM system. In the multi-path-propagation systems OFDM gives better option but on the other hand it also carries high peak average ratio (PAPR) at the transmitter end. This high PAPR value gives non linearity at transmission to make complex design. Thus, it is required to reduce the PAPR for lesser complexities, higher stability and greater efficiency. In this work several PAPR approaches has been discussed and distinct precoding matrices are utilized for PAPR reduction. Moreover, in this paper, comparison of μ-law companding and A-law companding approaches are also described to notice the effect on PAPR value. The result indicates that the proposed approach is efficiently reduced the PAPR values.

Kristam, Ramesh [2] proposed PAPR reduction approach depending on the pre-coding by utilizing Discrete Hartley Transform (DHT) for OFDM system. Moreover, in this research work, comparison of Hadamard Transform (WHT) with the proposed technique has also been discussed and it is concluded from the comparison that the proposed approach perform better than any other approach. These DHT-Pre-coded OFDM system did not necessitate any complex optimization, any increase in power but it is a simple circuitry as there is no complex operations. The simulation analysis demonstrates the proposed approach performs better as compared to other existing techniques. MATLAB simulation indicates that DHT-Pre-coded OFDM System shows improved PAPR gain as compared to Conventional OFDM-Original system,

Ogunkoya, Funmilayo [3] proposed pilot-assisted (PA) PAPR reduction technique in O-OFDM using multiple LEDs. This pilot assisted approach is relied on the data symbol phase rotation with P number of iterations of pilot symbol to attain reduction in PAPR approach. A result indicates exchange among various LEDs hardware complexity and the PA approaches to attain required PAPR reduction. By using the PA approaches, additionally PAPR reduction may be attained with the amalgamation of increased P and G.

Ogunkoya, Funmilayo[4] has presented PAPR approach for optical OFDM communication system. The PAPR approach is attained by rotating the data symbol phase with P iterations of arbitrary pilot symbol series. Generally, OFDM depends on the technique of frequency division multiplexing and in FDM separate streams of information are mapped on to different parallel frequency channels. Each channel is different from the others by frequency guard band to decrease interference between adjacent channels. In this work comparison of PAPR reduction technique and basic OFDM has been described and it is concluded that PAPR reduction gain of PA OFDM at a corresponding cumulative distribution function of 10^{-3} with P = 5 is ~2 dB. This gain is ~0.2 dB less than that of analytical results. The result analysis indicates that approach does not create any important bit error performance.

S. Mohapatra [5] A novel technique has been presented for Improvement of OFDM System using Pulse Shaping. OFDM is one of the attractive techniques for multicarrier modulation that is specifically suitable for transmission over wide channel. Here some distinct channels are located orthogonal to each other which are not dependent on one another. This attained by locating the carrier accurately at nulls in the modulation spectra of each other.

X. Li, L. J. Cimini [6] discussed the effect of clipping and filtering on the performance of OFDM. OFDM is an attractive technique for wireless communication applications. The simulation results indicate that proposed filtering and clipping is best approach for transmission of OFDM signal.

R. O"Neil [7] in research work, investigation is done on the clipping effect of band pass and baseband signals. The amount of in band distortion and out of band emissions can be traded off directly against reductions in the crest factor of the clipped signal. In this paper, Novel clipping techniques has been proposed that provides more control over the various trade-offs

Silva, Jair AL [8] has presented PAPR reduction approach depending on the constant envelope OFDM technique to ease the induced nonlinearities in direct-detection optical OFDM (DDO-OFDM) systems. OFDM employs various carriers in allocated bandwidth in order to transmit the information from source to destination. Every carrier employs one of the digital modulation techniques such as OPSK, BPSK, QAM, etc. at low symbol rate. These subcarriers are orthogonal to each other and have separate frequencies. The result indicates that presented approach uses 16-QAM and 2.66 GHz signal bandwidth. It also noticed from the results that proposed system also improve the fiber nonlinearity tolerance in fiber links without optical dispersion compensation. Moreover, the bit rate of proposed system is reduced by 1000 and considered considering a span of 960 km of standard single-mode fiber.

More, Aparna[9] presented both Iterative Clipping and SLM method is combined to provide enhanced PAPR compared to existing approaches. It makes use of closely spaced orthogonal subcarrier which is transmitted in parallel. OFDM systems have been developed for high data rate communications. In the IEEE 802.11 standard, the carrier frequency can go up as high as 2.4 GHz or 5 GHz. For example, the IEEE 802.16 standard proposes yet higher carrier frequencies ranging from 10 GHz to 60 GHz. OFDM is beneficial approach for high bit rate system and it is broadly utilized in wireless system due to its high data rate and many other benefits but there is one of the main demerit of OFDM system that it has high PAPR output signal and hence due to this demerit it limits the system performance. Therefore, in this work Iterative Clipping and Filtering (ICF) method has been presented and it gives better results for reducing PAPR. Selective Mapping (SLM) technique is an additional method that gives better performance for reduction of PAPR. Furthermore, in this work, both ICF and SLM method is combined to provide enhanced PAPR. The bit error rate is also improved by using proposed approach. The experiment analysis also indicates that the PAPR and BER of combined method are better than Clipping and SLM method separately.

Zhou, Ji, Zhenshan [10] proposed combined PAPR reduction approach for asymmetrically clipped optical OFDM. The presented approach merges the DFT spread approach with peak clipping approach. OFDM is well suited to all the dispersive channels, and especially to the wireless channel. In this work, under CR 6 dB of PAPR reduction may be acquired by the combined PAPR-reduction technique at the probability of 10^{-3} and bit error rate performance is hardly affected by the clipping distortion. Moreover, transmission over 100km SSMF is being executed in order to check the feasibility of presented approach.

Hasan, Md Mahmudul [11] a novel PAPR reduction technique has been proposed in this paper. This process utilizes the one of the significant property as its first step (pre-processing step) in OFDM system. In the next step, error filtering is done which is used to eliminate the content of stochastic processes that may minimize the autocorrelation of input data sequences. It becomes very efficient solution for PAPR issue in OFDM transmission. In the result analysis, it is indicated that the proposed approach may attain considerable reduction in PAPR without degrading computational complexity, power spectral level and error performance of the systems. Moreover it is indicated that the presented approach is independent of modulation process and also it may be applicable for different number of subcarriers under both AWGN and wireless Rayleigh fading channel.

Srinivasarao [12] proposed using linear non-symmetrical companding transform to reduce PAPR. The signal was coded and shaped using companding transform to reduce PAPR. It was inferred by simulations that the proposed CI coded companding transform improved the bit error rate (BER) performance of OFDM by reducing the PAPR significantly. Simulation results indicated that the proposed method operated well with decreased back off values of the nonlinear power amplifier, which increased the efficiency of the amplifier. And also smaller back off values reduced the required dynamic range of the amplifier which decreased the complexity and cost.

Alok Joshi [13] proposed a novel scheme here which reduced the computation complexity by tremendous margin and at the same time maintaining same PAPR reduction as conventional PTS scheme, by exploiting correlation among various candidate phase factors. This lead to exponential increase of computation complexity in terms of complex additions and multiplications as number of sub block increased. In the result section it was shown that the computational complexity was reduced significantly and at the same time PAPR reduction was same as convention PTS technique in terms of CCDF. Apart from this there was no change in spectrum of the original OFDM signal.

III. PROPOSED WORK

Here, we propose a new scheme, which is a hybrid of two of the works mentioned earlier in the review section. In the improved PTS [13] scheme with carrier interferometry (CI) spreading [12], we divide the 2-point inverse fast Fourier transform (IFFT) into two parts. Then the input symbol sequence is partially transformed, using the first stages of IFFT (L operations), into an intermediate signal sequence. Then the intermediate signal sequence is partitioned into a number of intermediate signal sub-sequences. Then, the remaining stages of IFFT (N-L operations) are applied to each of the intermediate signal sub-sequences and the resulting signal sub-sequences are summed after being multiplied by each member of a set of rotating vectors to yield distinct OFDM signal sequences. We then select the one with the lowest peak to average power ratio (PAPR) among these OFDM signal sequences for transmission. Then modulated signal is passed through companding transform i.e. CI spreading and then passed through the channel. On the other side, then inverse companding transform is performed on the received signal. Then signal is converted from serial to parallel, and FFT is applied on it. This signal is converted to serial and then de-mapped to get the resultant signal. The new PTS OFDM scheme must reduce the computational complexity to a great extent.

PTS method has better PAPR reduction performance as compared to other traditional approaches. OFDM sequence is taken as input which is distributed into number of sub sequence having length N. then, these sub sequence is passed through IFFT block having length N. Accurately, PTS will apply to G times and for every sub blocks, U number of sequence is produced form sub sequence and lowest PAPR is selected and saved. The process reiterate for every sub-block till all sub-blocks are recovered. Finally, all partially selected sequences are concatenated to form the final new sequence of length *N* to be transmitted.

IV. ADVANTAGE AND DISADVANTAGE OF OFDM

A. Advantages

1) Multipath delay spread tolerance
2) High transmission bitrates
3) Chance to cancel any cannel if is affected by fading
4) Flexibility: each transceiver has access to all subcarriers within a cell layer.
5) Easy equalization.
6) High spectral efficiency.
7) Resiliency to RF interference.
8) Lower multi-path distortion.

B. Disadvantages

1) High synchronism accuracy.
2) Distortion problem.
3) Large peak-to-mean power ratio.
4) More complex compared to single-carrier Modulation.
5) Linear power amplifier is being required.
6) Noisy and high peak to average power ratio.
7) Peak to average power ratio (PAPR) is high.
8) High power transmitter amplifiers need linearization.
9) Low noise receiver amplifiers need large dynamic range.
10) Capacity and power loss due to guard interval.
11) Bandwidth and power loss due to the guard interval can be significant.

V. OFDM APPLICATIONS

OFDM technique is the most prominent technique of this era .Some of its applications is given
Below:

A. Wireless LAN Networks
B. 5.3.1 HIPERLAN/2
C. IEEE 802.11g
D. IEEE 802.16 Broadband Wireless Access Systems.
E. Wireless ATM transmission
F. IEEE 802.11a

VI. CONCLUSION

OFDM is one of the popular approaches for transmitting multicarrier signal and it becomes the attractive choice for high speed data transmission over communication channel. There is only one demerit of this OFDM system which is its high PAPR. In this paper, distinct properties of OFDM System are analyzed and the advantages and disadvantages of this system are understood. At transmitter end, main problem of OFDM systems is high PAPR. High peaks of OFDM signals occur when the sinusoidal signals of the subcarriers are added constructively. These high peaks necessitate using larger and expensive linear power amplifiers. Since high peaks occur irregularly and infrequently, this means that power amplifiers will be operating inefficiently. The schemes mentioned by Srinivasarao et. al and Alok Joshi et. al are the best available methods to reduce PAPR.

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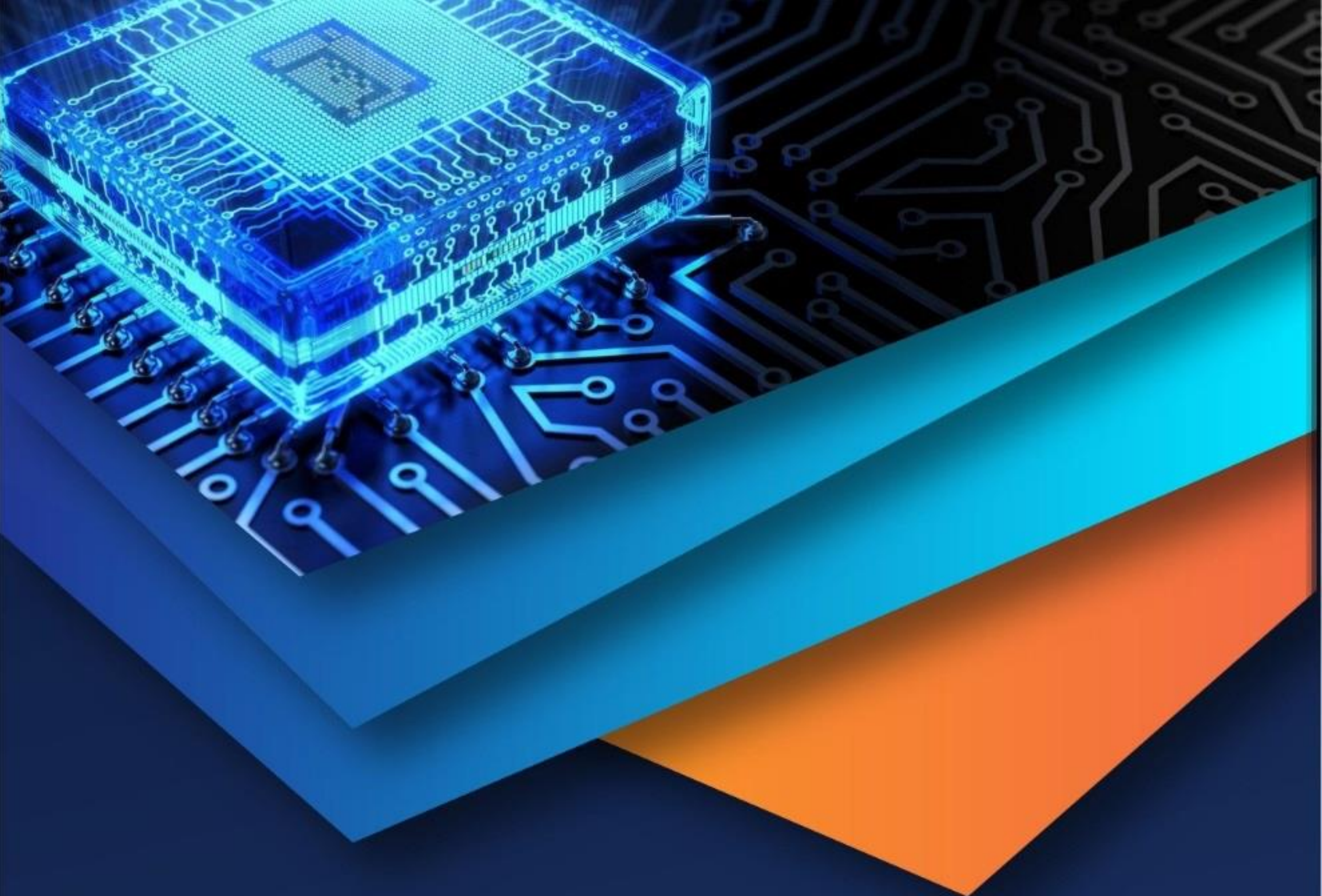

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