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Performance Evaluation of Turbo Codes On IEEE 802.11 PHY

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Abstract: Coding techniques are always an area of major scientific research. several techniques were invented that have contributed to evolvement of communication system. information transmitted through a noisy channel gets deteriorated and becomes unreliable. To cater for such data altering effects Forward Error Correction (FEC) techniques are used. an FEC technique, TURBO CODES is very effective in such cases. In this paper we have used different specifications such as coded and un-coded data; Different coding schemes varying the length of interleaver and effect of presence or absence of inter leaver in order to access the performance of turbo codes. Simulations are conducted on MATLAB using BPSK modulation scheme in presence of Additive White Gaussian Noise (AWGN) Channel. This paper depicts an implementation of turbocodeson 802.11 PHY model scenario developed in MATLAB Simulink which will help in field of turbo codes. It discusses the design, implementation and presents the comparison results.
Keywords: TURBO CODES, Wireless LAN, Adaptive modulation

I. INTRODUCTION

Codes with lower rate (i.e. bigger redundancy) correct more errors. Which implies that, with lower rate communication system can operate with lower transmit power, transmit over longer distances, tolerate more interference, use smaller antennas and transmit at a higher data rate. These properties make the code energy efficient. Most of the Available Wlan systems use Convolution Codes for Error Corrections. Which means the information is yet being lost. For every permutation of bandwidth (W) along with the channel type, signal power (S) and received noise power (N), there is a theoretical upper limit on the data transmission rate R, for which error-free data transmission is possible. This limit is called channel capacity or also Shannon capacity. Now, THERE WAS NEED OF A CODE TO REACH NEAREST TO THAT CAPACITY YET PROVIDE A GOOD ERROR CORRECTION CAPABILITY. The Parallelly Concatenated Convolutional Codes(PCCC), called turbo codes, has solved the confusion of structure and randomness through concatenation and interleaving respectively. The emerge of turbo codes has given most of the gain as said by the channel-coding theorem. Turbo codes have an astonishing performance of bit error rate (BER) at relatively low SNR.

II. THE 802.11 PHY

IEEE 802.11 is a standard set by IEEE defining a set of specifications for implementing Wi-Fi or wireless local area network(WLAN) computer communication in the 900 MHz and 2.4, 3.6, 5, and 60 GHz frequency bands. Physical layeris the first layer in the architecture of a digital communication network or the OSI / TCP-IP model. The physical layer describes the way of transmitting original bits instead of logical data packets over a physical connection, connecting network nodes. The bits may be categorised into words or symbols and converted to a physical signal that is transmitted over a hardware transmission medium. Physical layer converts the binary data into electrical optical or other impulses suitable for transmission over the network medium. It is the interface between MAC and wireless media where frames are transmitted and received. PHY uses signal carrier and spread spectrum modulation to transmit data frames over the media. Last but not the least, the PHY provides the carrier sense indication back to the MAC to verify activity on the media.

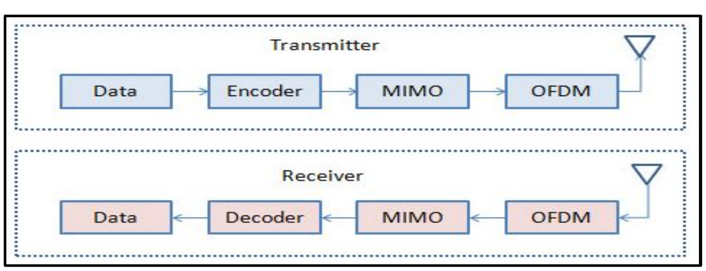

Fig. 1 General components of physical layer.

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III. METHODOLOGY/APPROACH

The Model Scenario comprises of the transmitting module, the receiving module and the AWGN channel. Form figure 1. We can see that transmitter consists of data source (random in nature), encoder (including interleaving) modulation mechanism and MIMO. An AWGN channel adds white Gaussian noise to the signal that passes through it. It is created in a model using the comm. AWGN Channel System-object, the AWGN Channel block, or the AWGN function. Gaussian function involved is given by P(z)=1/6sqrt(2*pi) exp [-1/2((z-a)/6)^2]. The Receiving Module comprises of Digital Demodulation, De-interleaving Convolution Decoding, iterative decoding And Collecting Data.an adaptive modulation technique has been adopted in order to tackle the problem of performance of turbo codes on higher snr as well, as for lower snr QPSK , BPSK etc are robust but for higher values we consider 16-QAM, 64-QAM etc.

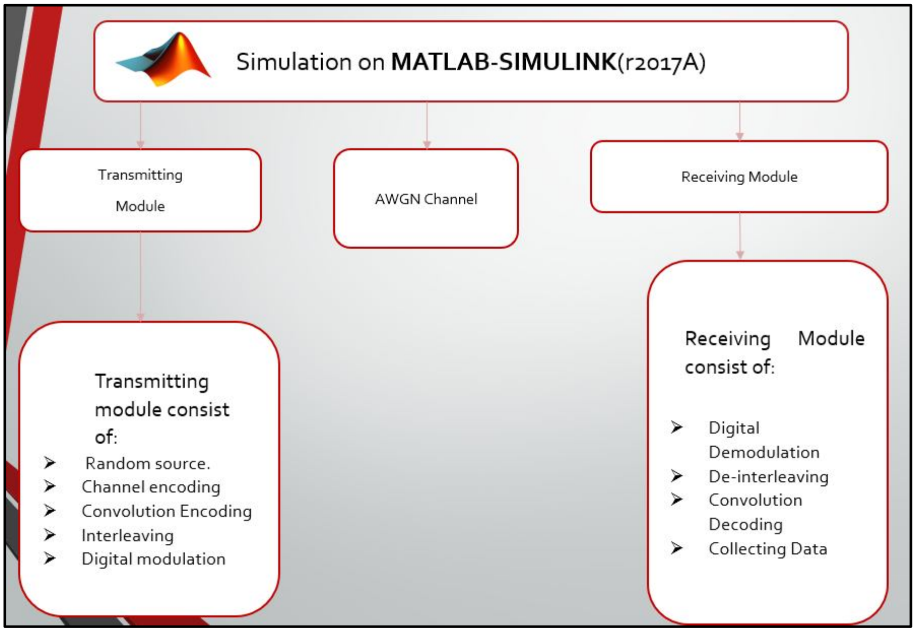

Fig. 2 methodology followed by the paper

IV. TURBO ENCODER

Turbo encoders are usually formed by parallelly concatenating two or more convolutional encoders. A convolutional encoder accepts messages of length *k* bits and generates codewords of *n* bits. Generally, it is made up of a shift register of *L* segments where L demotes the constraint length. In the upper branch, the convolutional encoder uses the “poly2trellis” function to create a trellis using the constraint length, code generator (octal) and feedback connection (octal). Then this output of samples is processed by the Deinterlacer block that separates the elements of the input signal to generate the output signals. The odd-numbered elements of the input signal become the first output signal, while the even-numbered elements of the input signal become the second output signal. Therefore, there are two signals .Data interleaving is generally used to scatter error burst and thus, reduce the error concentration to be corrected with the purpose of increasing the efficiency of the Convolutional Encoder by spreading burst errors introduced by the transmission channel over a longer time. In the lower branch, we have a Random Interleaver that, as its name indicates, interleaves the elements of the input vector using a random permutation. We select an output of 44 samples and a seed, defined as a variable, of 54123. Later, these samples are processed by a Convolutional Encoder and a Deinterlacer, both identical to the one placed in the upper branch.At this point, we have four output signals in the middle of the Turbo encoder. From these four bits stream we take three: the systematic bit stream, the parity bit stream and the interleaved parity stream. Then, the matrix interleaver rearranges the input vector by writing the elements into a matrix row-by-row and reading them out column- by-column. Finally, the Puncture block outputs the elements which correspond to 1s in the binary Puncture vector, to obtain a 3/4 code rate. Note that the standard suggests a code rate of 1/3, but because of practical issues of Simulink (sizes of the signals and matching all the sample time types) we had have to implement the 3/4 code rate. Puncturing is the process of systematically deleing bits from the output stream of a low-rate encoder in order to reduce the amount of data to be transmitted, thus forming a high-rate code. The bits are deleted according to a perforation matrix, where a “zero” means a discarded bit

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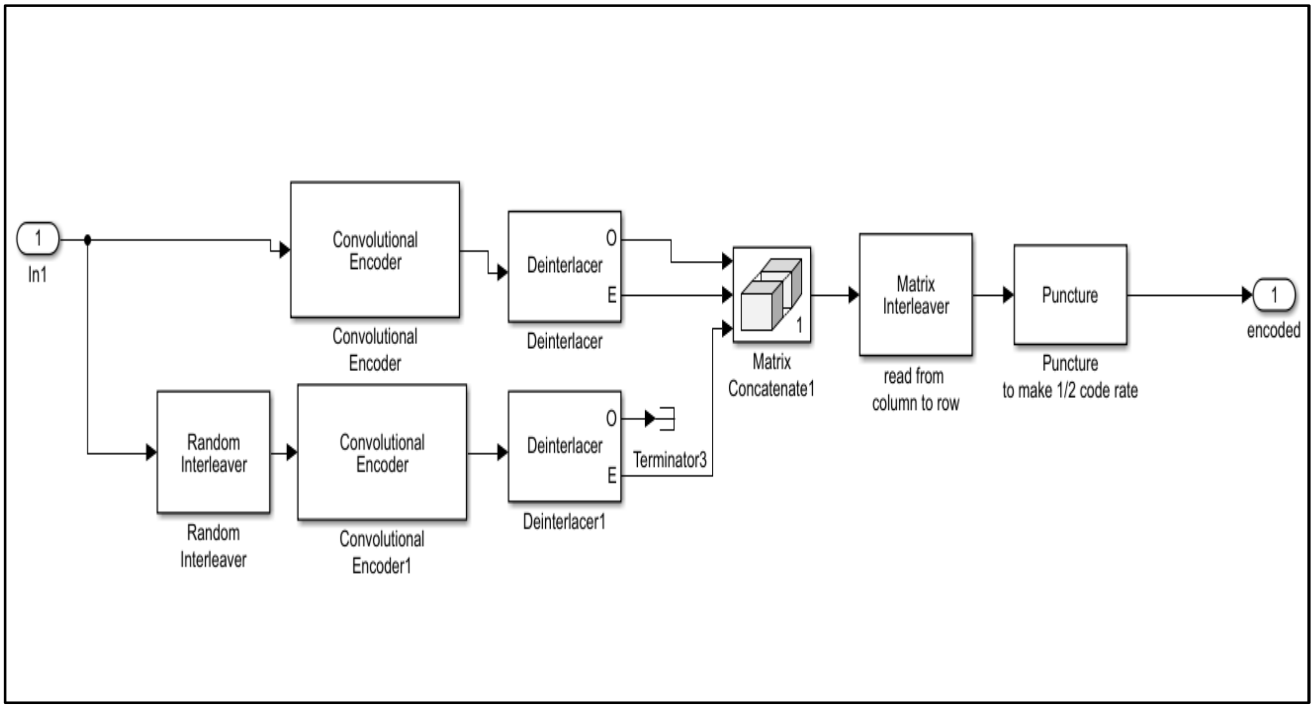


Fig. 3 Turbo Encoder block created in Simulink

V. TURBO DECODER

Turbo Decoding is an iterative decoding mechanism. The name Turbo itself is given because of the decoding algorithm it follows. Both inputs are processed by an APP Decoder Simulink block, which means “A posteriori probability (APP)” decoder. It uses the “poly2trellis” function to create a trellis using the constraint length, code generator (octal), and feedback connection (octal). The Trellis structure we set is the same we used in the transmitter: trellis = poly2trellis(5, [37 21],37);This block has two inputs: the input L(u) represents the sequence of log- likelihoods of encoder input bits, while the input L(c) represents the sequence of log-likelihoods of code bits. The outputs L(u) and L(c) are updated versions of these sequences, based on information about the encoder. If the convolutional code uses an alphabet of $2 \cdot n$ possible symbols, this block’s L(c) vectors have length $Q \cdot n$for some positive integer Q. Similarly, if the decoded data uses an alphabet of $2 \cdot k$ possible output symbols, then this block's L(u) vectors have length $Q \cdot k$. The integer Q is the number of frames that the block processes in each step.

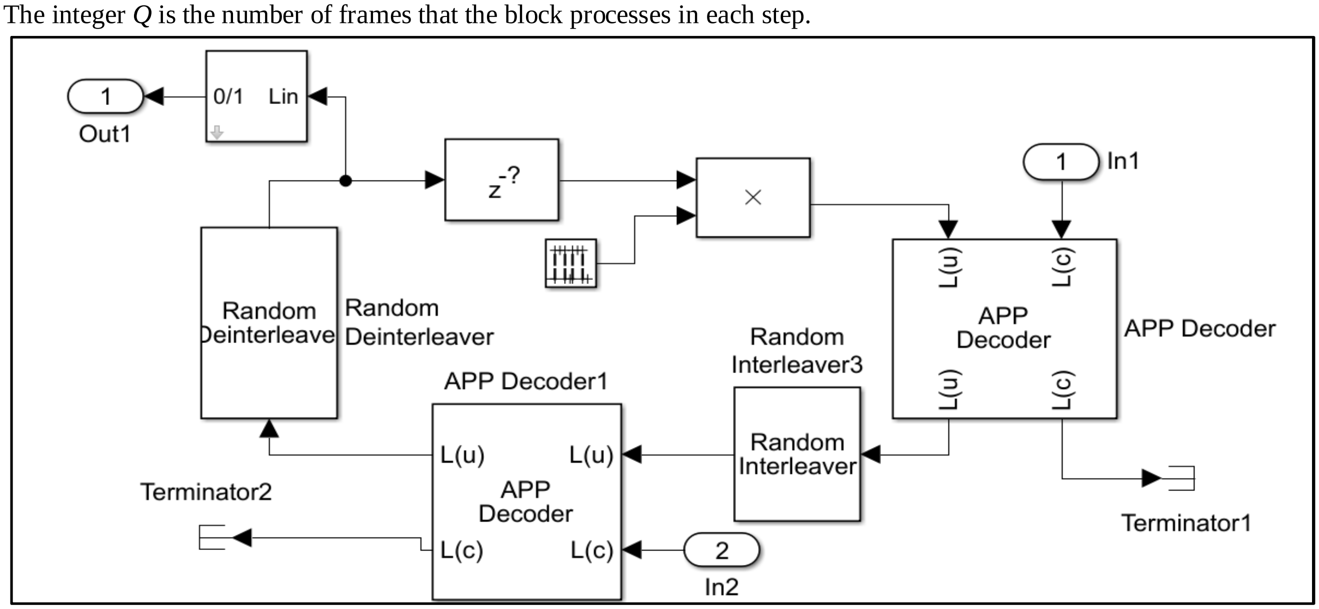


Fig. 4 Turbo Decoder created in simulink

The output of De-interleaver block is introduced as the L(u) input of the APP encoder. There is an intermediate computation for the upper APP encoder: the output from the Random De-interleaver is delayed n samples . Then, this is multiplied by a periodic signal of pulses with a period equal to 5 samples (our variable "Iter") and a width of 4 samples ("Iter-1"). This result is applied as the L(u) input of the upper APP Decoder. Finally, the output from this block is taken from the output of the second Random Deinterleaver and processed by a Hard Decision block which applies a mask based on the likelihood to binary transformation. A closer look at the turbo decoder and we find that the systematic channel observation

$y^{(s)}= \{y1^{(1)}, y2^{(1)}, ..., y\mathbf{N}^{(1)} \}$ is received by first decoder.

It also receives the observations of the first encoders parity bits

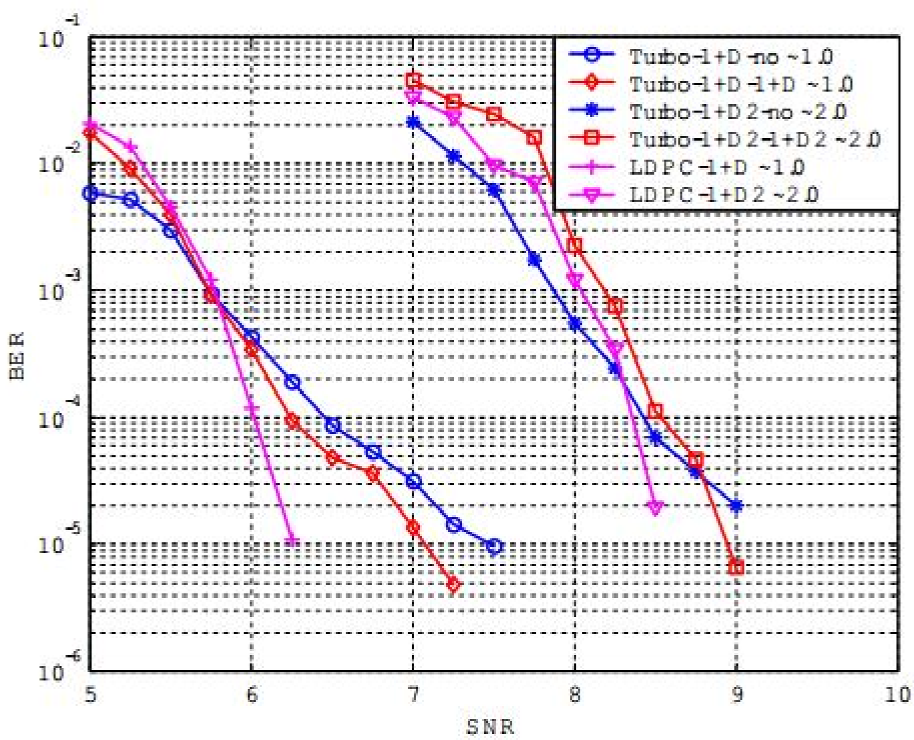
$y^{(p)}=\{y_1^{(2)}, y_2^{(2)}, ...,yn^{(2)}\}$

VI. ADAPTIVE MODULATION

Link adaptation is a key technology, required for using efficiently the available spectrum. Adapting the modulation order and power to the time-varying channel conditions was initially introduced, before joint bit and power loading was investigated. Since then, link adaptation has been extended into frequency domain and has become an essential feature for enhancing spectral efficiency in orthogonal frequency division multiplexing (OFDM) systems. Given a channel code, information theoretic analysis of the properties of bit-interleaved code words leads to so-called *effective* signal-to-noise ratio (SNR) values, which capture the short-term channel fading. The reason for adaptive modulation is that , modulation schemes like QPSK , BPSK etc are robust only for lower SNRs as compared to other FEC techniques . for higher SNRs like 10 dB or above , QAM is adopted . be it 16 QAM or 64QAM etc.

VII. RESULT And DISCUSSION

From above graph it can be concluded that turbo codes provide astonishing result at lower SNR as compared to LDPC. Further research can be done by modifying codes for performing at higher SNR level by the use of AMC(Adaptive Modulation and coding). So as modulation schemes like BPSK AND QPSK provides good results at lower SNR where as 16 QAM and 64 QAM provide robust results on higher SNR like greater than 10 dB.



V. ACKNOWLEDGEMENTS

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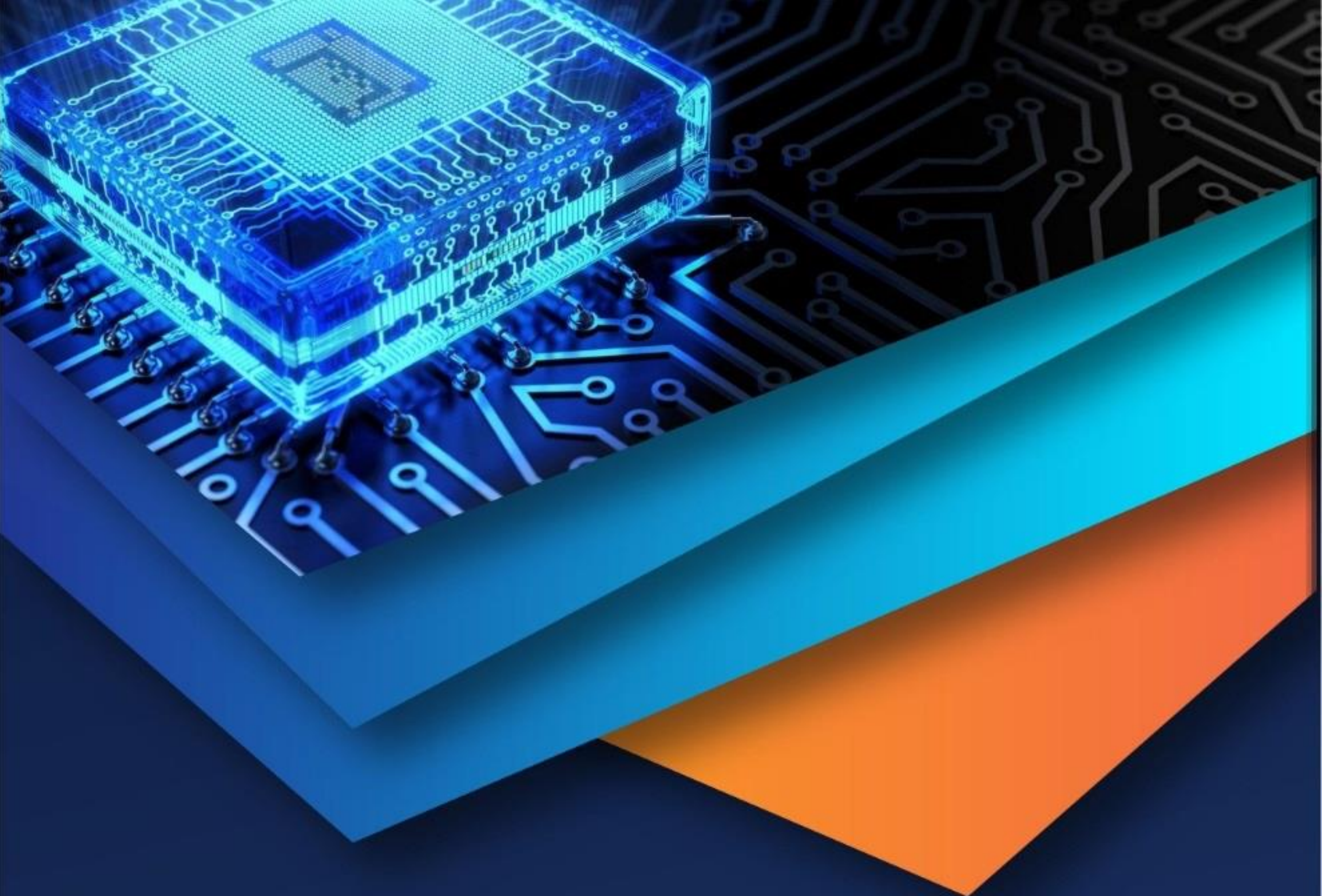

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