iJRASET
International Journal For Research in
Applied Science and Engineering Technology

# INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

**Volume:** 5 **Issue:** VI **Month of publication:** June 2017

**DOI:**

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

# An Efficient Design of Low Pass Fir Filter Using Kaiser, Parzen and Bartlett Hanning Window Technique

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***Abstract: In everyday enhancing field of signal processing has digital filter to play a vital role. Digital filters are widely used in the field of communication and computation purpose. On the other hand a digital finite impulse response (fir) filter that satisfying all the required condition is a challenge one. The fir filters are used in vast number of application due to their nature of frequency stability. In this paper, our main aim is to design fir filter using kaiser, parzen and bartlett hanning window techniques. The analysis is done with respect of frequency, phase, magnitude response of proposed low pass filter of order 10 by matlab simulation. On the basis of analysis kaiser window technique shows better magnitude response and parzen window shows bette step and impulse response.***
***Keyword: Dsp, Fir, Digital Filters Kaiser, Parzen And Bartlett Hanning Window, Low Pass Fir Filter***

## I. INTRODUCTION

The main aspect of Digital Signal Processing (DSP) is to manipulate various types of signals with the objective of filtering, measuring, or compressing and producing analog signals. Analog signals may vary by taking information and interpreting it into electric pulses of varying amplitude, whereas digital signal information is translated into binary format where each and every bit of data is symbolized by two distinguishable amplitudes. Another noticeable dissimilarity is that analog signal can be represented as square waves. DSP techniques are broadly used in many areas which includes speech processing, RADAR, SONAR etc. these techniques are applied in audio and video processing, aerospace, defense equipments, telecommunication, automatic control processing, spectral analysis, channel vocoders, homomorphics processing system, speech synthesizer, linear prediction system, analyzing the signals in RADAR tracking, etc. Digital filters play very vital role in DSP. A filter is essentially a network that selectively changes the wave shape of a signal in a desired manner. The objective of filtering is to improve the quality of the signal (for example to remove noise) or to extract information from signal. A digital filter is a mathematical algorithm implemented in harware/ software that operates on a digital input to produce a digital output[1].

### *A. Fir Filter*

Digital filters often operate on digitized analog signals stored in a computer memory. Digital filters are classified either as **Finite** duration unit pulse response (FIR) filters or Infinite duration unit pulse response (IIR) filters, depending on the form of the unit pulse response of the system. In the FIR system, the impulse response sequence is of finite duration, i.e. it has a finite number of non zero terms. The IIR system has an infinite number of non zero terms, i.e. its impulse response sequence is of infinite duration. The system with the impulse response has only a finite number of non zero terms. IIR filters are usually implemented using structures having feedback (recursive structures- poles and zeroes) and FIR filters are usually implemented using structures with no feedback (non recursive structures-all zeroes)[4].

An FIR filter of length M is described by the difference equation

$$\boldsymbol{Y(n) = \sum_{k=0}^{M-1} b_k x(n-1)} \quad \text{……………………………………………………………………………}(1)$$

Where, $\{b_k\}$ is the set of filter coefficient. From the difference equation we can observe that the response of FIR filter depends only on the present and past input samples. There are four types of FIR filters as

*B.* Low Pass Filter
*C.* High Pass Filter

*D.* Band Pass Filter
*E.* Band Stop Filter

There are essentially three well known methods for FIR filter design namely:
The window method
The frequency sampling technique
Optimal Filter Design Method

*F. Window Techniques*

The equivalent noise, bandwidth, processing gain, worst- case processing loss, and minimum resolution are considered for choosing suitable window. The desired frequency response of any digital filter is periodic in frequency and can be expanded in a fourier series, i.e.

$$(e^{j\omega}) = \sum_{n=-\infty}^{\infty} h_d(n) e^{-j\omega} \quad \ldots(2)$$

where,

$$h(n) = \frac{1}{2\pi}\int_0^{2\pi} H(e^{j\omega}) e^{j\omega n} d\omega \quad \ldots(3)$$

The Fourier coefficient of the series h(n) are identical to the impulse response of the digital filter. There are two difficulties with the implementation of above equation for designing a digital filter. First, the impulse response is of infinite duration and second, the filter is non- causal and unrealizable. No finite amount of delay can make the impulse response realizable hence the filter resulting from a Fourier series representation of $H(e^{j\omega})$ is an unrealizable IIR filter. Some of the window functions are Rectangular, Bartlett, Hanning, Hamming, Kaiser, Bartlett- Hanning, Parzen and Blackman Window[4].

*G. Kaiser Window Function*

The window function of a Kaiser window is given by

$$w_k(n) = \begin{cases} \frac{I_0(\beta)}{I_0(\alpha)}, & for\ |n| \le \frac{M-1}{2} \\ 0, & otherwise \end{cases} \quad \ldots(4)$$

Whre, α is an independent variable determined by Kaiser. The parameter β is expressed by

$$\beta = \alpha\left[1-\left(\frac{2n}{M-1}\right)^2\right]^{0.5} \quad \ldots(5)$$

The modified Bessel function of the first kind, $I_0(x)$, can be computed from its power series expansion given by

$$I_0(x) = 1 + \sum_{k=1}^{\infty}\left[\frac{1}{k!}\left(\frac{x}{2}\right)^k\right]^2 \quad \ldots(6)$$

*H. Parzen Window Function*

The following equation defines the N- point Parzen window over the interval $-\frac{(N-1)}{2} \le n \le \frac{(N-1)}{2}$ [2]

$$\omega(n) = \begin{cases} 1-6\left(\frac{|n|}{N/2}\right)^2 + 6\left(\frac{|n|}{N/2}\right)^3, & 0 \le |n| \le (N-1)/4 \\ 2\left(1-\frac{|n|}{N/2}\right)^3, & (N-1)/4 \le |n|\,(N-1)/2 \end{cases} \quad \ldots(7)$$

*I. Bartlett Hanning Function*

The window function of a Kaiser window is given by [3]

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ISSN: 2321-9653

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$$w(n) = a_0 - a_1\left|\frac{n}{N-1} - \frac{1}{2}\right| - a_2\cos\left(\frac{2\pi n}{N-1}\right) \quad (8)$$

## II. SIMULATION

Table 1: Parameter Specification

| PARAMETERS | VALUES |
|---|---|
| Sampling frequency(Fs) | 48000 |
| Cutt off frequency(Fc) | 10800 |
| ORDER(N) | 10 |

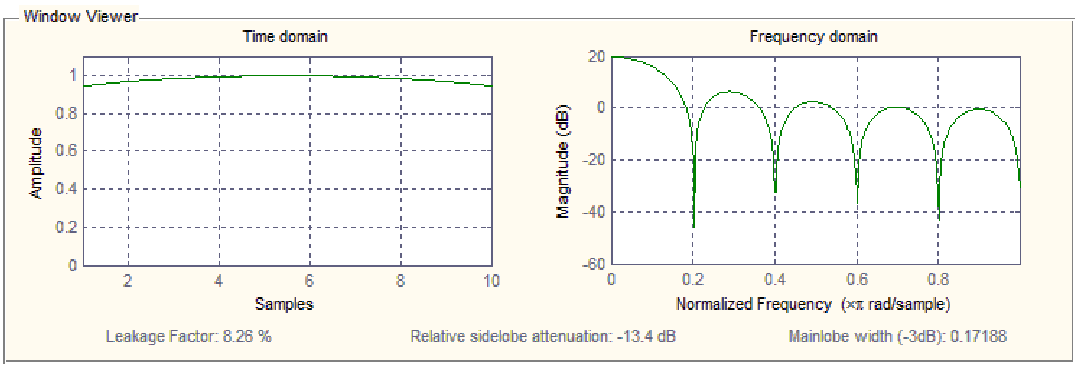


Figure 1: Time and frequency domain response of Kaiser window

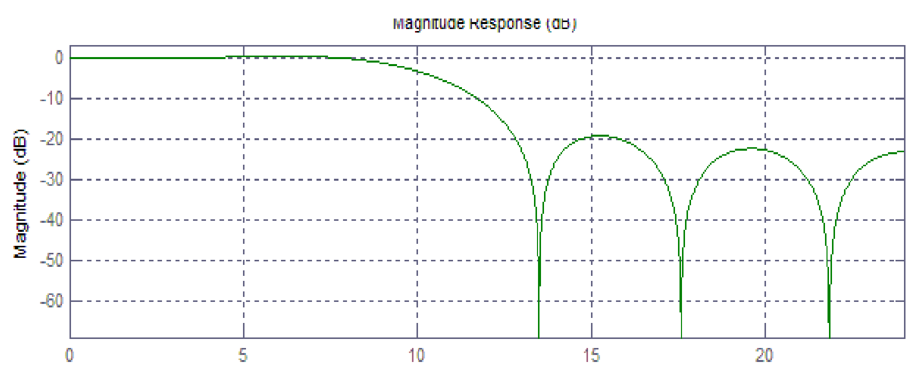


Figure 2: Magnitude response of Kaiser window

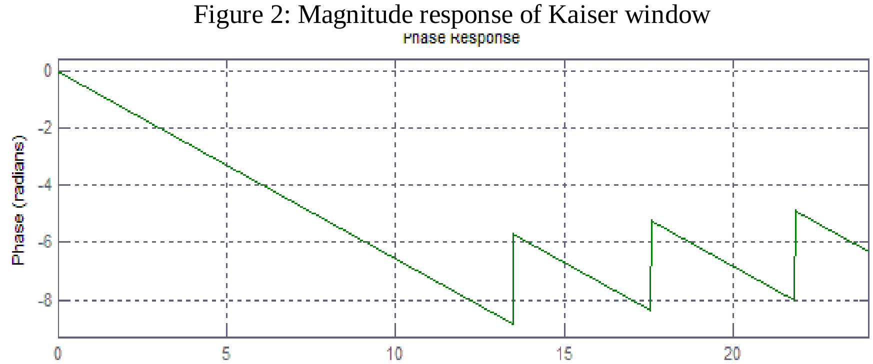


Figure 3: Phase response of Kaiser window

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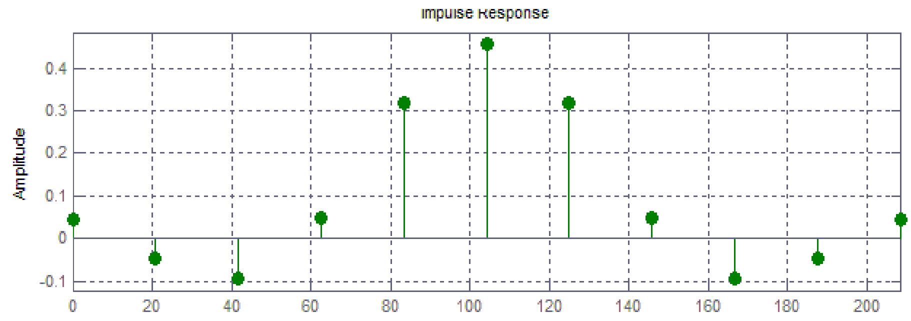


Figure 4: Impulse response of Kaiser window

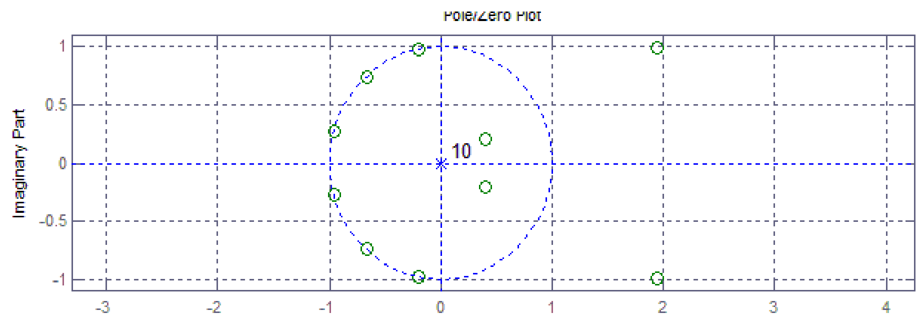


Figure 5: Pole zero response of Kaiser window

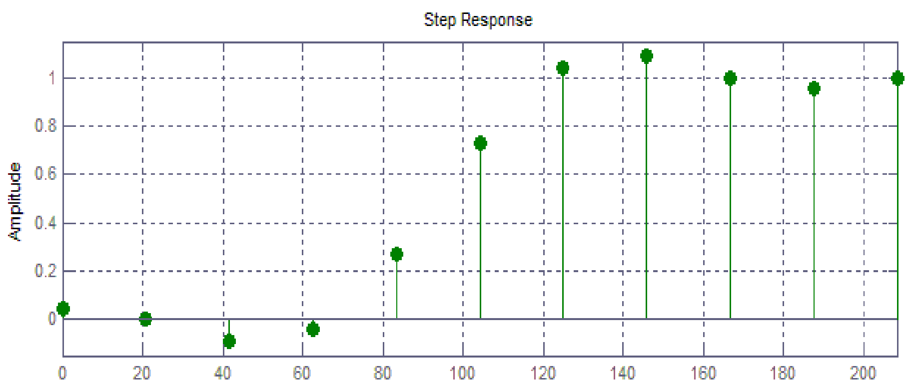


Figure 6: Step response of Kaiser window

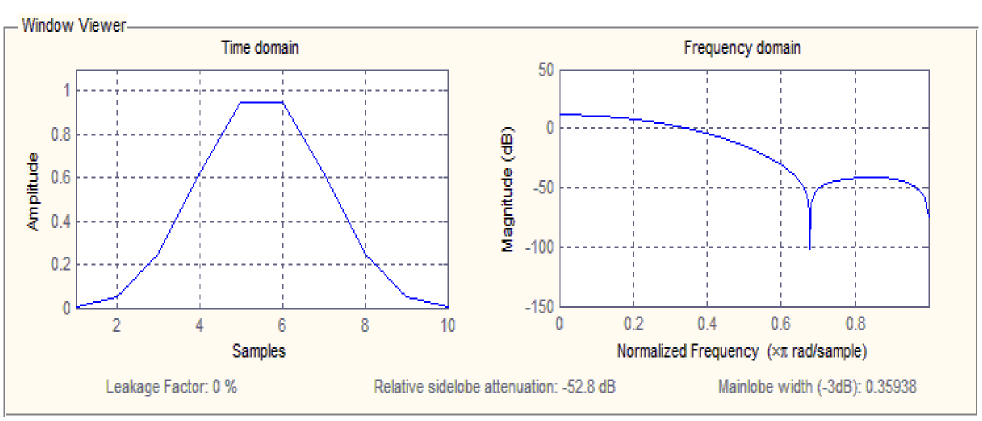


Figure 7: Time and frequency domain response of Parzen window

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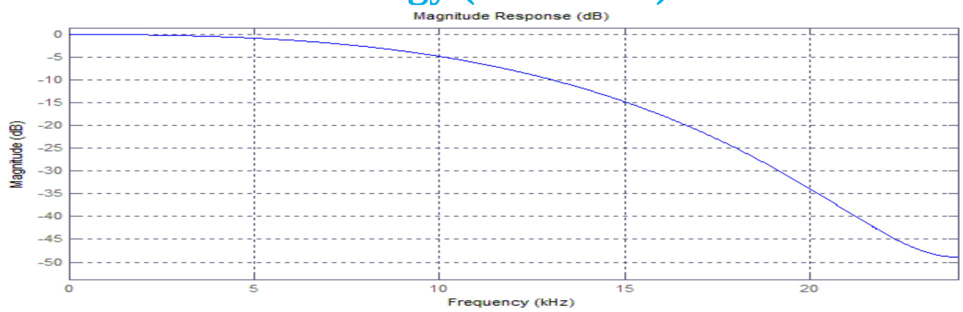


Figure 8: Magnitud response of Parzen window

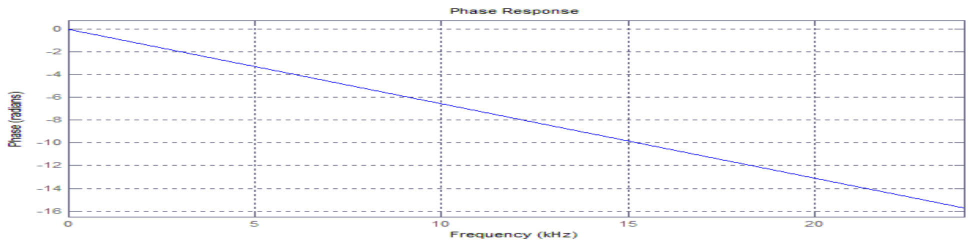


Figure 9: Phase response of Parzen window

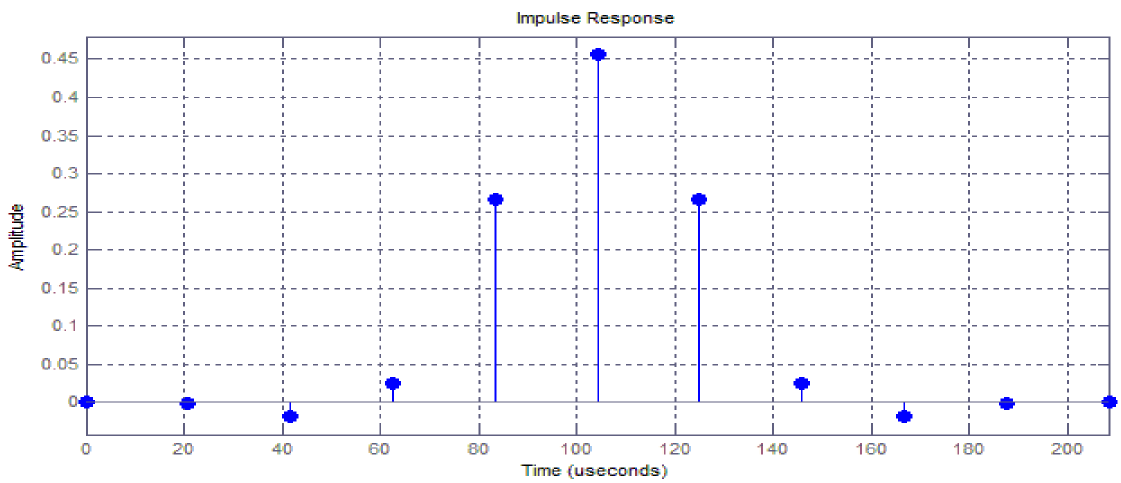


Figure 10: Impulse response of Parzen window

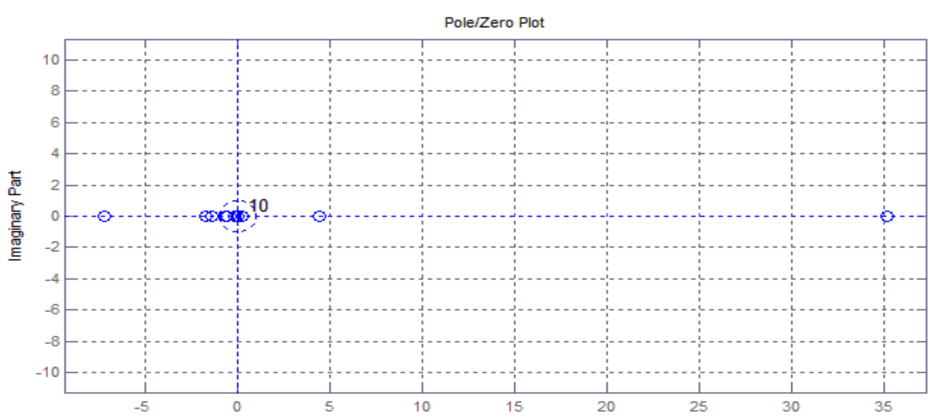


Figure 11: Poles and zeroes response of Parzen window

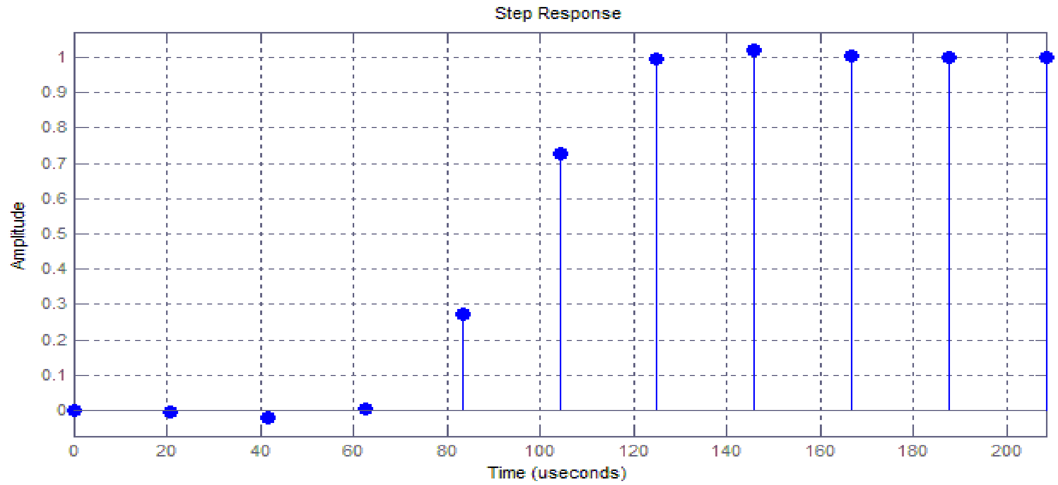


Figure 12: Step response of Parzen window

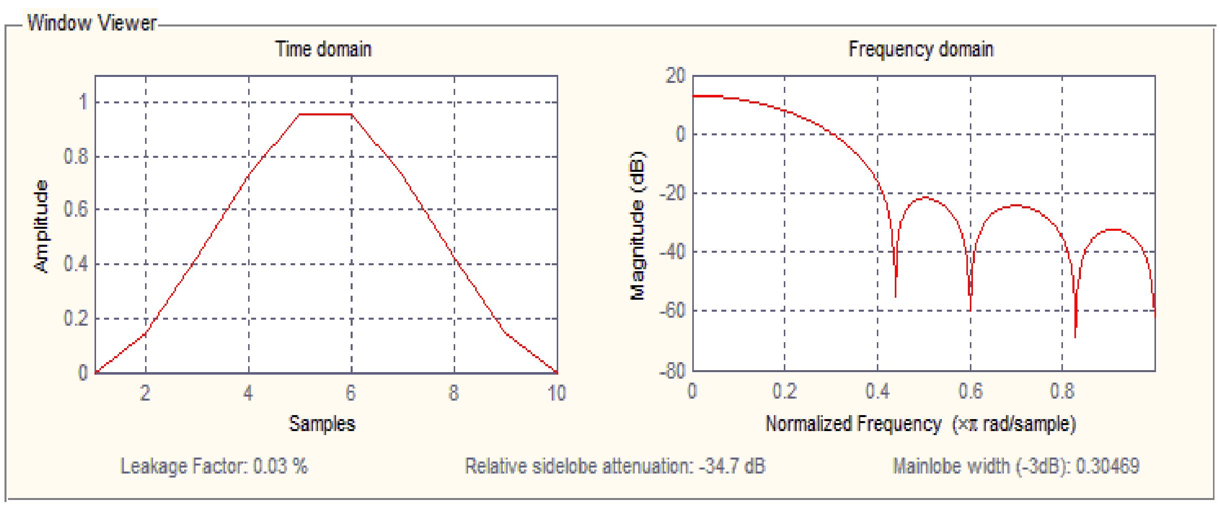


Figure 13: Time and frequency domain response of Bartlett Hanning window

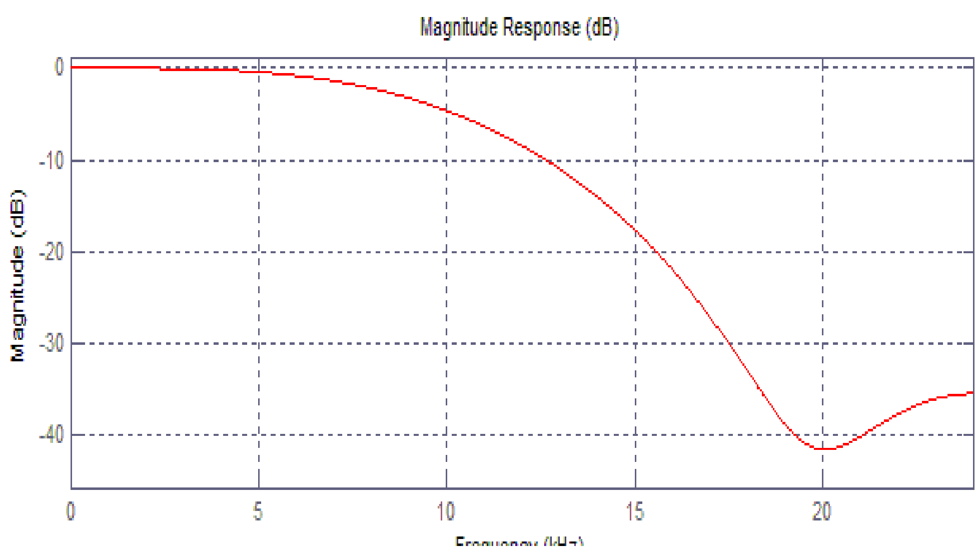


Figure 14: Magnitude response of Bartlett Hanning window

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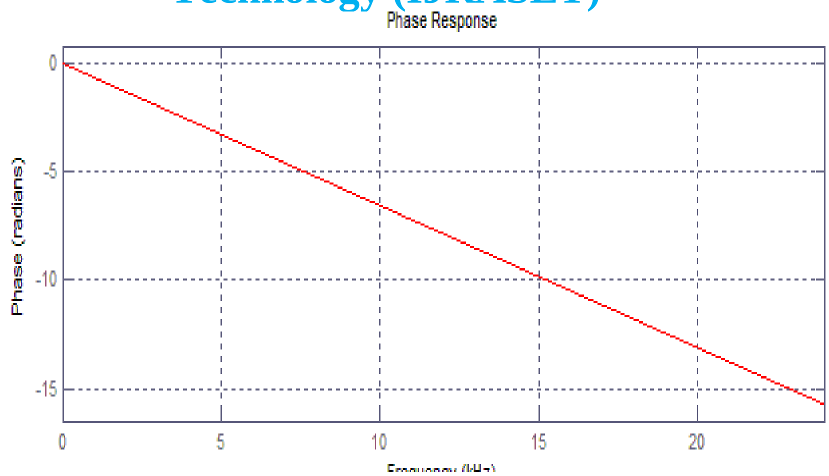


Figure 15: Phase response of Bartlett Hanning window

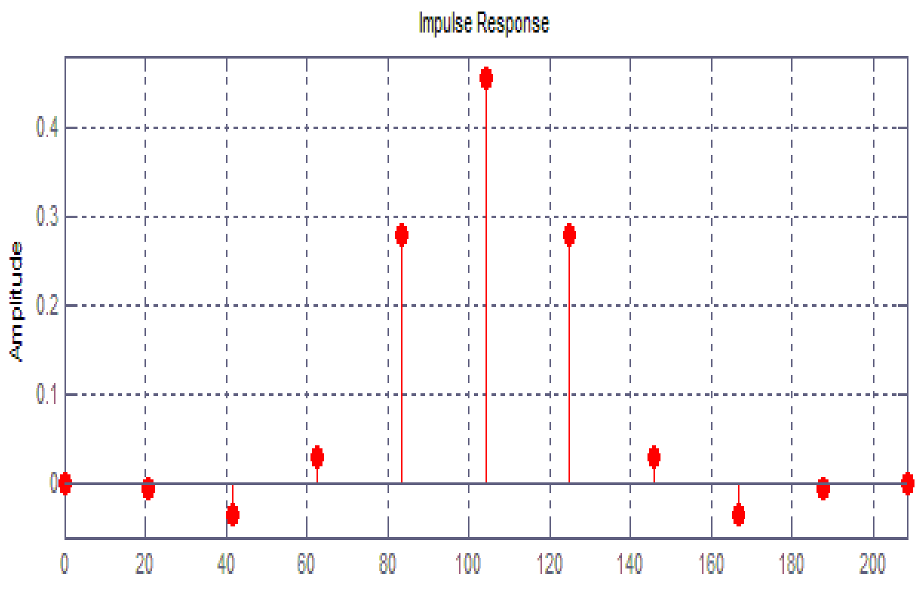


Figure 16: Impulse response of Bartlett Hanning window

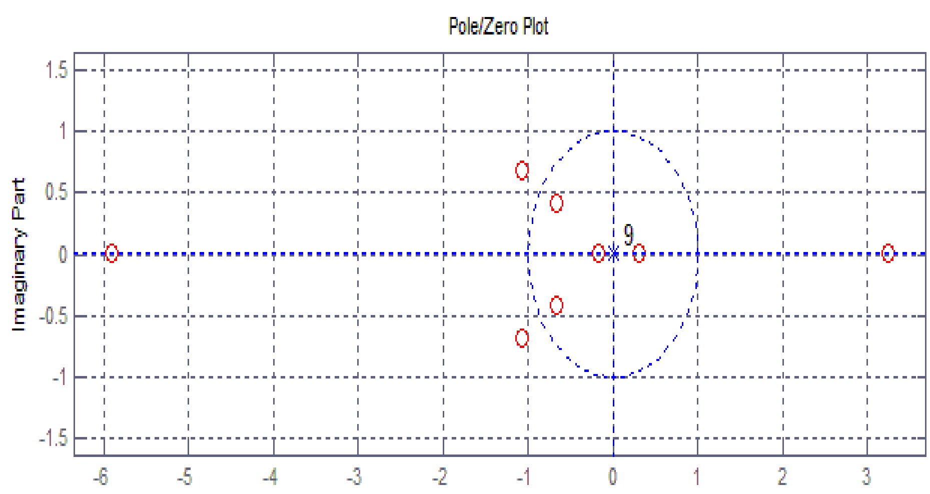


Figure 17: Poles zeroes response of Bartlett Hanning window

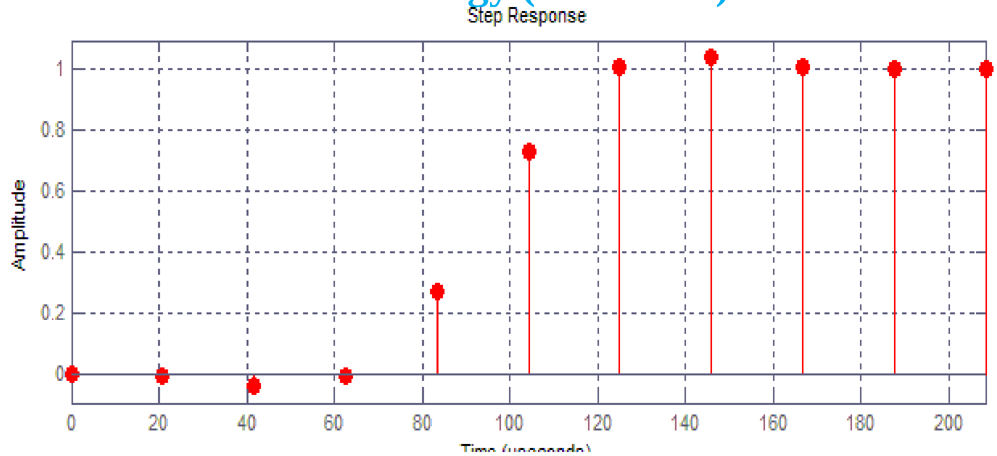


Figure 18: Step response of Bartlett Hanning window

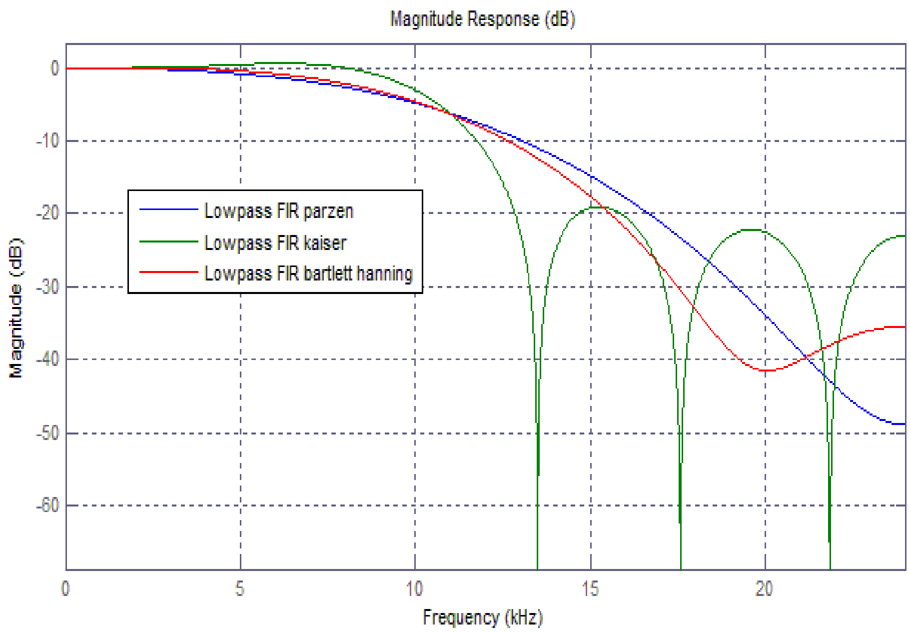


Figure19: Magnitude response comparison of above three window techniques

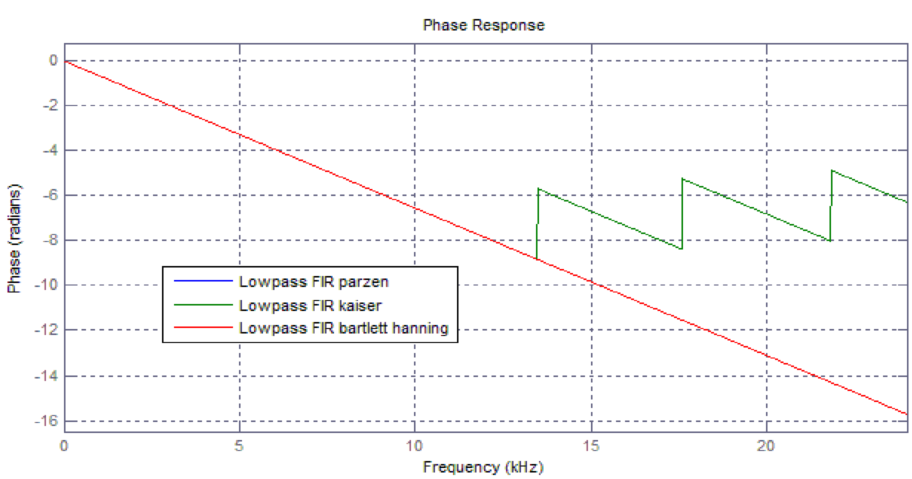


Figure20: Phase response comparison of above three window techniques

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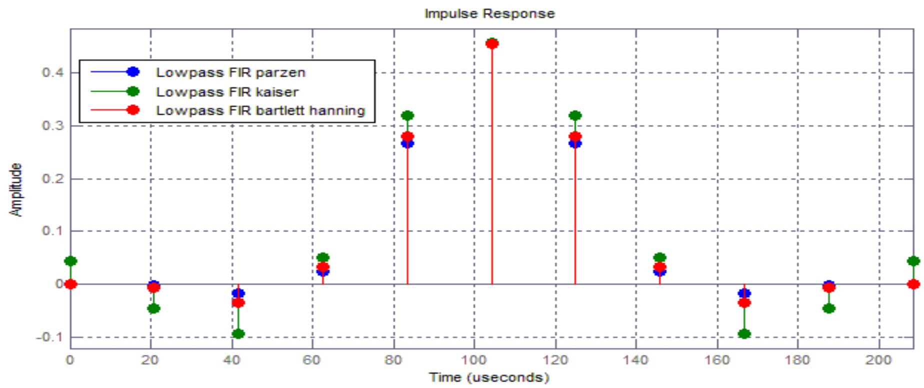


Figure 21: Impulse response comparison of above three window techniques

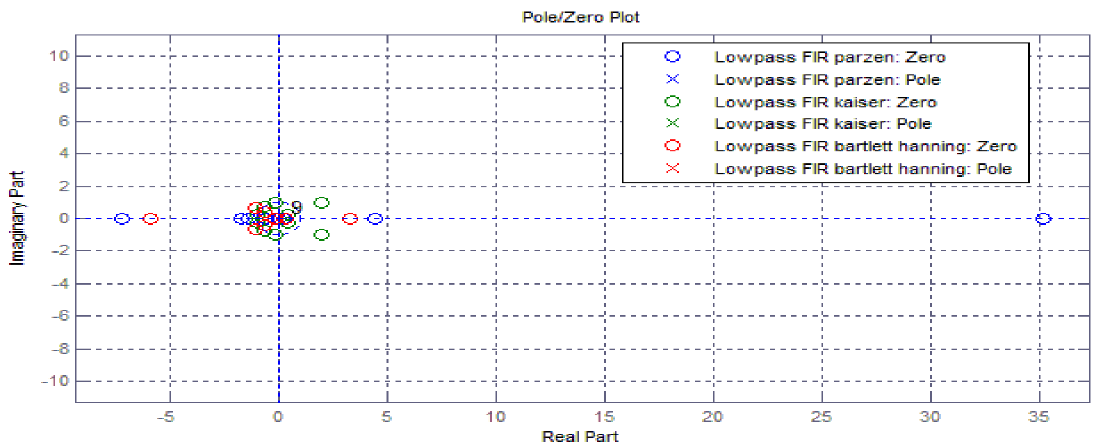


Figure 22: Pole zero response comparison of above three window techniques

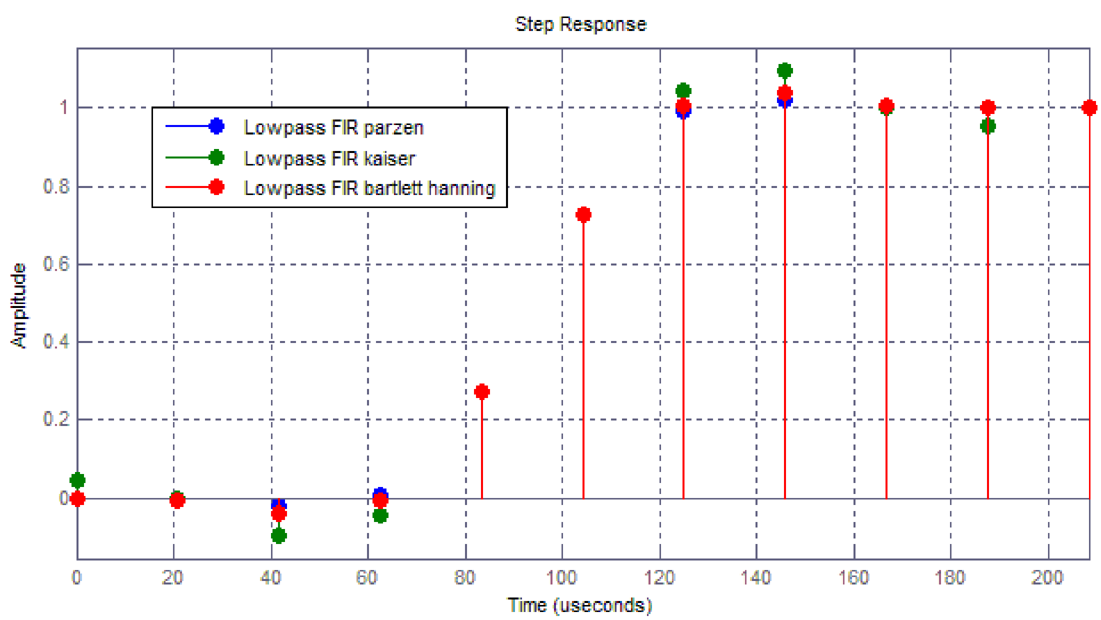


Figure 23: Step response comparison of above three window techniques

By using MATLAB 7.12.0 (R2011a) simulation technique we design all above simulation of LOW PASS FIR FILTER USING

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KAISER, PARZEN AND BARTLETT HANNING WINDOW TECHNIQUES. All above figure of responses shows difference about filters in form of simulation which are time domain and frequency domain. Magnitude response, phase response, impulse response, step response, pole/zero plot or filter coefficient respectively.

Then we done comparative analysis of our filter which is combined figure shows at above simulation.

## III. RESULTS

Table 2: Simulation result in MATLAB

| WINDOW TECHNIQUE | LEAKAGE FACTOR (%) | RELATIVE SIDELOBE ATTENUATION(dB) | MAINLOBE WIDTH ( -3dB) |
|---|---|---|---|
| KAISER | 8.26 | -13.4 | 0.17188 |
| PARZEN | -0 | -52.8 | 0.35938 |
| BARTLETT HANNING | 0.03 | -34.7 | 0.30469 |

In Parzen window beta value is increase then mainlobe width is increases but leakage factor is decreases. When leakage factor is 0% in Parzen window then wider mainlobe width(0.35938).

"Interpretation of above table 1 shows parameter specification of windows designing of low pass filters using Kaiser, Parzen and Bartlett Hanning window. Sampling frequency is 48000 Hz and cutoff frequency is 10800 Hz. Filter order is 10."

Table 3: Magnitude and frequency response comparison of Kaiser, Parzen and Bartlett Hanning window techniques

| Frequency(KHz) | Kaiser | Parzen | Bartlett Hanning |
|---|---|---|---|
| 1 | 0.07405 | -0.03808 | -0.00348 |
| 2 | 0.18000 | -0.15397 | -0.02257 |
| 3 | 0.14990 | -0.35731 | -0.07611 |
| 4 | -0.02091 | -0.66509 | -0.22055 |
| 5 | -0.12417 | -1.10122 | -0.41619 |
| 6 | 0.04750 | -1.66568 | -0.83420 |
| 7 | 0.40324 | -2.40507 | -1.42053 |
| 8 | 0.47407 | -3.33341 | -2.18925 |
| 9 | -0.37298 | -4.47706 | -3.52122 |
| 10 | -2.65324 | -5.84326 | -4.95286 |

Table 4: Phase and frequency response comparison of Kaiser, Parzen and Bartlett Hanning window techniques

| Frequency(KHz) | Kaiser | Parzen | Bartlett Hanning |
|---|---|---|---|
| 1 | -1.02566 | -0.03795 | -0.002287 |
| 2 | -2.03561 | -0.13245 | -0.01810 |
| 3 | -3.03215 | -0.27271 | -0.07216 |
| 4 | -4.01646 | -0.48523 | -0.18783 |
| 5 | -5.02564 | -0.83477 | -0.41356 |
| 6 | -6.02546 | -1.33642 | -0.79501 |
| 7 | -7.02351 | -1.89138 | -1.42258 |
| 8 | -8.02156 | -2.71224 | -2.22771 |
| 9 | -9.03642 | -3.77362 | -3.37719 |
| 10 | -10.05515 | -4.84115 | -4.59553 |

## IV. CONCLUSIONS

In this paper FIR low pass filter has been designed and simulated using Kaiser, Parzen and Bartlett Hanning window technique and then compared. In signal processing applications digital filters are more preferable than analog filters. The digital filters are easily

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ISSN: 2321-9653


designed and also easy to use in various types of signal filtering applications. The choice of technique to design a filter depends on the decision of the designer whether to compromise accuracy of approximation or ease of design.

From the magnitude, impulse, step and phase response of the three window techniques can be concluded that Kaiser window has best result for the magnitude response as it reaches the zero first in comparison to other two techniques. On the other hand in the impulse and the step response Parzen window shows more stability near the zeros value as compared to the another techniques.

On comparing the leakage factor we conclude that the Kaiser window technique has the maximum leakage factor and the Bartlett Hanning window technique gives the minimum leakage factor.

## REFERENCES

[1] Parul Shrivas, Kiran Kanwar, "An Efficient Design of Low Pass Fir Filter Using Rectangular and Hanning Window Technique", IJREST International Journal for Research in Emerging Science and Technology, Vol. 3, E-ISSN: 2349-761, Issue-8, Aug-2016.

[2] Girdhar Chandra, Nidhi Sahu, Rashmi Sahu, "Design of Low Pass Fir Filter Using Parzen and Nuttall Window Techniques" , IJREST International Journal for Research in Emerging Science and Technology, Vol. 3, E-ISSN: 2349-761, Issue-8, Aug-2016

[3] C. Uthayakumar, B. Justus Rabi, "Design of FIR filter using Window Method", IPASJ International Journal of Electronics and Communication, Vol. 2, ISSN 2321-5984, Issue 10, Oct' 2014.

[4] Manira Khatun, "Implement a new window function and design FIR filters by using this new window", IJECS International Journal of Engineering and Computer science, vol. 3, ISSN 2319-7242, pp. 4087-4090, Issue 3, Mar' 2014.

[5] S Salivahanan, C Gnanapriya, A Vallavaraj, "digital signal processing" Tata McGraw-Hill, 2nd Edition pp.3, 443- 448.

[6] Nikhil Agrawal, G Laxmi Sagar, Rahul Suryawanshi, "Designing a Low- Pass Fir Digital Filter By Using Rectangular Window and Bartlett Window Technique", International Journal for Research in Emerging Science and Technology, Vol. 3, E-ISSN: 2349-7610, Issue-5, May-2016

[7] Tao Zhang, "Research on design FIR digital filter using MATLAB and Window Function method" , Journal of Theoretical and Applied Information Technology, Vol. 48, ISSN: 1992-8645, 10th Feb. 2013, No.1 © 2005 – 2013.

[8] Sonika Gupta, Aman Panghal, Performance Analysis of FIR Filter Design by Using Rectangular, Hanning and Hamming Windows Methods", Vol. 2, ISSN: 2277-128X, Issue 6, June 2012.

[9] A Nagoor Kani, "digital signal processing" McGraw-Hill Education, 2nd Edition.

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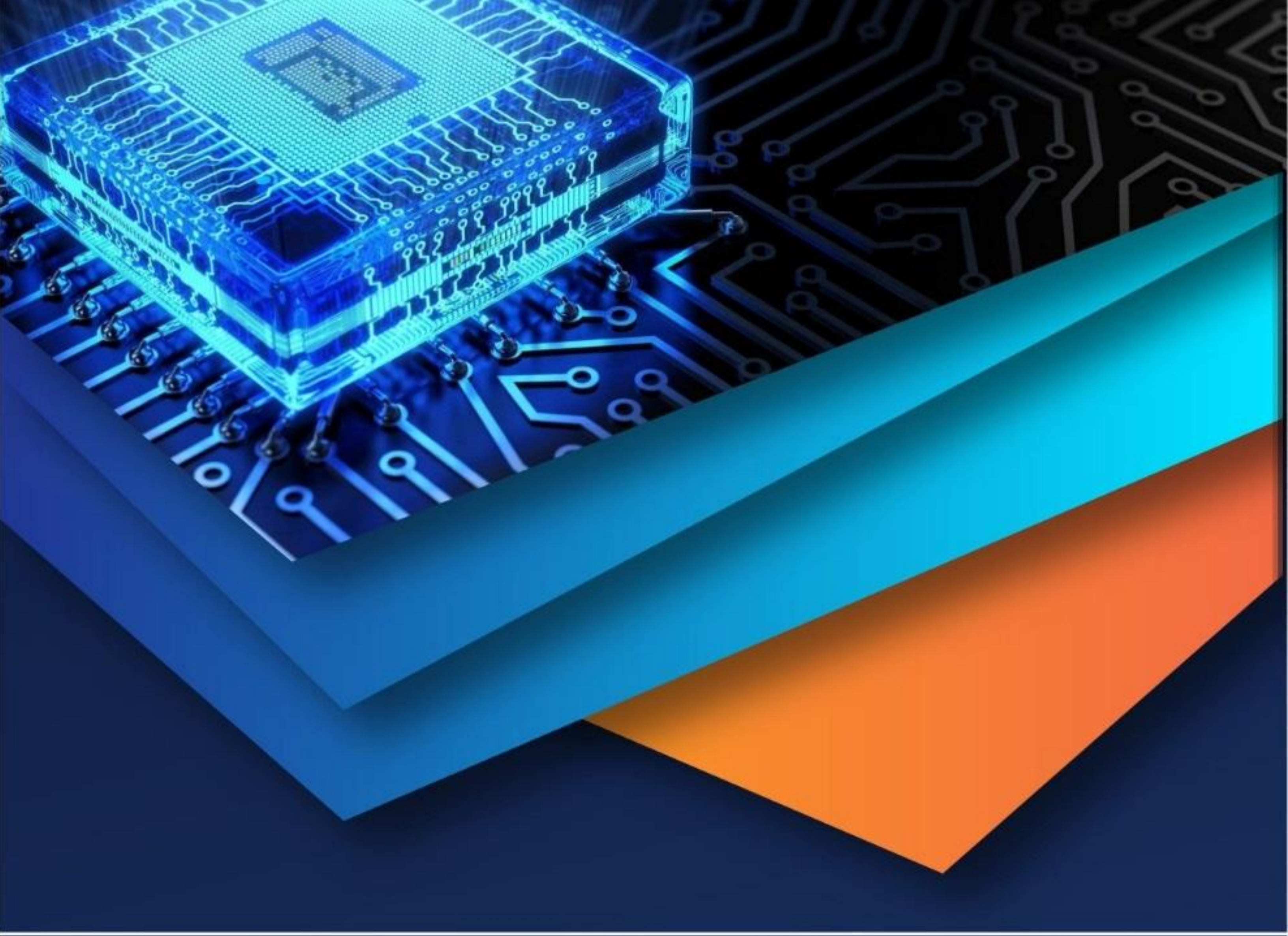


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