

M-ary phase-shift keying using finite impulse response filter based on window function method

Raed S. M. Daraghma

Department of Electrical and Electronics Engineering, Palestine Technical University (Kadorrie), Palestine

Article Info

Article history:

Received Nov 27, 2019

Revised Jun 29, 2020

Accepted Jul 11, 2020

Keywords:

Bit error rate

FIR filter

M-ary phase-shift keying (MPSK)

Window function

ABSTRACT

Digital filters are vastly utilized in the area of communication. A perfect digital filter efficiency is significant and hence to design a digital finite impulse response filter (FIR) favorable all the wanted situations is necessary. In this paper, a new proposed FIR digital filter designed, the fineness of the submitted filter is tested in terms of BER and then matched with another window, namely Hamming, Hanning, and Blackman. The design procedure done in the MATLAB software. It is concluded that the Blackman window is the best window to design the FIR digital filter, because it is bit error rate is better than another window.

This is an open access article under the [CC BY-SA](https://creativecommons.org/licenses/by-sa/4.0/) license.



Corresponding Author:

Raed S. M. Daraghma,
Department of Electrical and Electronics Engineering,
Palestine Technical University (Kadorrie),
Tulkam, Palestine.
Email: R.daraghmeh@ptuk.edu.ps

1. INTRODUCTION

Digital filters can be classified in infinite response (IIR) digital filter and finite impulse response (FIR) digital filters. An FIR method has many profitable features, such as only zeros, system stability, rapid working velocity, linear phase advantages and layout elasticity, so FIR has been vastly utilized in digital audio, image processing, data conveyance and other domains. In paper [1], the author designed OFDM to compact the influence of multipath reception, by splitting the broadband frequency-choosing channel to numerous strict level sub channels, which progresses the spectral capacity, and he discussed the rendering of several window functions. In paper [2], the author developed a fresh two-parameter window gained by the compound of two windows, recognized as exponential and hamming, outcomes offer that the submitted window can supply preferable ripple ratio than other windows. In paper [3], the author compared the signal's magnitude frequency outlines, which have been produced the filter influence of several digital filters, various processes such as frequency sampling, window function and convex optimization mechanism are operated employing MATLAB in the styling of FIR filter. In paper [4], the author used MATLAB to define filter parameters and simulate FIR band pass filters via window function procedure. The outcomes demonstrated that the performance of the prepared filter attains the specific demands. In paper [5], author proposed a new adaptable window function, established from integration of tangent hyperbolic function and measured cosine sequence, the filter prepared utilizing the submitted window mode minimizes additive white Gaussian noise from the ECG signal more accurately than Kaiser window.

In paper [6], the execution of Hamming, Hanning window has been examined considering their extent reaction, stage reaction, proportional commotion data transfer capacity, side flap move width,

the reaction in time and recurrence space utilizing MATLAB. In paper [7], the author presented FIR filter design by different window functions, he included that Blackman window is the perfect, since its side lobe make efficient than another window. In paper [8], the author modified a modern window function for FIR filter with a progressed frequency response. The window function was produced and applied to calculate the frequency response of distinct kinds of FIR filters. In paper [9], the author worked in time domain unit sample response, frequency domain response of sine function is examined. The output of FIR layout by Blackman window and Hamming window are done in his paper. In paper [10], the author presented FIR digital filter using Hamming window method, this window is optimized to decrease the extreme side lobe. In paper [11], the author reviewed different kinds of windows like: Triangular, Rectangular, Hanning, Hamming and Blackman, different properties in time and frequency domain discussed; different side lobe attenuation and transition presented. In paper [12], author progressed frequency response for suppression side lobe attenuation; his proposed window has better performance matched to popularly utilized window such as hamming, Hanning and Blackman window. In paper [13], author presented a new function which used to design an FIR filter. The suggested window is matched with Hamming & Kaiser Window. The outcome indicates that, the suggested window improves side-lobe roll-off ratio than hamming & Kaiser Window. In paper [14], FIR filter is formulated in MATLAB employing equiripple mode and the same filter is connected on Xilinx Spartan goal region-programmable outlet array appliance employing VHDL. The outcomes of all the filters demonstrate the superiority of FIR filter with WT.

In paper [15], author used signal to noise and average power to compare ECG Signal, before and after filtering. The outcomes are measured utilizing Gaussian, Bartlett and Hann window established FIR filter. In paper [16], plan method of lowpass FIR filter employing different window methods are introduced. The fundamental goal of this paper is to examine the stability, filter arrangement and the filter degree for various window techniques. The results demonstrate that the superiority of filter layout by utilizing hamming window technique since it has better performance in terms of stability and a linear phase. In paper [17], author introduced the definition and fundamental concepts of FIR digital filters, and the planning techniques formed on MATLAB. After the depiction of the procedure of layout of a FIR band-pass filter, the outcomes show that different performance of the designed FIR filter attain the specified desired, the destined technique is easy. In paper [18], a comparative analysis of speech signal is performed using different window techniques. It can be gained from the simulated outcomes that Blackman window holds nearly multiple power as matched to Hamming and Hanning window.

In paper [19], author designed mechanisms of digital low pass FIR filters employing rectangular window technique, Hamming window, Hanning window, and optimal Parks McClellan technique are given. The stability, figure of elements needed and filter coefficients explained for distinct layout methods. In paper [20], author given comparative survey of different filters using distinct window. It has been noticed that Kaiser window is better for noise free signal. In paper [21], author given the definition and main concepts of FIR digital filters, the matlab program is employed to perform FIR filter using revised coefficient of hamming window function and compute the equivalent noise bandwidth. In paper [22], author compared the frequency response of the adjusted window with that of Hamming window with quantized and popularized empirical outcomes. In paper [23], author used low-pass FIR filter in the speech filtering implementation. The filter is used to a recorded speech signal to take out high-frequency compositions of the speech signal. Signal comparison in time and frequency field between filtered speech and original speech proves that a high frequency composition of the main speech signal successively removes by utilizing this low pass filter. In paper [24], author analyzed different FIR filter design methods for realizing lowest level order. In paper [25], author presented various approaches of designing the FIR filter using Xilinx ISE tool.

In this Paper, we suggest a finite impulse response (FIR) digital filter set up on window function technique to attain M PSK. The suggested M PSK is simple to perform and its bit error rate (BER) performance matched to traditional M PSK. In addition, we matched the performance of several window functions performed in the M PSK including Hamming, Hanning and Blackman windows. In addition, the distinct window functions may result in several forms and coefficients such as bit error rate, which may assist us to select the suitable window function to plan the filter. The paper is coordinated as follows: in Section 2, we depict the fundamental M PSK concept and the purpose of FIR filter depend on window function, and hand some design standard for the digital FIR filter. Section 3 hands the simulation and analysis of M-ary phase-shift keying (MPSK) matched to traditional MPSK. This paper is ended with concluding comments in section 4.

2. M-PSK COMMUNICATION SYSTEM

In this part, we depict the principle M PSK link, the design of FIR digital filter depend on window function technique.

2.1. Communication link

The sending data is discrete binary flow; the signal wave is modulated in order to transmit it via communication link to mitigate the influence of noise. In LTE system, M-ary phase-shift keying (MPSK) is used. The binary digits 1 and 0 may be performed by the analog planes $+\sqrt{E_b}$ and $-\sqrt{E_b}$ respectively. The channel is additive white Gaussian noise (AWGN) wireless channel. The filter is $f(n)$ is FIR digital filter, which can employ distinct types of window functions. Moreover, the receiver is the opposite procedure of the sender. A whole M PSK connection is shown in Figure 1.

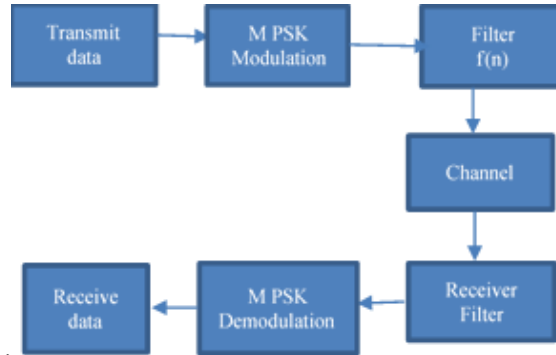


Figure 1. Block diagram of $M - PSK$ transmission-reception

The received signal for M PSK

$$y = \begin{cases} s_1 + n, & \text{when bit 1 is transmitted} \\ s_0 + n, & \text{bit 0 is transmitted} \end{cases} \quad (1)$$

The conditional probability distribution function (PDF) of y for the two states are:

$$p(y/s_0) = \frac{1}{\sqrt{\pi N_0}} e^{-\frac{(y+\sqrt{E_b})^2}{N_0}} \quad (2)$$

$$p(y/s_1) = \frac{1}{\sqrt{\pi N_0}} e^{-\frac{(y-\sqrt{E_b})^2}{N_0}} \quad (3)$$

Assuming that s_1 and s_0 are equally probable, the probability of error given s_1 is transmitted, will be given as:

$$p(e/s_1) = \frac{1}{2} \operatorname{erfc} \left(\sqrt{\frac{E_b}{N_0}} \right) \quad (4)$$

where

$$\operatorname{erfc}(x) = \frac{2}{\pi} \int_x^\infty e^{-x^2} dx \quad (5)$$

is the complementary error function.

Likewise, the probability of error given s_1 is transmitted as:

$$p(e/s_0) = \frac{1}{2} \operatorname{erfc} \left(\sqrt{\frac{E_b}{N_0}} \right) \quad (6)$$

The overall probability of bit error is:

$$p_b = \frac{1}{2} \operatorname{erfc} \left(\sqrt{\frac{E_b}{N_0}} \right) \quad (7)$$

2.2. Filter design

The output signal $\hat{s}(n)$ is taken by crossing the signal $s(n)$ during a filter $f(n)$, which can be depicted as a convolution method:

$$\hat{s}(n) = s(n) * f(n) \tag{8}$$

Subsequently, we utilize the window function technique to layout the FIR filter and we use a Hanning, Hamming and Blackman window. Hanning window function is given by:

$$H_{hn}(n) = \left(0.5 - 0.5 \cos\left(\frac{2\pi n}{N-1}\right)\right) R_N(n) \tag{9}$$

The Hamming window function is given by:

$$H_{hm}(n) = \left(0.54 - 0.46 \cos\left(\frac{2\pi n}{N-1}\right)\right) R_N(n) \tag{10}$$

The Blackman window function is:

$$H_B(n) = \left(0.42 - 0.5 \cos\left(\frac{2\pi n}{N-1}\right) + 0.08 \cos\left(\frac{4\pi n}{N-1}\right)\right) R_N(n) \tag{11}$$

where $R_N(n)$ is rectangular sequence.

Therefore, the FIR filter is:

$$f(n) = f_d(n) \cdot H(n) \tag{12}$$

where $H(n)$ one of the three-window function is, $f_d(n)$ is the ideal linear phase filter.

3. SIMULATION AND ANALYSIS

In this section, the performance of FIR digital filter with different window functions are examined. Different window functions is utilized in MPSK and its BER performance is given in Figures below. Figure 2 shows 4PSK BER curves in different window functions. We can see that the 4PSK without using any window functions is bad, we can draw conclusion that the performance of Blackman window is the best compared to hamming and hanning window. In Figure 3, we can find that the performance of all windows get bad (each window function needs more energy at the same bit error rate) because we increase the number of symbols from 1000 to 2000.

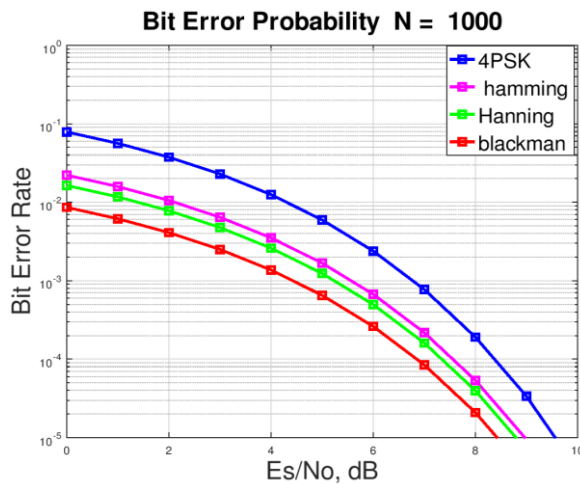


Figure 2. BER using distinct window functions compared to the traditional 4PSK, number of symbols = 1000

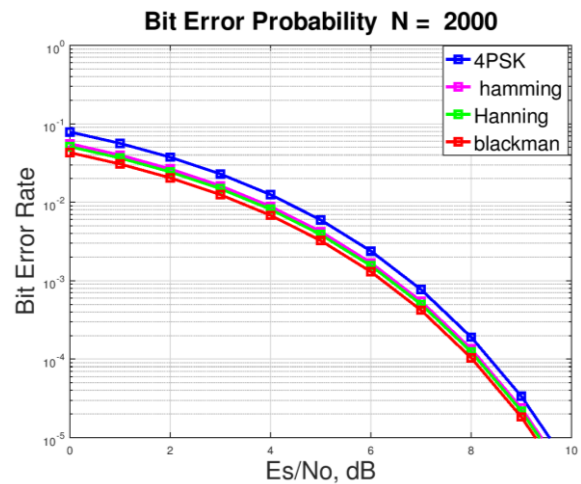


Figure 3. BER using distinct window functions compared to the traditional 4PSK, number of symbols = 2000

Figure 4 shows the Blackman window function is the best one. From Figure 5 it is obviously seen that the 8PSK has better performance for all window functions compared to 4PSK. Figure 6 shows a specific comparison of 16PSK without window function, Hamming, Hanning and Blackman. It is seen that the best performance in terms of bit error rate is a Blackman window. In Figure 7, it is obviously seen that the energy for all window functions are decreased, but the error was increased.

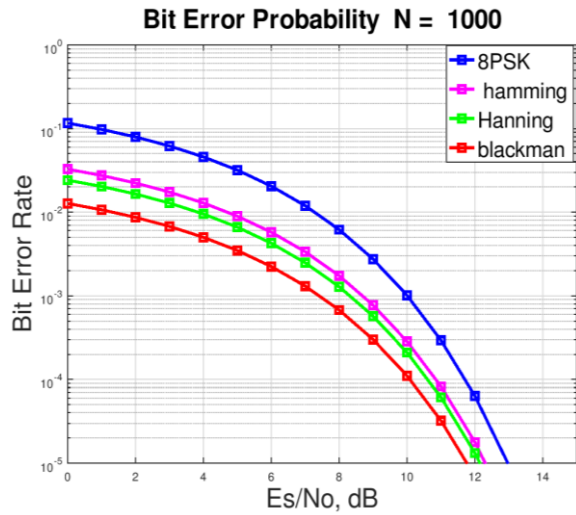


Figure 4. BER using distinct window functions compared to the traditional 8PSK, number of symbols = 1000

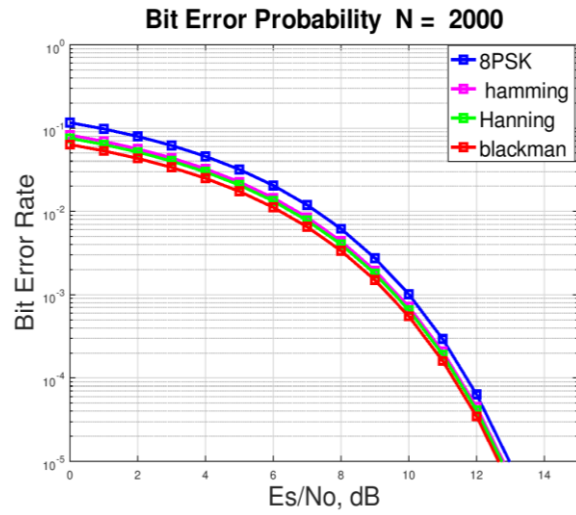


Figure 5. BER using distinct window functions compared to the traditional 8PSK, number of symbols = 2000

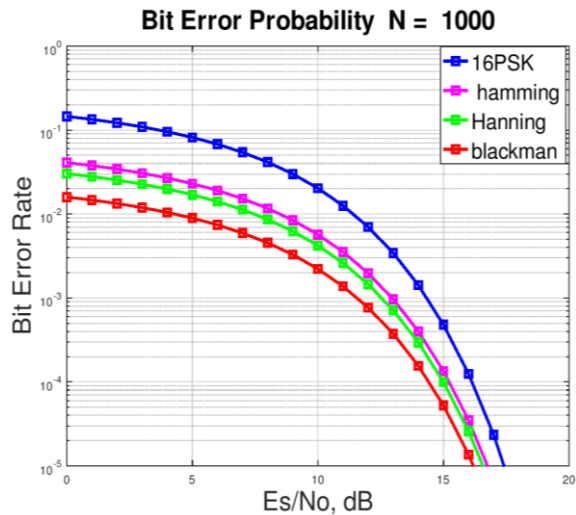


Figure 6. BER using distinct window functions compared to the traditional 16PSK, number of symbols = 1000

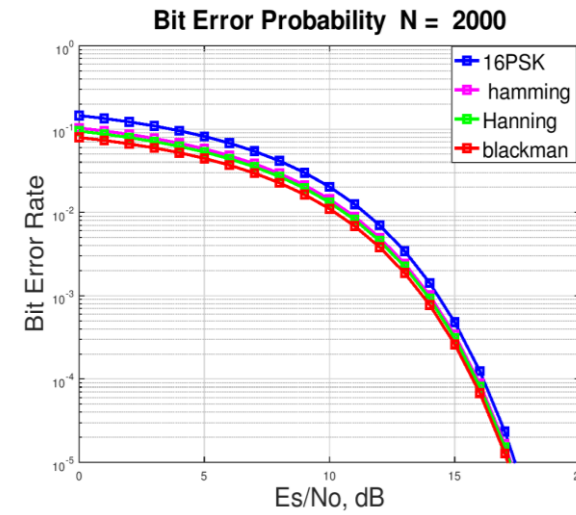


Figure 7. BER using distinct window functions compared to the traditional 16PSK, number of symbols = 2000

4. CONCLUSION

In this paper, we proposed a new filtered MPSK using window function FIR filter. The MPSK signal is achieved by convoluting the orginial MPSK signal with the FIR filter. The performance of distinct window functions has been examined. Comparatively, the blackman has better with MPSK performance in terms of bit error rate than hamming and hanning window functions. The blackman should be our first choice.

ACKNOWLEDGEMENTS

We would say to thank for that support our research. We sincerely thank the anonymous reviewers for their constructive comments and suggestions. I never forget, my deep thank for my university: Palestine Technical University Kadoorei (PTUK).

REFERENCES

- [1] X. Cheng, et al., "A Filtered OFDM Using FIR Filter Based on Window Function Method," *83rd Vehicular Technology Conference (VTC spring)*, pp. 1-5, 2016.
- [2] Kemal A. V. C. I., "Design of FIR Filters using exponential Hamming Window Family," *Turkish Journal of Electrical Engineering and Computer Sciences*, vol. 24, no. 4, pp. 2513-2524, 2016.
- [3] M. Iqbal, et al., "Analysis and Design of FIR Filters using Window Function in MATLAB," *International Journal of Computer Engineering and Information Technology*, vol. 3, no. 1, pp. 42-47, 2015.
- [4] R. Suklam and C. Pirak, "Multiband Digital Filter Design for WCDMA Systems," *International Conference on Circuit, System and Simulation (IPCSIT)*, vol. 7, 2011.
- [5] H. Rakshit and M. Ullah T., "FIR Filter Design Using an Adjustable Novel Window and Its Application," *International Journal of Engineering and Technology (IJET)*, vol. 4, pp. 1151-1162, 2015.
- [6] K. Rani and R. Baskar, "FIR Digital Filter Designed By using Hamming and Hanning (window) Method," *International Journal of Pure and Applied Mathematics*, vol. 119, no. 18, pp. 1565-1576, 2018.
- [7] R. Narwaria and M. Kumar, "Comparison of FIR Filter Using Different Windows Functions," *International Research of Engineering and Technology (IRJET)*, vol. 5, no. 10, pp. 634-637, 2018.
- [8] A. Mhattacharya, "A modified window function for FIR filter design with an improved frequency response and its comparison with the Hamming window," *International Journal of Science Engineering and Technology Research*, vol. 2, no. 5, pp. 1122-1128, 2013.
- [9] M. Myunddin, et al., "Designing a Low Pass Filter FIR Digital Filter by using Hamming Window and Blackman Window Technique," *Science Journal of Circuits, Systems and Signal Processing*, vol. 4, no. 2, pp. 9-13, 2015.
- [10] M. Islam, et al., "Design of FIR Filter Using Hamming Window," *International Journal of Emerging Research in Management and Technology*, vol. 3, no. 2, pp. 13-16, 2014.
- [11] M. Kaur and S. Kaur, "FIR Low Pass Filter Designing Using Different Window Functions and their Comparison using MATLAB," *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering*, vol. 5, no. 2, pp. 753-758, 2016.
- [12] P. Das and M. Karmakar, "A New Window Function to Design FIR Filter with an Improved Frequency Response for Suppressing Side Lobe Attenuation and Study Comparison with the other Windows," *International Journal of Engineering Research and Technology (IJERT)*, vol. 2, no. 12, pp. 314-321, 2013.
- [13] M. Shil, et al., "An adjustable window function to design an FIR filter," *IEEE International Conference on Imaging, Vision and Pattern Recognition*, pp. 1-5, 2017.
- [14] A. Mittal, et al., "Comparative study of 16-order FIR filter design using different multiplication techniques," *The insituation of engineering and technology, IET Circuits, Devices & Systems*, vol. 11, no. 3, pp. 196-200, 2017.
- [15] S. Sharma and R. Narwaria, "Performance Evaluation of Various Window Techniques for Noise Cancellation from ECG Signal," *International Journal of Computer Applications*, vol. 93, no. 19, pp. 1-5, 2014.
- [16] E. Singhal, "Performance Analysis of Finite Impulse Response (FIR) Filter Design Using Various Window Method," *International Journal of Scientific Research Engineering & Technology (IJSRET)*, vol. 1, no. 5, pp. 18-21, 2012.
- [17] E. Kumar, et al., "Design of Bandpass Finite Impulse Response Filter Using Various Window Method," *Int. Journal of Engineering Research and Applications*, vol. 3, no. 5, pp. 1057-1061, 2013.
- [18] J. Saini and R. Mehra, "Power Spectral Density Analysis of Speech Signal using Window Techniques," *International Journal of Computer Applications*, vol. 131, no. 4, pp. 33-36, 2015.
- [19] G. Gautam, et al., "Spectral Analysis of Rectangular, Hanning, Hamming and Kaiser Window for Digital FIR Filter," *International Journal of Advanced Smart Convergence*, vol. 4, no. 2, pp. 138-144, 2015.
- [20] J. Ferdous and M. Ali, "A Survey Report for Performance Analysis of Finite Impulse Response Digital Filter Using Different Window Techniques," *International Journal of Research in Engineering and Technology*, vol. 2, no. 12, pp. 265-270, 2013.
- [21] E. Kaur and E. S. Kaur, "Design of FIR filter using hanning window, hamming window and modified hamming windows," *International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)*, vol. 4, no. 5, pp. 2440-2443, 2015.
- [22] A. Bhattacharya, "A modified window function for FIR filter design with an improved frequency response and its comparison with the Hamming window," *International Journal of Science, Engineering and Technology Research (IJSETR)*, vol. 2, no. 5, pp. 1122-1128, 2015.
- [23] S. Rajput and S. Bhadauria, "Implementation of FIR Filter using Adjustable Window Function and Its Application in Speech Signal Processing," *International Journal of Advances in Electrical and Electronics Engineering*, vol. 1, no. 2, pp. 158-164, 2012.
- [24] G. S. Gawande, et al., "Performance Analysis of FIR Digital Filter Design Techniques," *International Journal of Computing and Corporate Research*, vol. 2, no. 1, pp. 1-9, 2012.
- [25] K. Dandade and P. Indurkar, "Review on Design of Digital FIR Filters," *International Research Journal of Engineering and Technology (IRJET)*, vol. 4, no. 2, pp. 358-362, 2017.

BIOGRAPHY OF AUTHOR

Raed S. M. Daraghma was born in 1977 in Palestine, he received his master degree from Jordan science and technology in electrical and communication engineering Jordan in 2010, and he got his P.H.D degree from anadolu university, turkey in 2016. He has published number of papers and journals. He has engaged in educational work many years manly teaches digital communication, mobile, digital communication networks etc. at Palestine technical university P.T.U. His mainly research areas include wireless sensor network, signal processing and electromagnetic waves.