ESP-JETA
ESP Journal of Engineering & Technology Advancements
ISSN: 2583-2646 / Volume 3 Issue 2 June 2023 / Page No: 87-90
Paper Id: JETA-V3I6P102 / Doi: 10.56472/25832646/JETA-V3I6P102

Original Article

An Efficient FIR filter Design Technique using Graphical Interface

Nutan V. Bansode[1], Hemant L. Jadhav[2]

[1]*MIT Academy of Engineering, Pune, India.*
[2]*International Center of Excellence in Engineering and Management, Aurangabad, India.*

Received Date: 26 May 2023 Revised Date: 28 May 2023 Accepted Date: 03 June 2023

Abstract: *Spectrum analysis using digital filters is crucial for both signal and picture processing. In this article, all sorts of FIR responses are generated as well as analyzed using windowing techniques. Based on the provided criteria, a window is chosen, and the filter's properties are studied. The design of a FIR filter is described in the second part of this work, which also shows how to put it into practice by simulating it on the MATLAB GUI platform using various windowing strategies for different orders of filter. The effects of various windowing approaches on the FIR filter's design performance are then compared and analyzed.*

Keywords: *FIR Filter Design, GUI, Hamming, Hanning, Rectangular Windowing Technique.*

I. INTRODUCTION

FIR filters are essential for digital signal processing because they have many advantages over model-based filters. There are numerous types of digital Filters, as well as numerous ways to categorize them. The frequency-related operations performed by digital filters include a HPF, LPF, BPF, and BSF. As a result, all such filters are capable of performing conditions that would be simply impossible with an analog application. There are several kinds of filter design techniques, including frequency sampling, optimum filter design, and windowing. The window approach is the method that is most frequently employed since it allows us to quickly obtain the response's coefficient of the necessary magnitude. A sort of digital filter for digital input is the FIR filter. The impulse response of the FIR filter has a limited lifetime. It is additionally referred to as a non-recursive filter because it lacks feedback.

II. RELATED WORK

Y. Xu, "Design of FIR Filter With Several Window Functions," In this paper, author has introduced FIR technique with window functions, and analyzes the necessity of using window functions from a mathematical point of view[1].

T. C. Singh and M. Kumar, "Digital FIR Filter Designs," In this paper, the author has designed 2D FIR filter the output responses are observed using Hamming window, Kaiser Window, and equiripple techniques[2].

K. Thesni, K. Praveen and L. Srivani, "Implementation and Performance Comparison of Digital Filter in FPGA," In this paper, the author has described the design of different variants of FIR filters, their implementation in Field Programmable Gate Array (FPGA) and the performance comparison using a hardware platform[3].

Anshul and K. Rathi, "Comparison of various window techniques for design FIR digital filter". In this paper, the authors have introduced the definition, types and various methods of FIR digital filter are studied. This paper presented the different techniques for designing of filters and then compared them [4].

C. M. Melgoza *et al*., "Comparing Radar Receiver Pulse Deinterleaving Performance of Differing Window Functions for Bandpass FIR Filter Design". In This paper, the author has introduced the performance of the Bartlett, Blackman-Harris, Chebyshev, Hamming, and Kaiser windows, which were analyzed by implementing each into a algorithm[5].

III. PROPOSED WORK

Window functions, also known as weighing functions, tapering functions are mathematical functions that have a zero value outside of the selected interval. They are well-known as an essential component of digital signal processing.

Window functions are commonly used to prevent spectral leakage during transform operations. The Fourier transform is based on the assumption that the signal to be converted is periodic across its whole duration, which is seldom the case. We are creating an FIR filter in MATLAB using three window functions.

A. Window Design

For signal or picture filtering, Hanning is a quick fourier transform window function. Before using FFT, data can be processed with Hanning to produce more realistic results. Only positive cosine values make up Hanning's computed window, which is effectively the first half of a cosine. The coefficients of a Hanning window are produced by the following equation :

$w(n)= 0.5(1-\cos(2\pi nN)), 0\leq n\leq N$

The window length L = N + 1.

- In the sense that it is a raised cosine window of the form, the Hamming window is an extension of the Hann window. (A3.10) with a matched form spectrum. The parameter an allows for the optimization of the destructive sidelobe cancellation indicated in the Hann window description.
  The coefficients of a Hamming window are calculated using the following equation:
  $W(n)= 0.54=0.46\cos(2\pi nN),$
  $0\leq n\leq N$
  The window length is L=N+1.
- In the sense that it is a raised cosine window of the form, the Hamming window is an extension of the Hann window. (A3.10) with a matched form spectrum. The parameter an allows for the optimization of the destructive sidelobe cancellation indicated in the Hann window description.
  The coefficients of a Hamming window are calculated using the following equation:
  $W(n)= 0.54=0.46\cos(2\pi nN),$
  $0\leq n\leq N$
  The window length is L=N+1.
- A rectangular window is typically used when you want to process a smaller slice of a much larger vector of data, possibly zero-padding within a larger window (for better time locality, because a larger FFT is too slow, doesn't fit in cache, or for some other reason).

B. Filter Type

The FIR filter is a type of digital filter used for digital input. The FIR filter's impulse response has a limited time. Because it has no feedback, it is also known as a non-recursive filter. When designing a frequency-selective filter, the passband, stopband, High-Pass, and Low-Pass must be specified

a) Low-Pass Filter:

While attenuating sound waves with higher frequencies, a low pass filter allows only the signals having frequencies lesser than the cut-off frequencies to pass through it. We can determine the cut-off frequency with the help of the design of the filter.

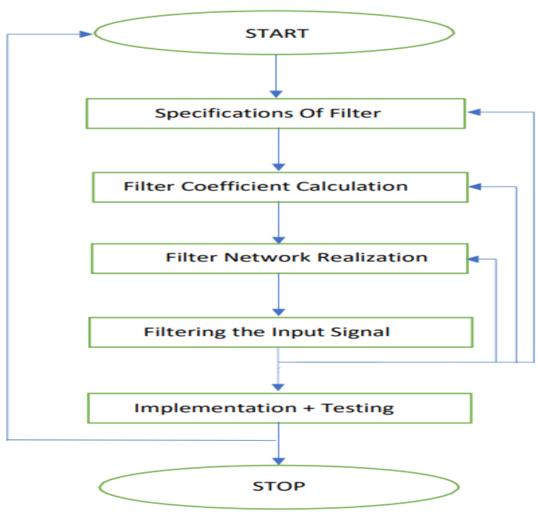

Figure 1: Flow char of FIR Filter Design

Window Design GUI:

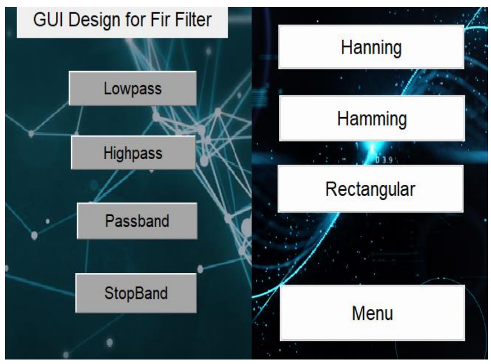

Figure 2: GUI for Filter Type Selection

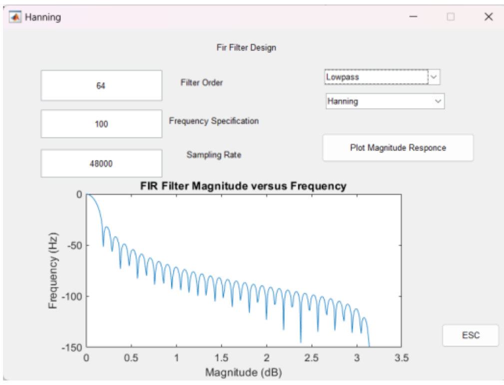

Figure 3: Magnitude Response (LPF using Hanning Window)

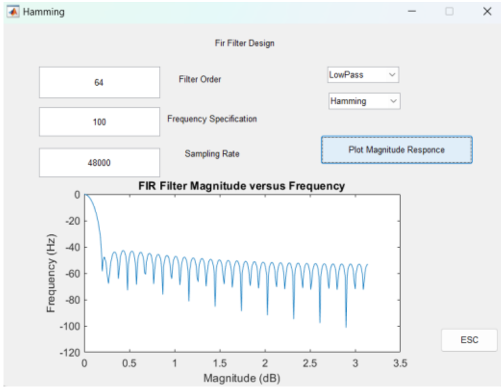

Figure 4: Magnitude Response (Using Hamming Window)

b) High-Pass Filter:

While attenuating sound waves with lower frequencies, a high pass filter allows only signals having frequencies greater than cut-off frequencies to pass through it. We can determine the cut-off frequency with the help of the design of the filter.

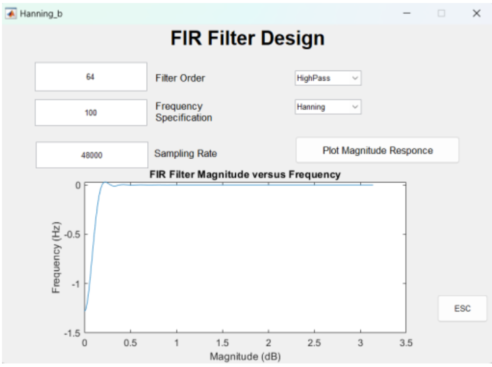

Figure 5: Magnitude Response(HighPass filter using Hanning Window)

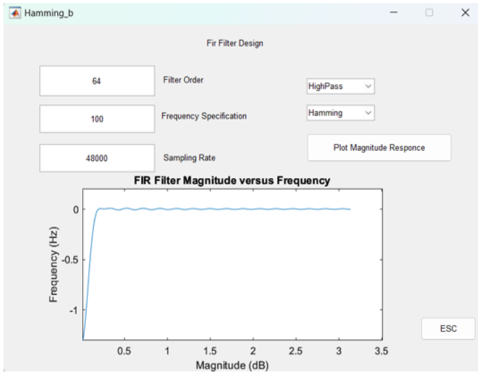

Figure 6: Magnitude Response (High Pass filter Hamming Window)

c) Band-Pass Filter:

A band-pass filter (BPF) is a device that allows frequencies within a specific range to pass while rejecting (attenuating) frequencies outside of that range

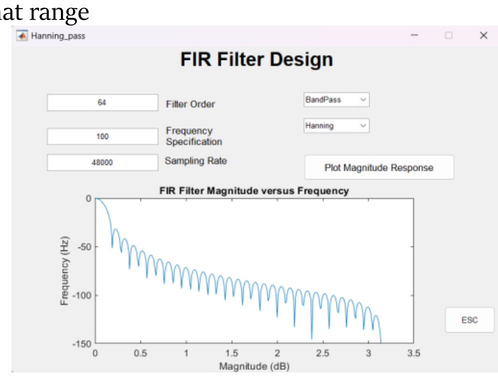

Figure 7: Magnitude Response (BandPass filter using Hanning Window)

d) Band-Stop Filter:

A band-stop filter in digital signal processing is a filter that passes most frequencies unchanged but attenuates those in a defined range to very low levels

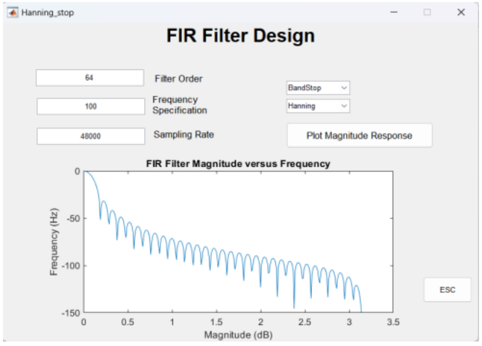

Figure 8: Magnitude Response (Bandstop filter using Hanning Window)

IV. FUTURE SCOPE

As making further advancements in our project, the now-made FIR Filter GUI Application can then be implemented on a hardware level. Moving on from Matlab to actual hardware, DSP Board can give in lots of constraints and is not just simply uploading the code into the processor, so taking that into consideration we have already made our application hardware compatible with the 3X DSK tool provided by Texas Instruments (TI). TI's Texas Made Semiconductor or TMS range of DSP starter Kit (DSK) Modules can be used for this purpose, likes of TMS320C3X DSK which comes equipped with all the required features and ports are among the best options available in the market for our use case.

V. CONCLUSION

In this paper, we have designed a Graphical User interface (GUI) for the Finite Impulse Response (FIR) Filter using the App Designer (previously 'guide') tool on Matlab. Various parameters for filter designing include Filter Type (Low-Pass, High-Pass, Band-Pass & Band-Stop), Windowing type (Rectangular, Hamming & Hanning). Further, Filter Order, Frequency Specification, and Sampling Rate values were also taken as the input parameters for our filter. A Magnitude (dB) vs Frequency (kHz) graph was plotted based on the given filter data. Thus an FIR Filter based on all the above-mentioned parameters was designed using the GUI. Moreover, we have also added provisions for further programming the actual hardware DSP board by flashing the code into it.

VI. REFERENCES

[1] Y. Xu, "Design of FIR Filter With Several Window Functions," 2021 IEEE 3rd International Conference on Frontiers Technology of Information and Computer (ICFTIC), 2021, pp. 638-642

[2] T. C. Singh and M. Kumar, "Digital FIR Filter Designs," 2021 Asian Conference on Innovation in Technology (ASIANCON), 2021, pp. 1-5, doi: 10.1109/ASIANCON51346.2021.9544766.

[3] K. Thesni, K. Praveen and L. Srivani, "Implementation and Performance Comparison of Digital Filter in FPGA," 2020 6th International Conference on Advanced Computing and Communication Systems (ICACCS), 2020, pp. 589-594, doi: 10.1109/ICACCS48705.2020.9074456.

[4] Anshul and K. Rathi, "Comparison of various window techniques for design FIR digital filter," 2017 IEEE International Conference on Power, Control, Signals and Instrumentation Engineering (ICPCSI), 2017, pp. 428-432, doi: 10.1109/ICPCSI.2017.8392331

[5] C. M. Melgoza et al., "Comparing Radar Receiver Pulse Deinterleaving Performance of Differing Window Functions for Bandpass FIR Filter Design," 2020 11th IEEE Annual Information Technology, Electronics and Mobile Communication Conference (IEMCON), 2020, pp. 0505-0510, doi: 10.1109/IEMCON51383.2020.9284927