

# Design of FIR filter using hanning window, hamming window and modified hamming window.

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**Abstract-** Digital filters are widely used in many digital signal processing applications. Therefore, digital filtering is one of the basic needs of digital signal processing. This paper introduces the definition and basic principles of FIR digital filters, and the design based on MATLAB. After the description of the process of design, the matlab program is used to implement FIR filter using modified coefficient of hamming window function and also calculate the equivalent noise bandwidth.

**Keywords-** FIR filters, hamming window, hanning window, modified hamming window, ENBW (Equivalent noise bandwidth).

## I. INTRODUCTION

Digital filters play an important role in digital signal processing applications. They are widely used in digital signal processing applications, such as digital signal filtering, noise reduction, frequency analysis, multimedia compression, biomedical signal processing and image enhancement etc. A digital filter is a system which passes some desired signals more than others to reduce or enhance certain aspects of that signal. It can be used to pass the signals according to the specified frequency pass-band and reject the other frequency than the pass-band specification. The basic filter types can be divided into four categories:

1. Low-pass
2. High-pass
3. Band-pass
4. Band-stop.

On the basis of impulse response, there are two fundamental types of digital Filters:  
1. Infinite Impulse Response (IIR) filters  
2. Finite Impulse Response (FIR) filters [1].

FIR filters are preferred over IIR filters, because FIR digital filters have a linear phase, highly stable, non-recursive structure and arbitrary amplitude-frequency characteristic etc. [1], [2].

The design and simulation analysis of the digital filter is quickly and efficiently achieved by using powerful computing capabilities of MATLAB [3]. FIR filter is described by the difference equation

$$y(n) = h(k)x(n - k) \quad (1)$$

Where,  $x(n)$  is input signal and  $h(n)$  is impulse response of FIR filter.

The transfer function of a causal FIR filter is described by;

$$H(z) = \sum_{k=0}^{N-1} h(k)z^{-k} \quad (2)$$

A simple and effective way to design digital FIR filter is window method. In this method, infinite impulse response of the prescribed filter is truncated by using a Window function. The main advantage of this design technique is that the impulse response coefficient can be obtained in closed form and can be determined very easily and quickly [4]. The Window method is simple in operation, easy to understand and very convenient method for designing digital FIR filter. The most popular and widely used window functions are: Rectangular window, Hanning window, hamming window and Kaiser window.

## II. LITERATURE SURVEY

In the literature survey, different windows are used for the applications of Digital FIR filter design and spectral performance analysis [5]-[6].

Najat Sh.Jasim Mohammed describes an adjustable Kaiser window function which is used for the performance enhancement study of FIR filters in [7].

GAO Jinding describes implementation of Linear FIR Low-pass Filter which is based on Kaiser Window Function and its application in filtering a signal is given in [8].

Yunlong, W., Shihu, W., Rendong, J., describes simple method for design an Fir filter as compare to other existed methods. This method is the simplest except rectangular window method. Filter transition bandwidth is smaller than  $4.65/N$  for filter order  $N$ . For the same filter specifications filter order obtained by using the new method is much smaller than by using Kaiser window if minimum stop band attenuation is in the range of

39.5db to 48.5db and corresponding maximum pass band ripple is from 0.35db to 0.18db.[9]

Mahrokh G. Shayesteh describe new window function is described in [10]. In the analysis of Fourier transform of these different window functions, for the fixed length the Hanning and Hamming window have significantly lower side-lobe amplitude but the main lobe width is wider compare to Rectangular window. The Kaiser window is a kind of adjustable window function which provides independent control of the main lobe width and ripple ratio. But the Kaiser window has the disadvantage of higher computational complexity due to the use of Bessel functions [10].

### III. FIR FILTER DESIGN

The design of a digital filter involves following five steps.

**(a) Filter specification:** This may include stating the type of filter, for example low pass filter, the desired amplitude and/or phase responses and the tolerances, the sampling frequency, the word length of the input data.

**(b) Filter coefficient calculation:** The coefficient of a transfer function  $H(z)$  is determined in this step, which will satisfy the given specification. The choice of coefficient calculation method will be influenced by several factors. The most important of which are the critical requirements i.e. specification. The window, optimal and frequency sampling method are the most commonly used.

**(c) Realization:** This involves converting the transfer function into a suitable filter network or structure.

**(d) Analysis of finite word length effects:** The effect of quantizing the filter coefficients and input data as well as the effect of carrying out the filtering.

**(e) Implementation:** This involves producing the software code and/or hardware and performing the actual filtering.

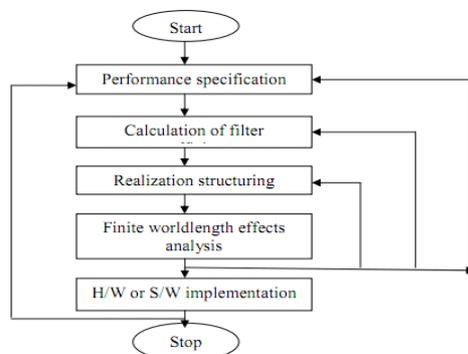


Fig 1. Flow diagram of FIR filter design

### IV. DESIGN STEPS FOR FIR FILTERS VIA WINDOW METHOD

1. Define filter specifications.
2. Specify the window functions according to the filter specifications.
3. Compute the filter order required for a given set of specifications.
4. Compute the window function coefficients.
5. Compute the ideal filter coefficients according to the filter order.
6. Compute FIR filter coefficients according to the obtained window function and ideal filter coefficients.
7. If the resulting filter has too wide or too narrow transition region, it is necessary to change the filter order by increasing or decreasing it according to needs, and after that steps 4, 5 and 6 are iterated as many times as needed.

### V. PROPOSED WORK

In this paper FIR filter is designed using modified coefficient of Hamming window. FIR filter designed using modified coefficient of the Hamming window function provides smaller main lobe width and sharp transition band compare to Hamming window. This type of filter is very useful in spectral analysis of different types of signals. In this paper, we define window function of modified hamming window, Hanning Window and Hamming Window. Further, we compare the equivalent noise bandwidth of FIR filters using modified hamming window, Hanning window and Hamming window functions. The simulation results show that the filter designed using modified window function is more efficient than Hanning and Hamming window function.

In this paper following window functions are used for designing a FIR filter.

(i). Hanning window function

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

$$0, \text{ otherwise} \quad (7)$$

(ii). Hamming window function

$$w(n) = 0.54 - 0.46 \cos(2n\pi/N-1), 0 \leq n \leq N-1$$

$$0, \text{ otherwise} \quad (8)$$

(iii). A Generalized Hamming window function

$$w(n) = \alpha - 1 - \alpha \cos(2n\pi/M-1), 0 \leq n \leq N-1$$

$$0, \text{ otherwise} \quad (9)$$

Modified coefficient of Hamming window function for  $\alpha = 0.74$

$$w(n) = 0.74 - 0.26 \cos(2n\pi/M-1), 0 \leq n \leq N-1$$

$$0, \text{ otherwise} \quad (10)$$

Normalized Equivalent Noise Bandwidth:

The windowing of a signal in time also affects the resolution bandwidth that can be achieved. When calculating the spectrum of a signal segment the resolution bandwidth achieved with a window is always lower than the resolution bandwidth

achieved without a window. The normalized equivalent noise bandwidth (NENBW) of a window is one measure of how much it reduces the resolution bandwidth that can be achieved. To compensate for this a longer signal segment should be processed. Equivalent noise bandwidth (ENBW) compares the window to an ideal or rectangular filter. It is the equivalent width of a rectangular filter that passes the same amount of white noise as the window. The normalized ENBW (NENBW) is the ENBW multiplied by the time duration of the signal being windowed.

## VI. MATLAB SIMULATION RESULT

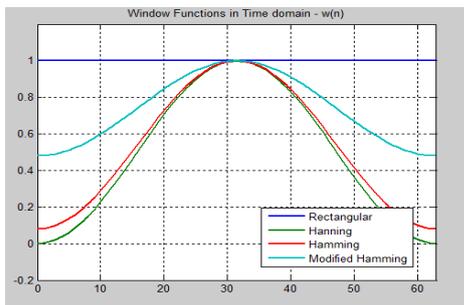


Fig.2 Window function in time domain

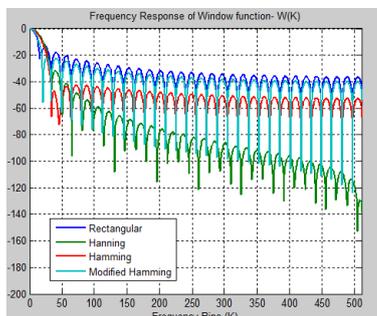


Fig.3 Frequency response of window function

Table1. Equivalent noise bandwidth (ENBW)

Window function	ENBW(Bins)
Rectangular	1
Hanning	1.52
Hamming	1.37
Modified hamming	1.06

## VII.CONCLUSION

In Signal processing applications digital filters are more preferable than analog filters. The digital filters are easily designed and also easy to use in various types of signal filtering applications. The choice of technique to design the filter depends on

the decision of designer whether to compromise accuracy of approximation or ease of design. In this view FIR filter has been designed using Modified coefficient of the Hamming window function and simulated with MATLAB programs. The results show that the filter design using Modified window function has a small main lobe width and sharp transition band compared to Hanning and Hanning window function. So that for same length this window function provides efficient results compare to Hanning and Hamming window function and this type of filters are very useful in spectral analysis and many other applications. The equivalent noise bandwidth of modified hamming window also reduces as compared to hamming window and hanning window. On the basis of the desired filter characteristics, different parameters can be easily changed in the Matlab program to meet the engineering requirements in the FIR filter design process.

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