Rajshahi University of Engineering & Technology

Department : Electrical & Computer Engineering

Course No: ECE 4124

Course Name: Digital Signal Processing Sessional

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Experiment No:9

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Experiment Name: To obtain the coefficients of an FIR lowpass filter to meet the specifications given using window method.

Theory:

Finite Impulse Response (FIR) and Infinite Impulse Response (IIR) filters are the two main digital filters used in digital signal processing . FIR filters differ from IIR filters because they have an impulse response of a finite duration.The Hamming window is a commonly used window function for filter design due to its reasonable trade-off between main lobe width and side lobe suppression.[1]

Specifications for the filter:

Passband edge frequency : A passband is the range of frequencies or wavelengths that can pass through a filter.

Transition width: Transition width is the difference between these two frequencies

Stopband attenuation : The minimum required attenuation in the stopband.

Sampling frequency: a desired frequency response can be approximated by sampling it at N evenly spaced points and then obtaining N-point filter response.

Summary of important features of common window functions:

Name of window function	*Transition width (Hz) (normalized)*	*Passband ripple (dB)*	*Main lobe relative to side lobe (dB)*	*Stopband attenuation (dB) (maximum)*	*Window function* $w(n), 0 \le n \le N$
Rectangular	$0.92/N$	$\frac{4\pi}{N+1}$	-13	-21	1
Hanning	$3.11/N$	$\frac{8\pi}{N}$	-31	-44	$0.5-0.5\cos\left(\frac{2\pi n}{N}\right)$
Hamming	$3.32/N$	$\frac{8\pi}{N}$	-41	-53	$0.54-0.46\cos\left(\frac{2\pi n}{N}\right)$
Balckman	$5.56/N$	$\frac{12\pi}{N}$	-57	-75	$0.42-0.5\cos\left(\frac{2\pi n}{N}\right)+0.08\cos\left(\frac{4\pi n}{N}\right)$

[2]

Here the hamming window method has been used for simplicity.

The filter co efficients are obtained from hd(k)=h(k)*w(k);where,
h(k)=(2*cutoff_frequency*sin(k*(2*pi*cutoff_frequency)))/(k*(2*pi*cutoff_frequency));
h(k)=2*cutoff_frequency ; if(n=0)
w(k)=0.54+0.46*cos(2*pi*k/n);

To obtain cut off frequency,
CutOffFrequency=(EdgeFrequency+(TransitionWidth/2))/SamplingFrequency ;
del_f=Tranition_Width/SamplingFrequency ;
N=3.3/del_f ; N=number of coefficients.

Code:

```
clc;
clear all;
close all;
EdgeFreq=input('Enter passband edge frequency:');
TranWidth=input('Enter Transition Width:');
stopband_attenuation=input('Enter Stopband Attenuation:');
Sampling_freq=input('Enter Sampling frequency:');

del_f=TranWidth/Sampling_freq ;

n=3.3/del_f ;
n
range=floor(n/2) ;
range
cutoff_freq=(EdgeFreq+(TranWidth/2))/Sampling_freq ;
cutoff_freq
h=zeros(1,range+1);
w=zeros(1,range+1);
hd=zeros(1,range+1);
  h0=2*cutoff_freq;
        w0=0.54+0.46*cos(0);
        hd0=h0*w0;
        hd0
for k=1:range

h(k)=(2*cutoff_freq*sin(k*(2*pi*cutoff_freq)))/(k*(2*pi*cutoff_f
req));
        w(k)=0.54+0.46*cos(2*pi*k/n);
        hd(k)=h(k)*w(k);

    end
hd
```

Output:

```
Enter passband edge frequency:1.5
Enter Transition Width:0.5
Enter Stopband Attenuation:50
Enter Sampling frequency:8

n =

   52.8000


range =

    26


cutoff_freq =

    0.2188


hd0 =

    0.4375


hd =

  Columns 1 through 8

    0.3112    0.0601   -0.0857   -0.0534    0.0326    0.0435   -0.0075   -0.0321

  Columns 9 through 16

   -0.0052    0.0209    0.0106   -0.0114   -0.0112    0.0043    0.0092    0.0000

  Columns 17 through 24

   -0.0062   -0.0020    0.0034    0.0023   -0.0014   -0.0019    0.0003    0.0013

  Columns 25 through 27

    0.0002   -0.0009         0
```

Conclusion:

Here by using hamming window method,filter coefficients from (-26 to 26) has been achieved by determining specifications.To make the filter causal (necessary for implementation) 26 has been added to each index so that the indices start at zero.The spectrum of the filter indicates that the specifications were satisfied.

Reference:

1.https://www.allaboutcircuits.com/technical-articles/design-examples-of-fir-filters-using-window-method/

2.
https://www.google.com/url?sa=i&url=https%3A%2F%2Fslideplayer.com%2Fslide%2F16742815%2F&psig=AOvVaw3feVAmTafjcmXBJnszRDFP&ust=1691236905706000&source=images&cd=vfe&opi=89978449&ved=0CBEQjRxqFwoTCKCk18n6woADFQAAAAAdAAAAABAE