Abstract

This report is the discuss the procedure of designing a FIR filter to satisfy the given properties. Kaisar window is used for the implementation. All the operations were done in MATLAB 2016a (By mathworks).

Content

2.Filter specification

Property	Symbol	Value	Units
Maximum passband ripple,	$\tilde{A}p$	0.06	dB
Minimum stopband attenuation,	$\tilde{A}a$	49	dB
Lower passband edge,	Ω_{p1}	1200	rad/s
Upper passband edge,	Ω_{p2}	1500	rad/s
Lower stopband edge,	Ω_{a1}	1050	rad/s
Upper stop band edge,	Ω_{a2}	1600	rad/s
Sampling Frequency,	Ωs	4000	rad/s

Table 1;Properties derived from index number

Parameter	Symbol	Method	Value	Unit
Lower transition width	B_{t1}	$\Omega_{p1} - \Omega a_1$	150	rad/s
Upper transition width	B_{t2}	$\Omega_{a2} - \Omega_{p2}$	100	rad/s
Critical transition width	B_t	$Min(B_{t1},B_{t2})$	100	rad/s
Lower cutoff frequancy	ω_{c1}	Ω_{p1} - $B_t/2$	1150	rad/s
Upper Cutoff Frequancy	ω_{c2}	Ω_{p1} + $B_t/2$	1550	rad/s
Sampling Period	T	$2\pi/ \Omega s$	1.570×10^{-3}	s

Table 2; derived parameters from table 1

3.Method

Step 1

Construct the impulse response of the bandpass filter h(nT) using ideal conditions.

$$H(ej\omega T)\begin{cases}1 \;\; ; \;\; \omega c1 < |\omega| < \omega c1 \\ 0\;; \qquad\qquad Otherwise\end{cases}$$

Step 2

Choose δ such that actual pass band attenuation is less than or equal maximum pass band attenuation(Ãp) and stopband attenuation is higher or equal than minimum stop band attenuation (Ãa).

$\delta=\min(\delta_p,\delta_a)$ $\delta_{p=}(10^{0.05\,\tilde{A}p}-1)/(\,10^{0.05\,\tilde{A}p}+1)$ $,\delta_2=10^{-0.05\,\tilde{A}a}$

Step 3

Actual stopband attenuation A is calculated as

$Aa=-20\log_{10}(\delta)$

Step 4

Construct alpha such that

$$\alpha=\begin{cases}0 \;\; ; for\ Aa < 21 \\ 0.5842(Aa-21)^{0.4}+0.07886(Aa-21); for\ 21 < Aa < 50 \\ 0.1102(Aa-8.7) \;\; ; for\ Aa > 50\end{cases}$$

Step 5

Choose D and N as following

$$D=\begin{cases}0.9222\,; for\ Aa \le 21 \\ \frac{Aa-7.95}{14.36}; for\ Aa > 21\end{cases}$$

$$N \ge \frac{\omega_s\,D}{B_t}+1$$

Step 6

Form kaiser window function as follows

$$w_k(nT)\begin{cases}\frac{I_0(\beta)}{I_0(\alpha)}\ for\ |n| \le N \\ 0\ otherwise\end{cases}$$

$$\beta=\sqrt{1-(\frac{n}{M})^2}$$ M=(N-1)/2

$$I_0(X)=1+\sum_{k=1}^{\infty}(\frac{1}{k!}(\frac{X}{2})^k)^2$$

Step 7

Form the impulse response of the band pass filter

$$h_w(nT)=w_k(nT)\times h(nT)$$

Parameter	Value
δ_p	3.45×10^{-3}
δ_a	3.54×10^{-3}
Aa	49.236dB
α	4.45
D	2.87
N	117
M	58

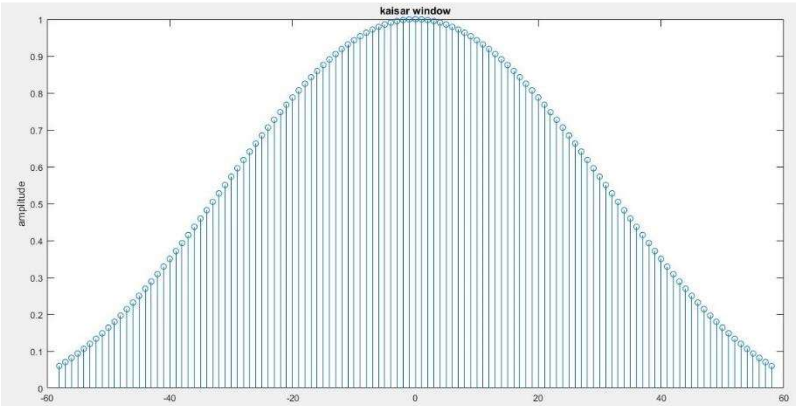

Figure 1.Kaisar window for N=117

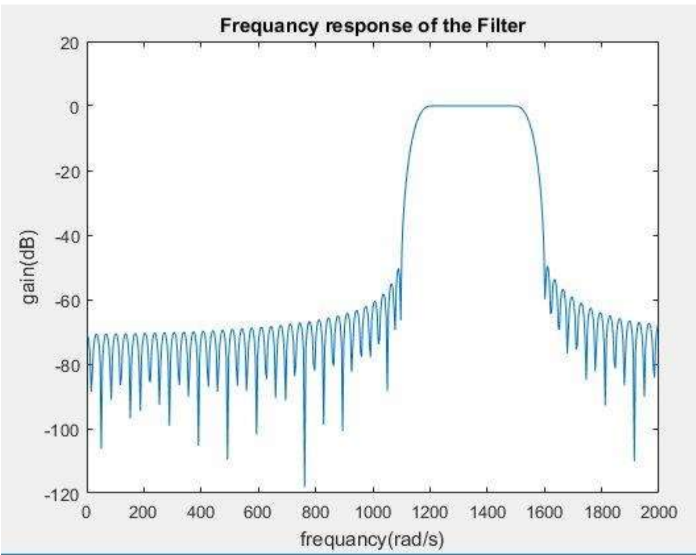

Figure 2. Frequancy responseof the FIR filter

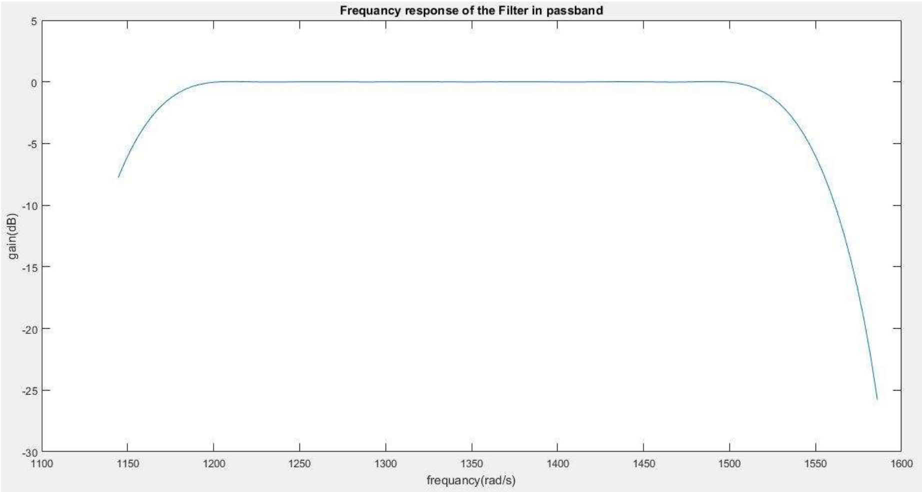

Figure 3 passband of the FIR filter

4.Testing the filter

Testing of the filter was done by giving a sum of three sinusoids as input.

$$\sum_{i=1}^{3} \sin\left(\Omega_1 nT\right)$$

Where Ω_1 is the mid frequency of the lower stop band, Ω_3 is the mid frequency of upper stopband and Ω_2 is the mid frequency of the passband.