Kiran Talele's

Digital FIR Filter Design using Frequency Sampling Method @ Sardar Patel Institute of Technology, Andheri, Mumbai

Dr. Kiran TALELE
Dean – Students, Alumni & External Relations

Bharatiya Vidya Bhavans'
Sardar Patel Institute of Technology Andheri(w) Mumbai

1

Dr. Kiran TALELE
Teacher . Instructor . Guide . Mentor . Coach

@ Bharatiya Vidya Bhavans' Sardar Patel Institute of Technology Andheri(w) Mumbai

- **Associate Professor,** Electronics Engineering Department (1997)
- **Dean,** Students, Alumni & External Relations (2022)

@ Sardar Patel Technology Business Incubator(SP-TBI), Funded by Department of Science & Technology(DST), Govt. of India

- **Co-ordinator** (2015)

@ IEEE Bombay Section

- **Treasurer** (2020)
- **Executive Committee Member** (2015)

2

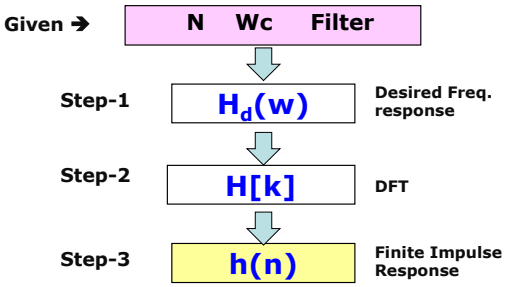
2

FIR filter Design using Frequency Sampling Method

Kiran Tulshiram Vasumati TALELE

3

ALGORITHM To Design Linear Phase F I R Filter Using Frequency Sampling Method



4

Q1. Design 6th order **Linear Phase** Low Pass FIR filter with cut off frequency $w_c = 0.5\pi$ radian using Frequency Sampling Method

Solution :

Linear Phase LPF Design

Order N-1 = 6

N = 7

Cutoff frequency Wc = 0.5 π

5

Q2. Design sixth order Linear Phase HPF with cutoff frequency Wc = 0.5 π using Frequency Sampling Method.

Solution :

Linear Phase HPF Design

Order N-1 = 6

N = 7

Cutoff frequency Wc = 0.5 π

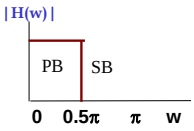
6

H.W-1 **Given** $H(e^{jw}) = \begin{cases} e^{-j3w} & 0 \le w \le 0.5\pi \\ 0 & 0.5\pi \le w \le \pi \end{cases}$

Design the filter using Frequency Sampling Method.

Hint :

Magnitude Spectrum :



Phase Response :

$f(w) = e^{jf} = e^{-j3w}$

Phase : $\phi = -3w$

$f = -\left(\frac{N-1}{2}\right)w = -3w$

Linear Phase LPF
Wc = 0.5π N = 7 FSM

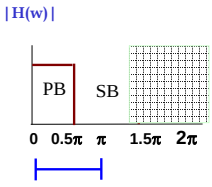
7

H.W-2 **Given** $H(e^{jw}) = \begin{cases} e^{-j3w} & 0 \le w < 0.5\pi \\ 0 & 0.5\pi \le w < 1.5\pi \\ e^{j3w} & 1.5\pi \le w \le 2\pi \end{cases}$

Design the filter using Frequency Sampling Method.

Hint :

Magnitude Spectrum :



Phase Response :

$f(w) = e^{jf} = e^{-j3w}$

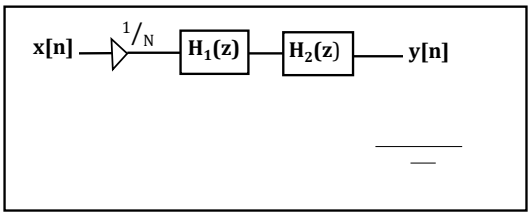
Phase : $\phi = -3w$

$f = -\left(\frac{N-1}{2}\right)w = -3w$

Linear Phase LPF
Wc = 0.5π N = 7 FSM

8

Frequency Sampling Realization



9

Q3 The frequency response of Low Pass Filter is given by,

$$H(e^{jw}) = \begin{cases} e^{-j3w} & 0 \le w \le 0.5\pi \\ 0 & 0.5\pi \le w \le \pi \end{cases}$$

Realize the filter using Frequency Sampling Method.

Solution :

$$H(e^{jw}) = \begin{cases} e^{-j3w} & 0 \le w \le 0.5\pi \\ 0 & 0.5\pi \le w \le \pi \end{cases}$$

- Phase : $\phi = -3w$

For a Linear phase FIR Filter with symmetric h(n),

$$f = -\left(\frac{N-1}{2}\right)w = -3w$$

$N = 7$

(I) Find H[k]

$$H(e^{jw}) = \begin{cases} e^{-j3w} & 0 \le w \le 0.5\pi \\ 0 & 0.5\pi \le w \le \pi \end{cases}$$

$$Put \;\; w = \frac{2\pi k}{N} = \frac{2\pi k}{7}$$

$$H[k] = \begin{cases} e^{-j3\left(\frac{2\pi k}{7}\right)} & 0 \le w \le w_c = 0.5\pi \\ 0 & otherwise \end{cases}$$

$$H[k] = \begin{bmatrix} 1 & k=0 & w=0 \\ e^{-j\frac{6\pi}{7}} & k=1 & w=0.28\pi \\ 0 & k=2 & w=0.56\pi \\ 0 & k=3 & w=0.84\pi \\ 0 & k=4 & \\ 0 & k=5 & \\ e^{j\frac{6\pi}{7}} & k=6 & \end{bmatrix}$$

(II) Frequency Sampling Realization

- By Freq Sampling, $H(z) = \frac{1}{N} H_1(z) \; H_2(z)$

Where (1) $N = 7$

(2) $H_1(z) = 1 - z^{-N} == 1 - z^{-7}$

(3) $H_2(z) = \sum_{k=0}^{N-1} \frac{H[k]}{1 - e^{\frac{j 2\pi k}{N}} z^{-1}}$

$$H_2(z) = \frac{H[0]}{1 - z^{-1}} + \frac{H[1]}{1 - e^{j\frac{2\pi}{7}} z^{-1}} + \frac{H[6]}{1 - e^{j\frac{12\pi}{7}} z^{-1}}$$

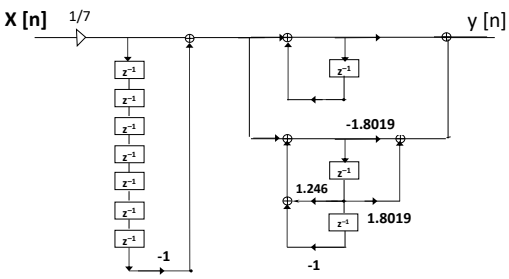
$$H_2(z) = \frac{1}{1 - z^{-1}} + \frac{e^{-j\frac{6\pi}{7}}}{1 - e^{j\frac{2\pi}{7}} z^{-1}} + \frac{e^{j\frac{6\pi}{7}}}{1 - e^{-j\frac{2\pi}{7}} z^{-1}}$$

13

$$H_2(z) = \frac{1}{1 - z^{-1}} + \frac{e^{-j\frac{6\pi}{7}}}{1 - e^{j\frac{2\pi}{7}} z^{-1}} + \frac{e^{j\frac{6\pi}{7}}}{1 - e^{-j\frac{2\pi}{7}} z^{-1}}$$

14

$$H_2(z) = \frac{1}{1 - z^{-1}} + \left[\frac{-1.8019 + 1.8019 z^{-1}}{1 - 1.246 \; z^{-1} + z^{-2}} \right]$$



15

Dr. Kiran TALELE

- Academic : PhD
- Professional :
  - Dean-Students, Alumni & External Relations @ Bharatiya Vidya Bhavans' Sardar Patel Institute of Technology (SP-IT), Mumbai
  - Co-ordinator @ Sardar Patel Technology Business Incubator (SP-TBI), Mumbai
  - Treasurer-IEEE Bombay Section

091-9987030881 www.talelesir.com talelesir@gmail.com
https://www.linkedin.com/in/k-t-v-talele/
www.facebook.com/Kiran-Talele-1711929555720263

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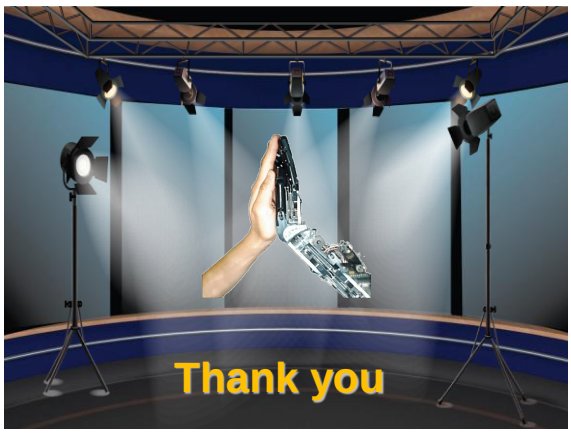
16

16

- **Dr. Kiran TALELE** is an Associate Professor in Electronics & Telecommunication Engineering Department of Bharatiya Vidya Bhavans' Sardar Patel Institute of Technology, Mumbai with 33+ years experience in Academics.
- He is a Dean of Students, Alumni and External Relations at Sardar Patel Institute of Technology, Andheri Mumbai. He is also a Co-ordinator of Sardar Patel Technology Business Incubator, Mumbai.
- His area of research is Digital Signal & Image Processing, Computer Vision, Machine Learning and Multimedia System Design.
- **He has published 85+ research papers at various national & international refereed conferences and journals. He has published 22 patents at Indian Patent Office. One patent is granted in 2021.**
- He is a Treasurer of IEEE Bombay Section and Mentor for Startup Incubation & Intellectual Asset Creation.
- He received incentives for excellent performance in academics and research from Management of S.P.I.T. in 2008-09. He is a recipient of P.R. Bapat IEEE Bombay Section Outstanding Volunteer Award 2019.

17



18