Design of FIR filters

Kaiser Window

Maximum passband ripple δp = 0.05 dB
Minimum stopband attenuation δs = 40 dB
Passband edge f_p= 20000000 rad/s
Stopband edge f_a= 25000000 rad/s
Sampling frequency f_s= 700000000 rad/s

Calculation of Parameters

1 Choose Delta

$$\delta_a = 10^{-\left(\frac{A_a}{20}\right)}$$

=0.01 dB

$$\delta_p = \frac{10^{\left(\frac{-Ap}{20}\right)} - 1}{10^{\left(\frac{-Ap}{20}\right)} + 1} = 0.0029\, dB$$

$$= \min(\delta_p, \delta_a) = 0.0029 dB$$

2 Calculate Aa

$$A_a = 20 \log_{10} \delta = 50.8175\, dB$$

3 Calculate α

$$\alpha = \begin{cases} 0, A_a \leq 21 \\ 0.5842\,(A_a - 21)^{0.4} + 0.07886(A_a - 21),\ 21 < A_a \leq 50 \\ 0.1102\,(A - 8.7)\,,\ otherwise \end{cases}$$

$$\alpha = 0.1102(A_\alpha - 8.7) = 4.6413$$

4 Calculate D

$$D = \begin{cases} 0.9222, & A_a \leq 21 \\ \dfrac{A_a - 7.95}{14.36}, & otherwise \end{cases}$$

$$D = \frac{A_a - 7.95}{14.35} = 2.9852$$

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5 Calculate Transition Band Width

$$\begin{aligned} B_t &= f_a - f_p \\ &= 100 - 50 \\ &= 5000000\, rad/sec \end{aligned}$$

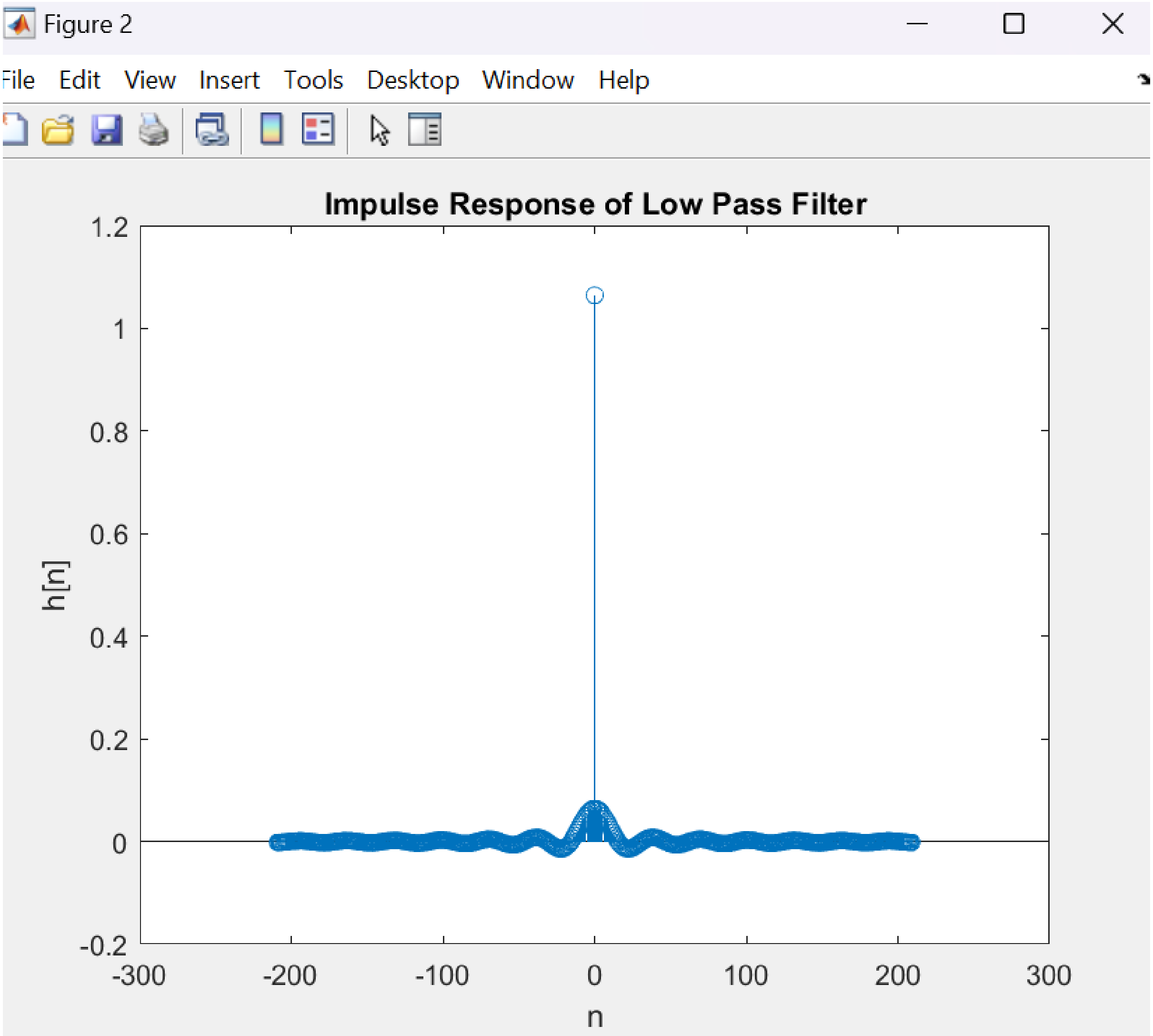
6 Calculate N

$$N \geq \frac{f_s}{B_t + 1}, \; N\, is\, odd$$

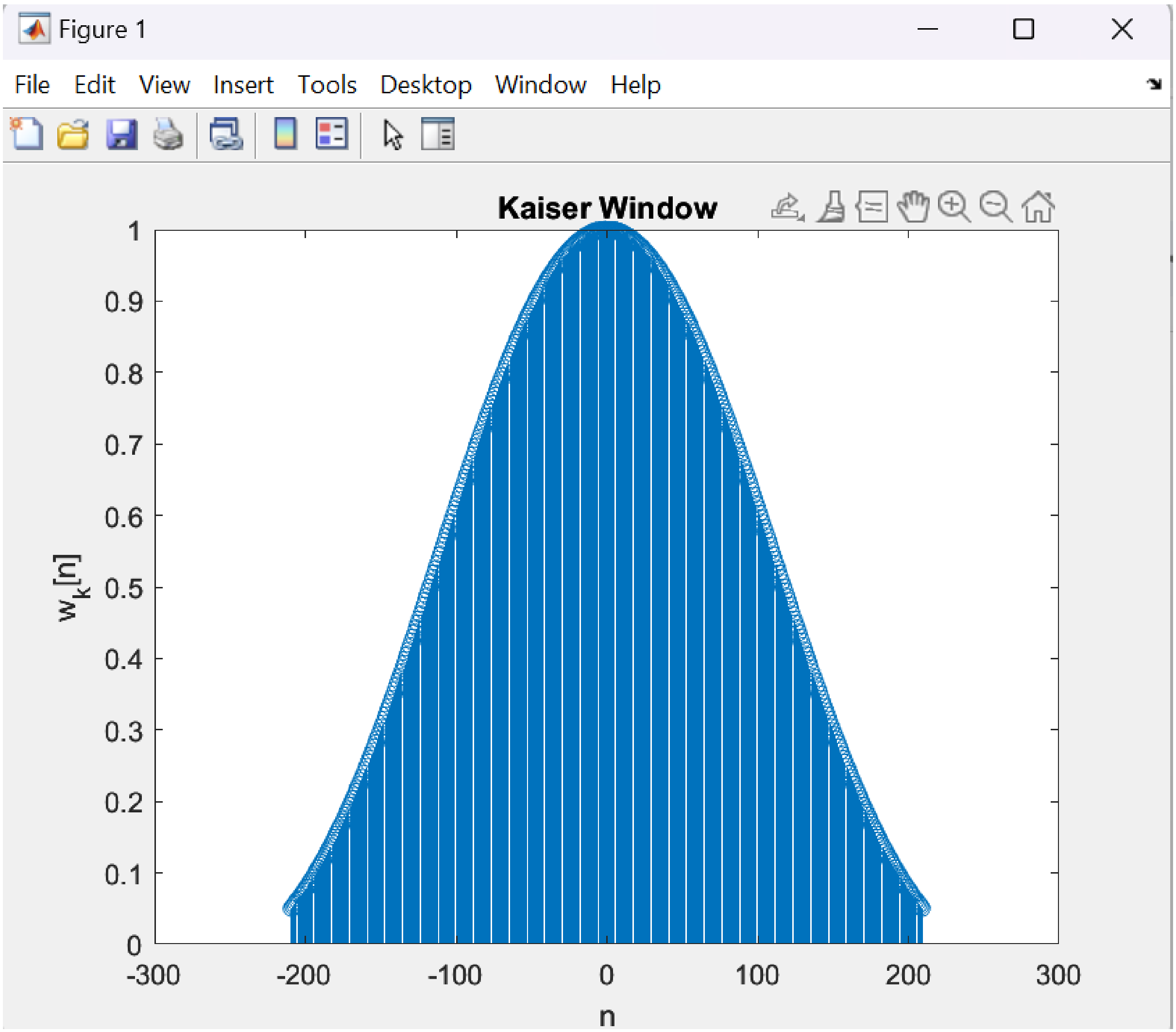
$$N = 419$$

Results

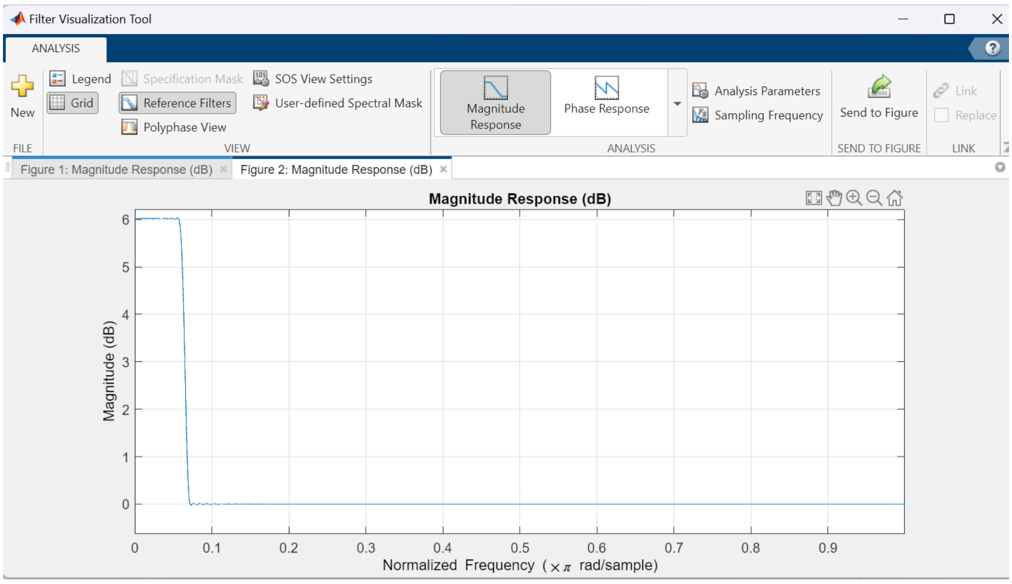
1 Impulse response



2 Kaiser Window



3 Magnitude Response of Digital Filter



Coefficients

Columns 1 through 11

-0.0001 -0.0001 -0.0001 -0.0001 -0.0001 -0.0000 -0.0000 0.0000 0.0000 0.0001 0.0001

Columns 12 through 22

0.0001 0.0001 0.0001 0.0001 0.0002 0.0002 0.0001 0.0001 0.0001 0.0001 0.0001

Columns 23 through 33

0.0000 -0.0000 -0.0001 -0.0001 -0.0002 -0.0002 -0.0002 -0.0003 -0.0003 -0.0003 -0.0003

Columns 34 through 44

-0.0003 -0.0002 -0.0002 -0.0001 -0.0001 0.0000 0.0001 0.0002 0.0002 0.0003 0.0004

Columns 45 through 55

0.0004 0.0004 0.0004 0.0004 0.0004 0.0004 0.0003 0.0002 0.0002 0.0000 -0.0001

Columns 56 through 66

-0.0002 -0.0003 -0.0004 -0.0005 -0.0006 -0.0006 -0.0007 -0.0007 -0.0007 -0.0006 -0.0005

Columns 67 through 77

-0.0004 -0.0003 -0.0002 0.0000 0.0002 0.0003 0.0005 0.0006 0.0008 0.0009 0.0009

Columns 78 through 88

0.0010 0.0010 0.0009 0.0008 0.0007 0.0005 0.0003 0.0001 -0.0001 -0.0003 -0.0006

Columns 89 through 99

-0.0008 -0.0010 -0.0012 -0.0013 -0.0014 -0.0014 -0.0013 -0.0012 -0.0011 -0.0009 -0.0006

Columns 100 through 110

-0.0004 -0.0000 0.0003 0.0006 0.0009 0.0012 0.0015 0.0017 0.0018 0.0019 0.0019

Columns 111 through 121

0.0018 0.0016 0.0014 0.0011 0.0007 0.0003 -0.0002 -0.0006 -0.0011 -0.0015 -0.0019

Columns 122 through 132

-0.0022 -0.0024 -0.0026 -0.0026 -0.0026 -0.0024 -0.0021 -0.0017 -0.0013 -0.0007 -0.0001

Columns 133 through 143

0.0005 0.0011 0.0017 0.0023 0.0028 0.0032 0.0034 0.0036 0.0036 0.0034 0.0031

Columns 144 through 154

0.0027 0.0021 0.0014 0.0007 -0.0002 -0.0011 -0.0019 -0.0028 -0.0035 -0.0042 -0.0047

Columns 155 through 165

-0.0050 -0.0051 -0.0050 -0.0047 -0.0042 -0.0035 -0.0026 -0.0016 -0.0004 0.0008 0.0021

Columns 166 through 176

0.0034 0.0046 0.0056 0.0065 0.0072 0.0076 0.0077 0.0075 0.0069 0.0061 0.0049

Columns 177 through 187

0.0034 0.0017 -0.0002 -0.0023 -0.0044 -0.0064 -0.0084 -0.0102 -0.0117 -0.0128 -0.0135

Columns 188 through 198

-0.0136 -0.0132 -0.0122 -0.0106 -0.0083 -0.0053 -0.0018 0.0024 0.0070
0.0120 0.0173

Columns 199 through 209

0.0229 0.0285 0.0342 0.0396 0.0448 0.0496 0.0538 0.0575 0.0604 0.0625
0.0638

Columns 210 through 220

1.0643 0.0638 0.0625 0.0604 0.0575 0.0538 0.0496 0.0448 0.0396 0.0342
0.0285

Columns 221 through 231

0.0229 0.0173 0.0120 0.0070 0.0024 -0.0018 -0.0053 -0.0083 -0.0106
-0.0122 -0.0132

Columns 232 through 242

-0.0136 -0.0135 -0.0128 -0.0117 -0.0102 -0.0084 -0.0064 -0.0044 -0.0023
-0.0002 0.0017

Columns 243 through 253

0.0034 0.0049 0.0061 0.0069 0.0075 0.0077 0.0076 0.0072 0.0065 0.0056
0.0046

Columns 254 through 264

0.0034 0.0021 0.0008 -0.0004 -0.0016 -0.0026 -0.0035 -0.0042 -0.0047
-0.0050 -0.0051

Columns 265 through 275

-0.0050 -0.0047 -0.0042 -0.0035 -0.0028 -0.0019 -0.0011 -0.0002 0.0007
0.0014 0.0021

Columns 276 through 286

0.0027 0.0031 0.0034 0.0036 0.0036 0.0034 0.0032 0.0028 0.0023 0.0017
0.0011

Columns 287 through 297

0.0005 -0.0001 -0.0007 -0.0013 -0.0017 -0.0021 -0.0024 -0.0026 -0.0026
-0.0026 -0.0024

Columns 298 through 308

-0.0022 -0.0019 -0.0015 -0.0011 -0.0006 -0.0002 0.0003 0.0007 0.0011
0.0014 0.0016

Columns 309 through 319

0.0018 0.0019 0.0019 0.0018 0.0017 0.0015 0.0012 0.0009 0.0006 0.0003
-0.0000

Columns 320 through 330

-0.0004 -0.0006 -0.0009 -0.0011 -0.0012 -0.0013 -0.0014 -0.0014 -0.0013
-0.0012 -0.0010

Columns 331 through 341

-0.0008 -0.0006 -0.0003 -0.0001 0.0001 0.0003 0.0005 0.0007 0.0008
0.0009 0.0010

Columns 342 through 352

0.0010 0.0009 0.0009 0.0008 0.0006 0.0005 0.0003 0.0002 0.0000 -0.0002
-0.0003

Columns 353 through 363

-0.0004 -0.0005 -0.0006 -0.0007 -0.0007 -0.0007 -0.0006 -0.0006 -0.0005
-0.0004 -0.0003

Columns 364 through 374

-0.0002 -0.0001 0.0000 0.0002 0.0002 0.0003 0.0004 0.0004 0.0004
0.0004 0.0004

Columns 375 through 385

0.0004 0.0004 0.0003 0.0002 0.0002 0.0001 0.0000 -0.0001 -0.0001
-0.0002 -0.0002

Columns 386 through 396

-0.0003 -0.0003 -0.0003 -0.0003 -0.0003 -0.0002 -0.0002 -0.0002 -0.0001
-0.0001 -0.0000

Columns 397 through 407

0.0000 0.0001 0.0001 0.0001 0.0001 0.0001 0.0002 0.0002 0.0001 0.0001
0.0001

Columns 408 through 418

0.0001 0.0001 0.0001 0.0000 0.0000 -0.0000 -0.0000 -0.0001 -0.0001
-0.0001 -0.0001

Column 419

-0.0001

Observation:
In my opinion, the high-frequency magnitude response of a signal bears a striking resemblance to that of an ideal low-pass filter. However, a challenge arises as the coefficients tend to become large, potentially leading to a slower response. Nonetheless, if our objective doesn't necessarily demand an ideal low-pass filter, we have the option to utilize fewer coefficients.
Given this situation, the question arises: should our focus be on designing the best and ideal low-pass filter, or is it acceptable to make compromises on the coefficients?