Department of Electronics and
Electrical Communication
Engineering, IIT Kharagpur

Experiment 1: Sampling

Samyak Sheersh, Anubhav Mitra

Roll Numbers: 22EC30045, 22EC30007
Group Number: 24

13 August 2024

1 Objectives

1. To design FIR filters for various orders and cutoff frequencies.
2. To assess whterhe pasband and stop band frequencies are attenuated by the filter designed.
3. To assess the response of such FIR filters to noise contaminated signals.

2 Definitions of windows and LPF

2.1 LPF

$$h_d[n] = \begin{cases} \frac{\omega_c}{\pi} & n = k \\ \frac{\sin(\omega_c(n-k))}{\pi(n-k)} & otherwise \end{cases} \tag{1}$$

2.2 Rectangular Window

$$w[n] = \begin{cases} 1 & n = 0, 1, \ldots, N-1 \\ 0 & otherwise \end{cases} \tag{2}$$

2.3 Triangular Window

$$w[n] = \begin{cases} 1 - 2\frac{n - \frac{N-1}{2}}{N-1} & n = 0, 1, \ldots, N-1 \\ 0 & otherwise \end{cases} \tag{3}$$

2.4 Hanning Window

$$w[n] = \begin{cases} \frac{1}{2} - \frac{1}{2}\cos(\frac{2\pi n}{N-1}) & n = 0, 1, \ldots, N-1 \\ 0 & otherwise \end{cases} \tag{4}$$

2.5 Hanning Window

$$w[n] = \begin{cases} 0.54 - 0.46\cos(\frac{2\pi n}{N-1}) & n = 0, 1, \ldots, N-1 \\ 0 & otherwise \end{cases} \tag{5}$$

2.6 Blackmann Window

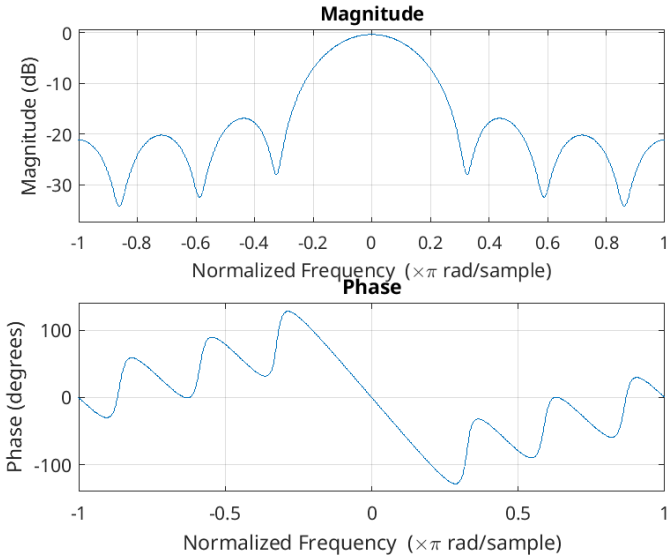
$$w[n] = \begin{cases} 0.42 - 0.5\cos(\frac{2\pi n}{N-1}) + 0.08\cos(\frac{4\pi n}{N-1}) & n = 0, 1, \ldots, N-1 \\ 0 & otherwise \end{cases} \tag{6}$$

3 Observation Tables, Graphs and Diagrams

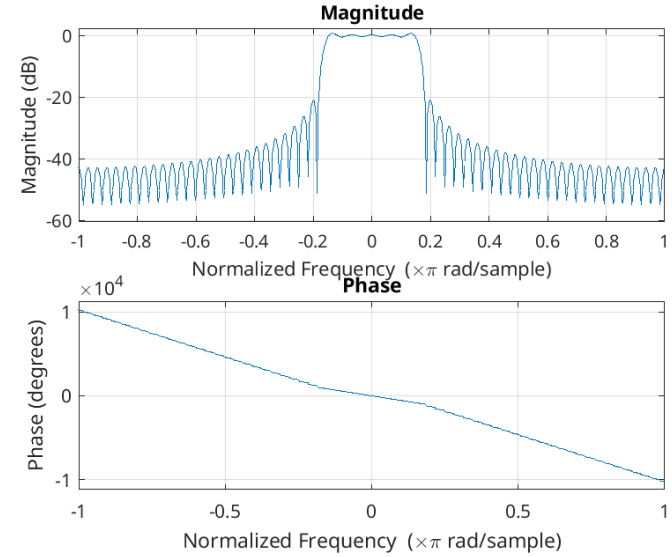
Outputs of the `freqz` function

3.1 Rectangular Window

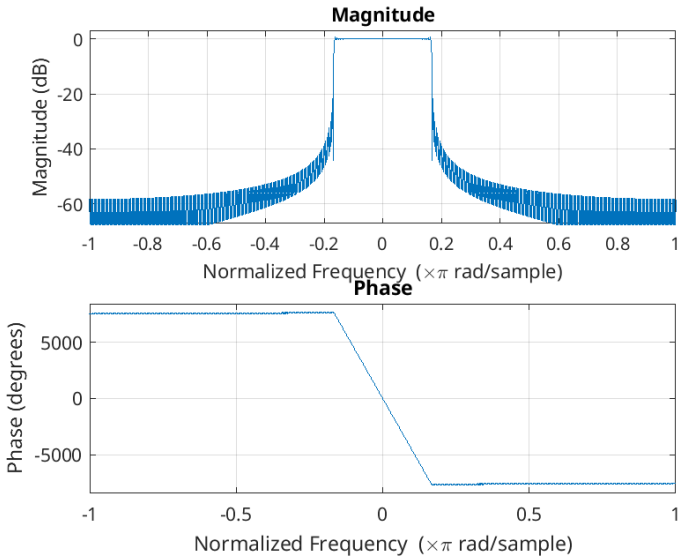
3.1.1 N=8



3.1.2 N=64

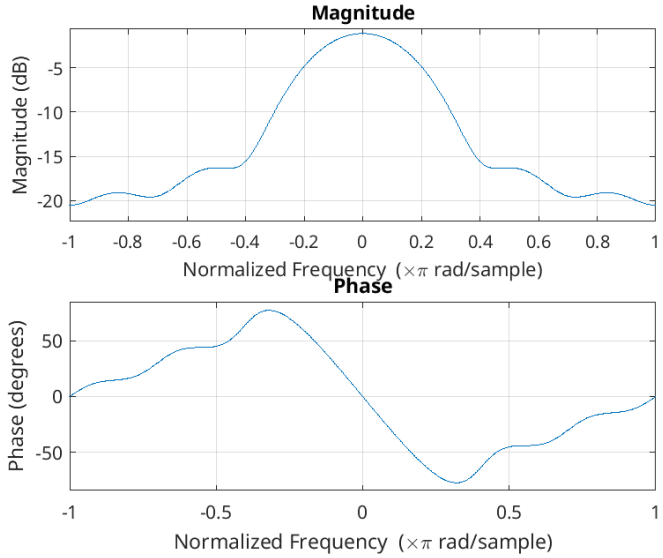


3.1.3 N=512

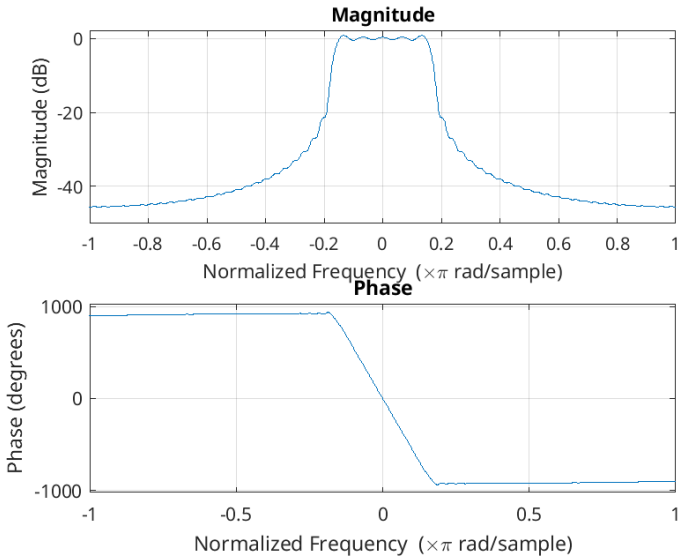


3.2 Triangular Window

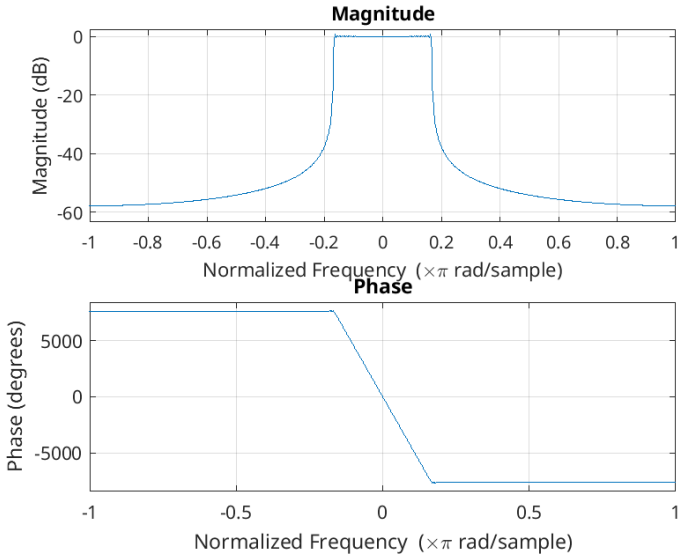
3.2.1 N=8



3.2.2 N=64

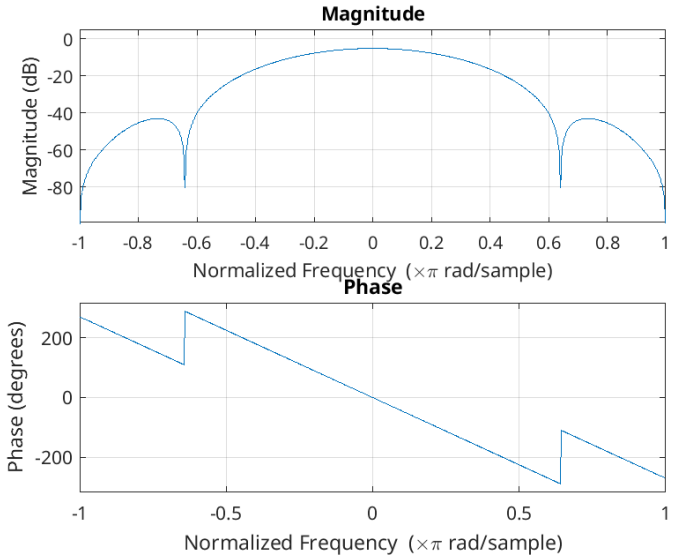


3.2.3 N=512

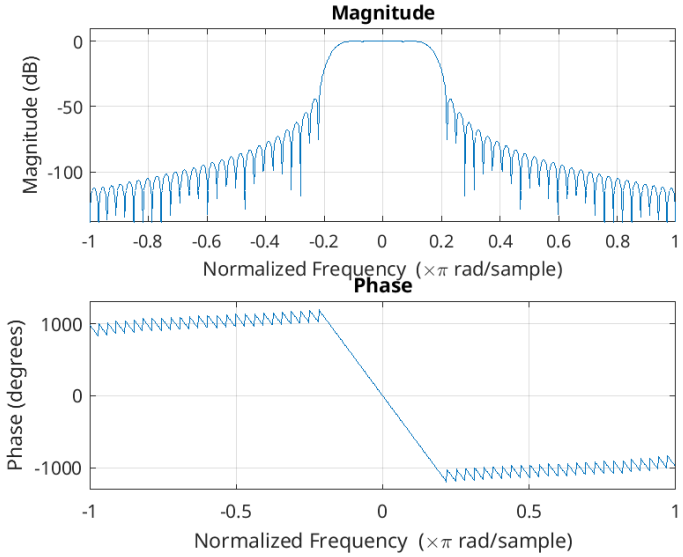


3.3 Hanning Window

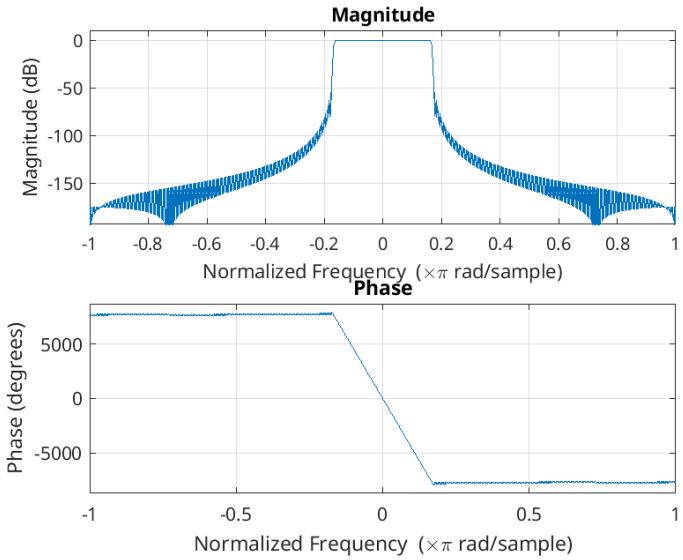
3.3.1 N=8



3.3.2 N=64

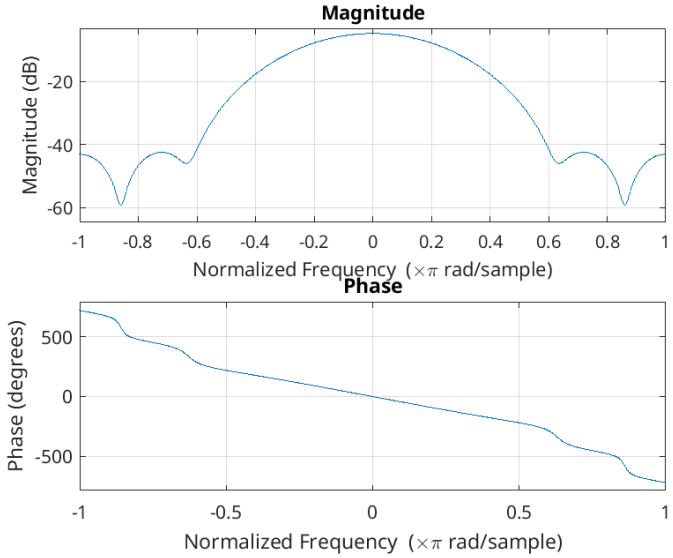


3.3.3 N=512

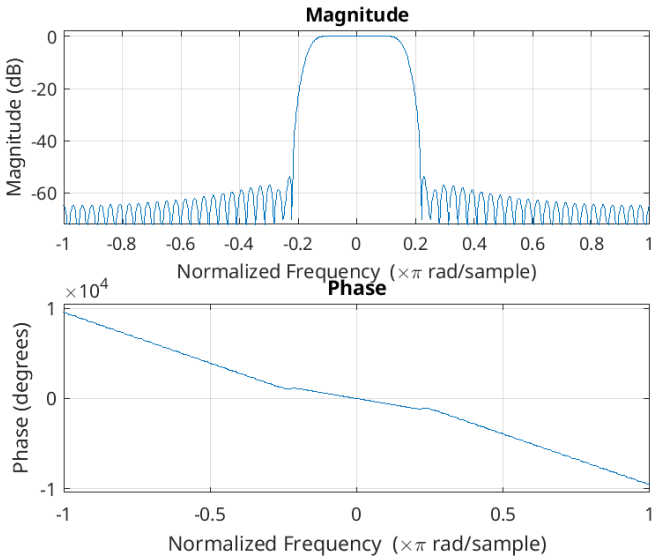


3.4 Hamming Window

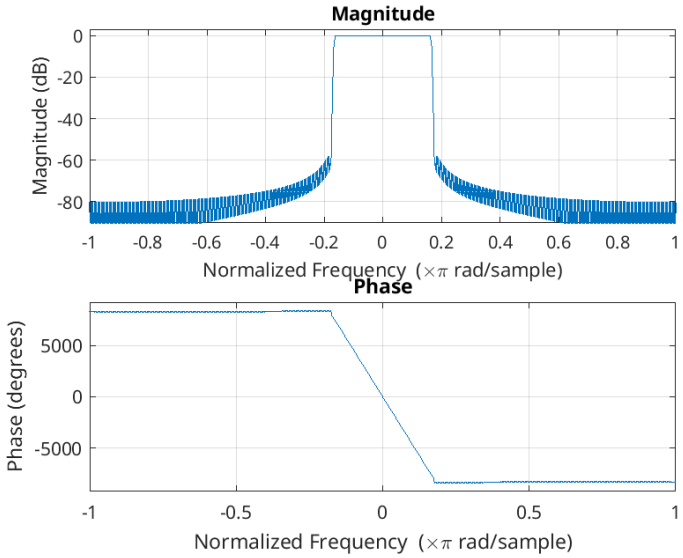
3.4.1 N=8



3.4.2 N=64

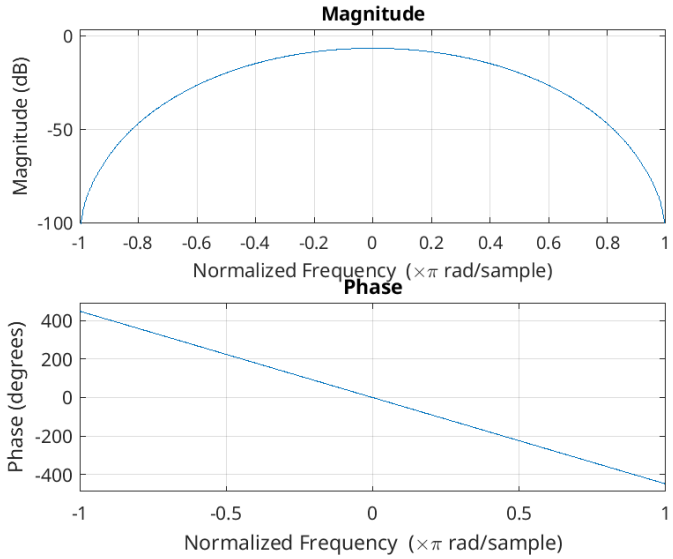


3.4.3 N=512

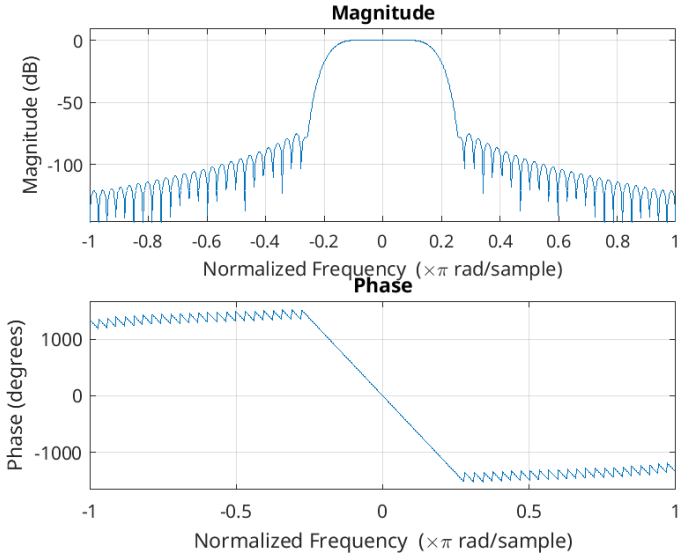


3.5 Blackmann Window

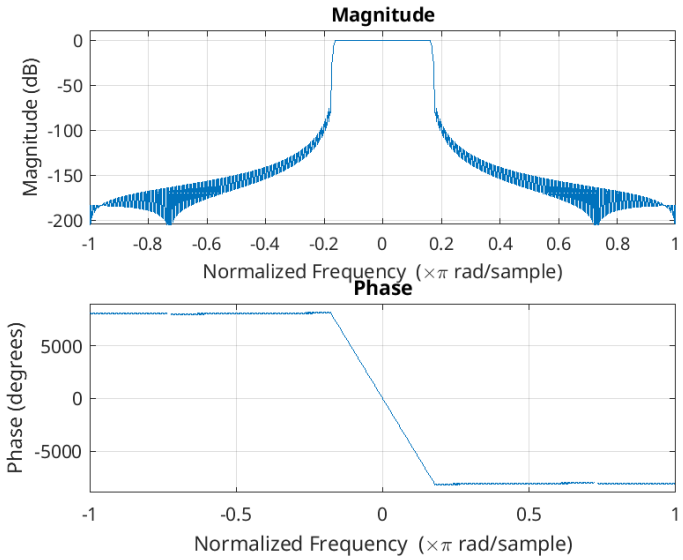
3.5.1 N=8



3.5.2 N=64



3.5.3 N=512


Magnitude
Magnitude (dB)
0
-50
-100
-150
-200
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
Normalized Frequency (×π rad/sample)
Phase
Phase (degrees)
5000
0
-5000
-1
-0.5
0
0.5
1
Normalized Frequency (×π rad/sample)