University of Dhaka
Department of Robotics and Mechatronics Engineering
RME 402: Digital Signal Processing Lab
Lab Assignment

1. Filtering of Noisy Signals:

A signal $x(n)$ is the sum of a desired signal $s(n)$ and interference $v(n)$:

$$x(n) = s(n) + v(n)$$

where

$$s(n) = \sin(\omega_2 n), \quad v(n) = \sin(\omega_1 n) + \sin(\omega_3 n)$$

with

$$\omega_1 = 0.05\pi, \quad \omega_2 = 0.20\pi, \quad \omega_3 = 0.35\pi \qquad \text{[radians/sample]}$$

In order to remove $v(n)$, the signal $x(n)$ is filtered through a bandpass FIR lowpass filter that is designed to pass the frequency ω_2 and reject the interfering frequencies ω_1, ω_3. An example of such a filter of order $M = 100$ can be designed with the methods of Chapter 11 of [1] (using a Hamming-window design) and has impulse response:

$$h(n) = w(n)\left[\frac{\sin(\omega_b(n - M/2)) - \sin(\omega_a(n - M/2))}{\pi(n - M/2)}\right], \quad 0 \le n \le M$$

where $\omega_a = 0.15\pi$, $\omega_b = 0.25\pi$, and $w(n)$ is the Hamming window:

$$w(n) = 0.54 - 0.46\cos\left(\frac{2\pi n}{M}\right), \quad 0 \le n \le M$$

It has an effective passband $[\omega_a, \omega_b] = [0.15\pi, 0.25\pi]$. To avoid a computational issue at $n = M/2$, you may use MATLAB's built-in function `sinc`, which is defined as follows:

$$\text{sinc}(x) = \frac{\sin(\pi x)}{\pi x}$$

Lab Procedure

a. On the same graph plot $x(n)$ and $s(n)$ versus n

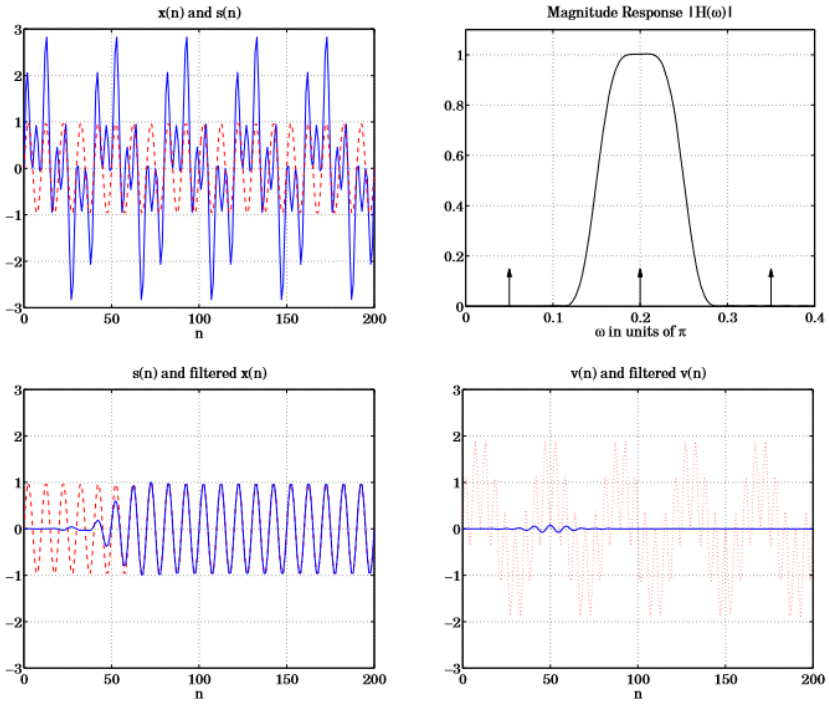
b. Filter $x(n)$ through the filter $h(n)$ using MATLAB's built-in function `filter`, and plot the filtered output $y(n)$, together with $s(n)$. Apart from an overall delay introduced by the filter, $y(n)$ should resemble $s(n)$ after the M initial transients.

c. To see what happened to the interference, filter the signal $v(n)$ separately through the filter and plot the output, on the same graph with $v(n)$ itself.

d. Using the built-in MATLAB function `freqz`, or the textbook function `dtft`, calculate and plot the magnitude response of the filter over the frequency interval $0 \le \omega \le 0.4\pi$:

$$|H(\omega)| = \left|\sum_{n=0}^{M} h(n)e^{-j\omega n}\right|$$

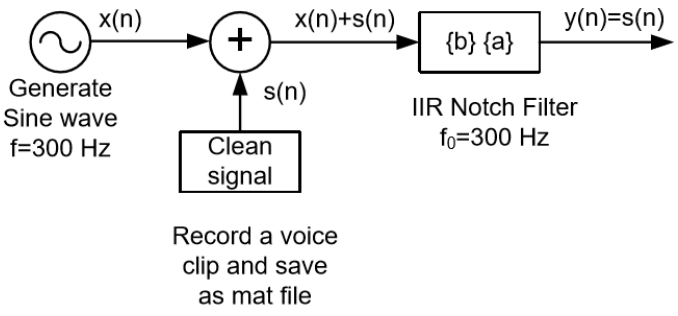
Indicate on that graph the frequencies $\omega_1, \omega_2, \omega_3$.

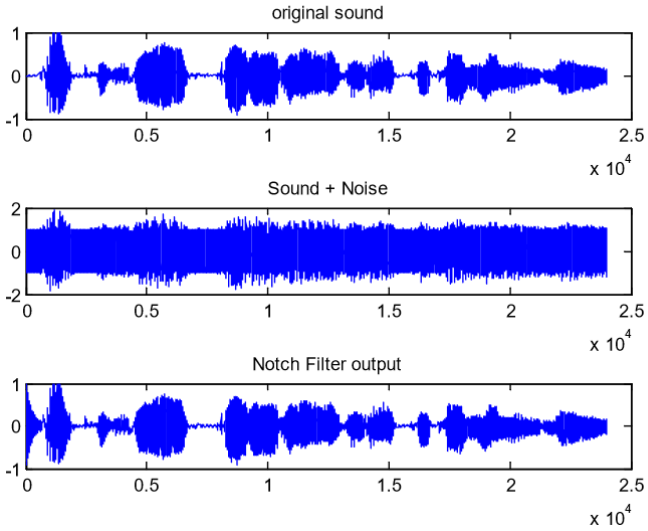


References:

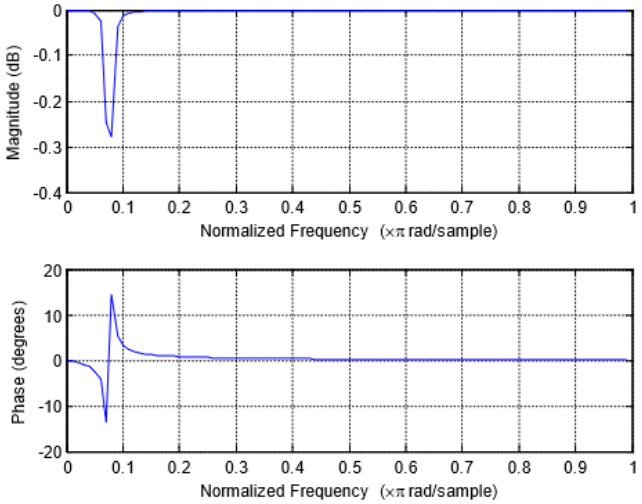
[1] S. J. Orfanidis, *Introduction to Signal Processing*, online book, 2010, available from: http://www.ece.rutgers.edu/~orfanidi/intro2sp/

2. **Design of an IIR Notch Filter and apply it to remove an unwanted sinusoid from a sound clip:** A disturbing sine signal is added purposefully with a clean sound signal. The signal now becomes noisy. Then filter the noisy signal with the notch filter. Get the clean signal after filtering it using the designed notch filter.





The frequency and Phase response follows



References:

Digital Signal Processing by EC Ifeachor.