Assignment 1

NEIL DHAMI - EE18BTECH11031

Download all python codes from

```
https://github.com/neildhami18/IITH_Academics/EE3025/Assignment1/codes
```

and latex-tikz codes from

```
https://github.com/neildhami18/IITH_Academics/EE3025/Assignment1
```

1 Problem

(7.1) The command

```
output_signal = signal.lfilter(b, a, input_signal)
```

in Problem (2.3) is executed through the following difference equation

$$\sum_{m=0}^{M} a(m)\, y(n-m) = \sum_{k=0}^{N} b(k)\, x(n-k) \tag{1.0.1}$$

where the input signal is $x(n)$ and the output signal is $y(n)$ with initial values all 0. Replace **signal.filtfilt** with your own routine and verify.

2 Solution

One of the easiest approach compute output of a digital filter is to convert our operations into Z-domain. From the time shifting property of Z transfrom,

$$\mathcal{Z}\{x(n-k)\} = z^{-k}X(z) \tag{2.0.1}$$

$$\mathcal{Z}\{y(n-m)\} = z^{-m}Y(z) \tag{2.0.2}$$

where $X(z)$ and $Y(z)$ are the z-transforms of $x(n)$ and $y(n)$ respectively.
The equation obtained in Z domain:

$$Y(z)\sum_{m=0}^{M} a(m)\, z^{-m} = X(z)\sum_{k=0}^{N} b(k)\, z^{-k} \tag{2.0.3}$$

$$H(z) = \frac{Y(z)}{X(z)} = \frac{\sum_{k=0}^{N} b(k)\, z^{-k}}{\sum_{m=0}^{M} a(m)\, z^{-m}} \tag{2.0.4}$$

From the coefficients b,a and from (2.0.4) we evaluate $H(k)$ as:

$$H(k) = H\left(z = e^{-\jmath 2\pi k/N}\right). \tag{2.0.5}$$

The in-built **signal.fft** command evaluates $X(k)$ from our input signal $x(n)$.
Now, we can easily obtain $Y(k)$ as:

$$Y(k) = H(k)\, X(k) \tag{2.0.6}$$

Finally, we obtain out output $y(n)$ from $Y(K)$ using **signal.ifft** command.
Below is the following python code for the above question. This code plots the output signals and returns the corresponding soundfiles.

```
codes/ee18btech11031.py
```

3 Verification

Plotting the time domain output signal $y(n)$ obtained using signal.filtfilt as well as own filter apply function.

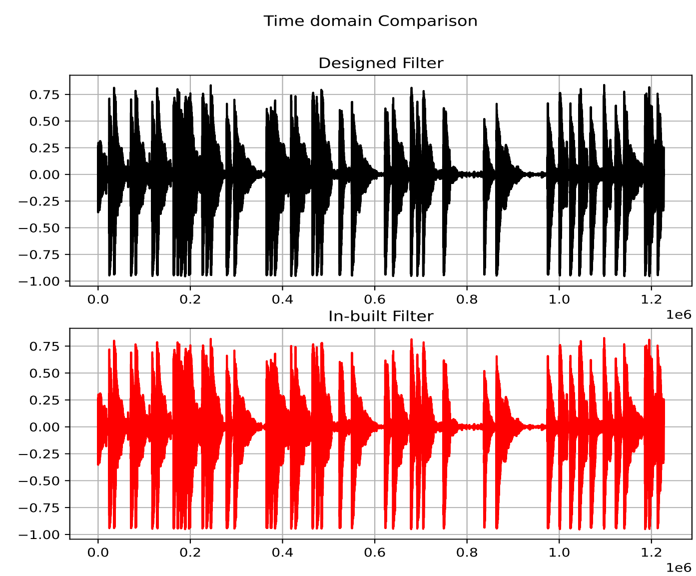

Fig. 0: Time domain response

Comparing plots of the Frequency Response of both, own filter apply function, and signal.filtfilt for further verification

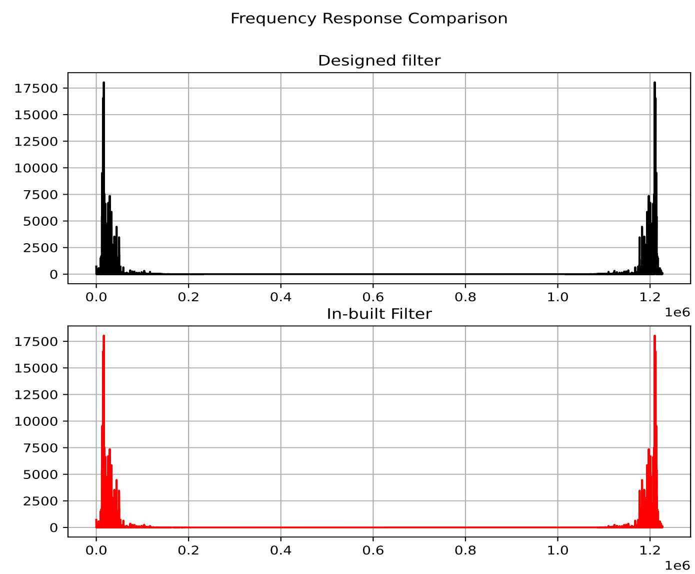

Fig. 0: Frequency domain response