ASSIGNMENT 3

Assignment-3

Q1) $$H(z) = \prod_{k=1}^{M} \frac{z^{-1}-d_k}{1-d_k z^{-1}} \prod_{k=1}^{M_c} \frac{(z^{-1}-e_k')(z^{-1}-e_k)}{(1-e_k z^{-1})(1-e_k' z^{-1})} \quad |z| \in R_z$$

Inverse of this system is

$$H^{-1}(z) = \frac{1}{H(z)}$$

$$= \prod_{k=1}^{n} \frac{1-d_k z^{-1}}{z^{-1}-d_k} \prod_{k=1}^{M_c} \frac{(1-e_k z^{-1})(1-e_k' z^{-1})}{(z^{-1}-e_k')(z^{-1}-e_k)}$$

$$= \prod_{k=1}^{M_c} \left(\frac{z-d_k}{1-d_k z}\right) \prod_{k=1}^{M_c} \frac{(z-e_k)(z_k-e_k')}{(1-e_k' z)(1-e^k z)}$$

$$= H\left(\frac{1}{z}\right)$$

$\Rightarrow$ corresponds to $h[-n]$

$\Rightarrow h_i[n] = h[-n]$

Q4) $$H(z) = \frac{(1-1.5z^{-1}-z^{-2})(1+0.9z^{-1})}{(1-z^{-1})(1+0.7jz^{-1})(1-0.7jz^{-1})}$$

$$= \frac{(1-2z^{-1})(1+\frac{1}{2}z^{-1})\cdot(1+0.9z^{-1})}{(1-z^{-1})(1+0.7jz^{-1})(1-0.7jz^{-1})}$$

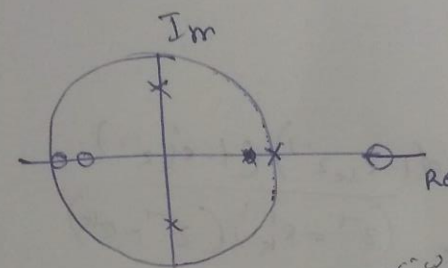
$$= \frac{(1-0.6z^{-1}-2.35z^{-2}-0.9z^{-3})}{1-z^{-1}+0.49z^{-2}-0.49z^{-3}}$$

$$= \frac{X(z)}{Y(z)} \text{ (let)}$$

Cross multiplying and taking inverse z-tx

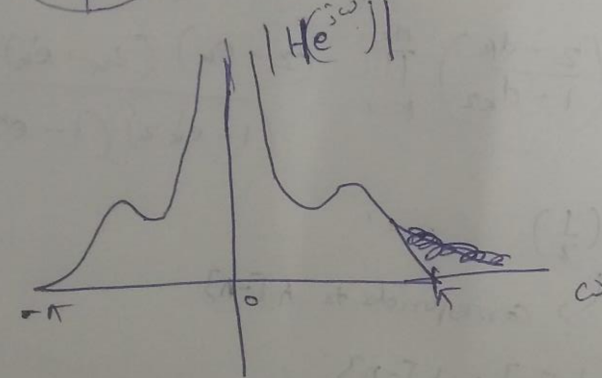
$$y[n] - y[n-1] + 0.49\,y[n-2] - 0.49\,y[n-3] = x[n] - 0.6\,x[n-1] - 2.35\,x[n-2] - 0.9\,x[n-3]$$

(b)



ROC
$|z| > 1$

(c)

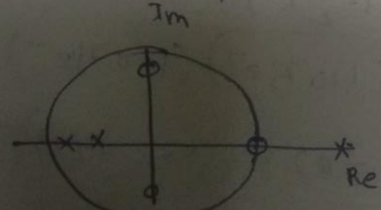


(d) (i) Not stable as ROC doesn't have $|z| = 1$

(ii) $h[n]$ ~~does~~ isn't const as $n \to \infty$

(iii) Peaks at $\omega = \pm \pi/2$ in the graph of $|H(e^{j\omega})|$ shown (c); so this is false.

(iv)



ROC includes $|z| = 1$
but system is two sided,
so it's false.

Q6) It is false.

Proof

$$h[n] = \frac{\sin \omega_c (n-4.3)}{\pi(n-4.3)} \leftrightarrow H(e^{j\omega}) = \begin{cases} e^{-4.3\omega}, & |\omega|<\omega_c \\ 0, & \text{otherwise.} \end{cases}$$

Although delay is const. ($grd[H(e^{j\omega})]=4.3$, resulting M is not an integer.

$$h[n] = \pm h[M-n]$$

$$H(e^{j\omega}) = \pm e^{j\omega M} \cdot H(e^{-j\omega})$$

$$e^{-4.3j\omega} = \pm e^{j(M+4.3)\omega}, \quad |\omega|<\omega_c$$

$$M = -8.6$$

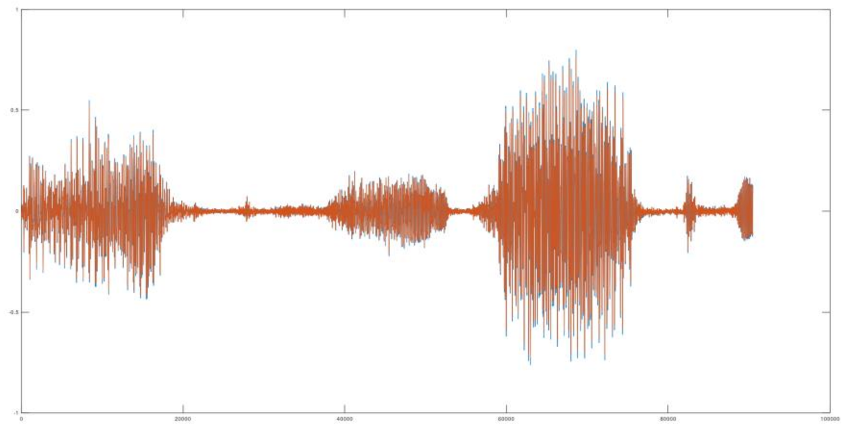
Question 7:

a) **Code:**

```
pkg load signal;
[sound,Fs] = audioread('rhino.wav');
plot(sound);
disp(Fs);
soundsc(sound,44100);
```

The frequency of sampling was 44100 Hz

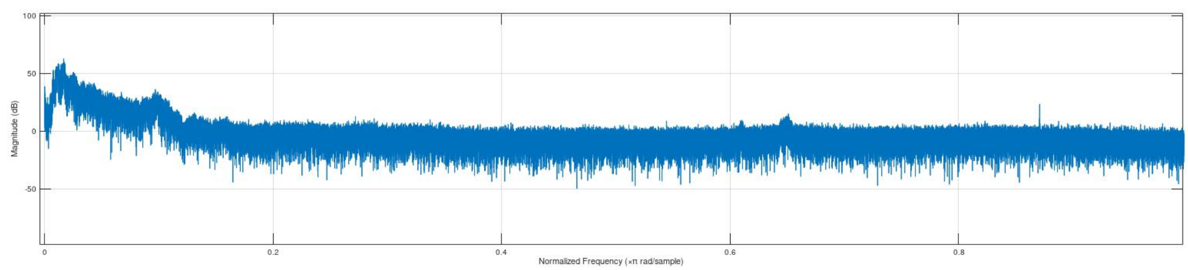
Plot:

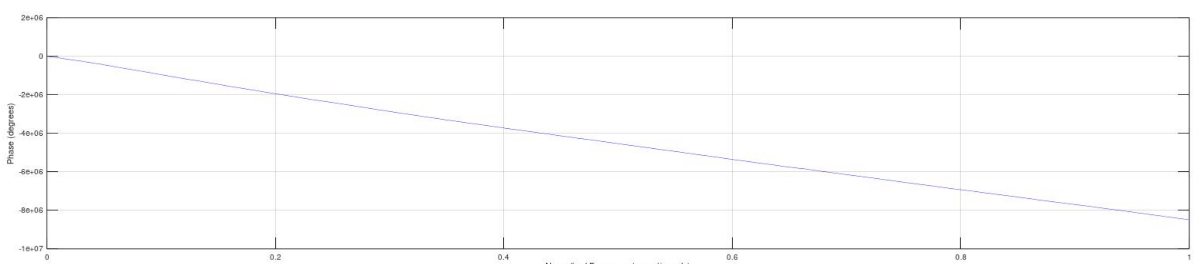


b) **Code:**

```
pkg load signal;
[sound,Fs] = audioread('rhino.wav');
disp(Fs);
channel = sound(:,1);
freqz(channel);
```

Plot of channel 1:





It is inferred that lower frequencies are more dominant.

c) **Code:**

```
pkg load signal;
[sound,Fs] = audioread('rhino.wav');
disp(Fs);
channel = sound(:,1);
sound = sound + 0.01*randn(90462,2);
```

d) Code:

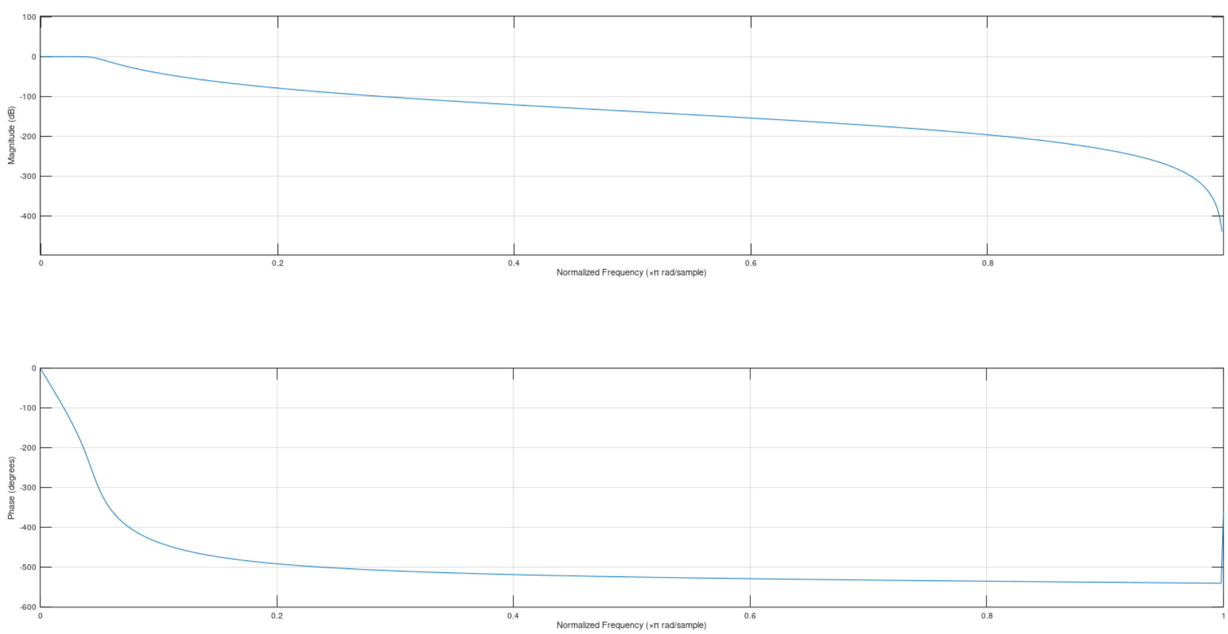
```
pkg load signal;
[sound,Fs] = audioread('rhino.wav');
sound1=sound;
disp(Fs);
channel = sound(:,1)
sound1 = sound + 0.01*randn(90462,2);
soundsc(sound1,44100);
```

The sound is not very clear anymore. There is a constant hissing sound now present.

e) **Code:**

```
clc;clear;close all;
pkg load signal;
[sound,Fs] = audioread('rhino.wav');
sound1=sound;
channel = sound(:,1)
sound1 = sound + 0.01*randn(90462,2);
[bf,x] = butter(6,1000*2/44100);
freqz(bf,x);
```

Plot of the butterworth filter:



f) Code:

```
clc;clear;close all;
pkg load signal;
[sound,Fs] = audioread('rhino.wav');
```

```
sound1=sound;
channel = sound(:,1)
sound1 = sound + 0.01*randn(90462,2);
[bf,x] = butter(6,1000*2/44100);
clean(:,1) = filter(bf,x,sound1(:,1));
clean(:,2) = filter(bf,x,sound1(:,2));
soundsc(clean,44100);
```

The signal cleans up. This is because we used a low pass filter with a cutoff of 1 kHz. The frequency of the original signal was mostly under 1 kHz, which was passed by the filter but higher frequencies were blocked by the filter.