ECE - 6255

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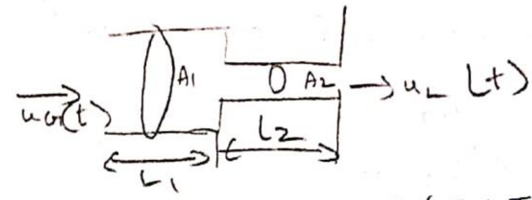
DIGITAL SPEECH PROCESSING ASSIGNMENT - 3

Prob 5.8

(1) $r_G = r_L = 1$

$r_1 = \dfrac{A_2 - A_1}{A_2 + A_1}$



$$V_a(t) = \frac{0.5\,(1+r_G)(1+r_L)(1+r_1)\,e^{-j\Omega(\tau_1+\tau_2)}}{1 + r_1 r_G e^{-2j\Omega\tau_1} + r_1 r_L e^{-2j\Omega\tau_2} + r_L r_G e^{-j2\Omega(\tau_1+\tau_2)}}$$

↳ Transfer function.

Substituting values

$$V_a(t) = \frac{(0.5)(2)(2)(1+r_1)\,e^{-j\Omega(\tau_1+\tau_2)}}{1 + r_1\left(e^{-2j\Omega\tau_1} + e^{-2j\Omega\tau_2}\right) + e^{-2j\Omega(\tau_1+\tau_2)}}$$

$r_L = r_G = 1 \qquad r_1 = \dfrac{A_2 - A_1}{A_2 + 1}$

We know poles are given by denominator $= 0$

$$\Rightarrow 1 + r_1\left(e^{-2j\Omega\tau_1} + e^{-2j\Omega\tau_2}\right) + e^{-2j\Omega(\tau_1+\tau_2)} = 0$$

$$1 + \frac{A_2 - A_1}{A_2 + A_1}\left(e^{-2j\Omega t_1} + e^{-2j\Omega\tau_2}\right) + e^{-2j\Omega(\tau_1+\tau_2)} = 0$$

$\cancel{A_2 = A_1}$ $$1 + r_1\left(e^{-2j\Omega\tau_1} + e^{-2j\Omega\tau_2}\right) + \frac{e^{-j\Omega(\tau_1+\tau_2)}}{e^{+j\Omega(t_1+\tau_2)}} = 0$$

$$e^{j\Omega(\tau_1+\tau_2)} + r_1\left(e^{j\Omega(\tau_1+\tau_2)}\right)\left(e^{-2j\Omega\tau_1} + e^{-2j\Omega\tau_2}\right) + e^{-j\Omega(\tau_1+\tau_2)} = 0$$

$$e^{j\Omega(\tau_1+\tau_2)} + e^{-j\Omega(\tau_1+\tau_2)} + r_1\left[e^{j\Omega(\tau_2-\tau_1)} + e^{-j\Omega(\tau_2-\tau_1)}\right] = 0$$

$\cos x = \dfrac{e^{x} + e^{-x}}{2}$ (eulers form)

$$\Rightarrow \cos\left[\Omega(T_2+T_1)\right] + r_1 \cos\left[\Omega(T_2-T_1)\right] = 0$$

$$\cos(A+B) = \cos A \cos B - \sin A \sin B$$

$$\cos(A-B) = \cos A \cos B + \sin A \sin B$$

$$r_1 = \frac{A_2 - A_1}{A_2 + A_1}$$

$$\cos(\Omega T_2 + \Omega T_1) + \frac{(A_2 - A_1)}{A_2 + A_1} \cos(\Omega T_2 - \Omega T_1) = 0$$

$$(A_2 + A_1) \cos(\Omega T_2 + \Omega T_1) + (A_2 - A_1) \cos(\Omega T_2 - \Omega T_1) = 0$$

$$(A_2+A_1)\left[\cos(\Omega T_2)\cos(\Omega T_1) - \sin(\Omega T_2)\sin(\Omega T_1)\right]$$
$$+ (A_2 - A_1)\left[\cos(\Omega T_2)\cos(\Omega T_1) + \sin(\Omega T_2)\sin(\Omega T_1)\right] = 0$$

$$A_2 \cos(\Omega T_2)\cos(\Omega T_1) + \cancel{A_1 \cos(\Omega T_2)\cos(\Omega T_1)}$$
$$- A_2 \cancel{\sin(\Omega T_2)\sin(\Omega T_1)} - A_1 \sin(\Omega T_2)\sin(\Omega T_1)$$
$$+ A_2 \cos(\Omega T_2)\cos(\Omega T_1) + A_2 \cancel{\sin(\Omega T_2)\sin(\Omega T_1)}$$
$$- \cancel{A_1 \cos(\Omega T_2)\cos(\Omega T_1)} - A_1 \sin(\Omega T_2)\sin(\Omega T_1) = 0$$

$$\cancel{2} A_2 \cos(\Omega T_2)\cos(\Omega T_1) = \cancel{2} A_1 \sin(\Omega T_2)\sin(\Omega T_1)$$

$$\frac{A_1}{A_2} \frac{\sin(\Omega T_2)}{\cos(\Omega T_2)} = \frac{\cos(\Omega T_1)}{\sin(\Omega T_1)}$$

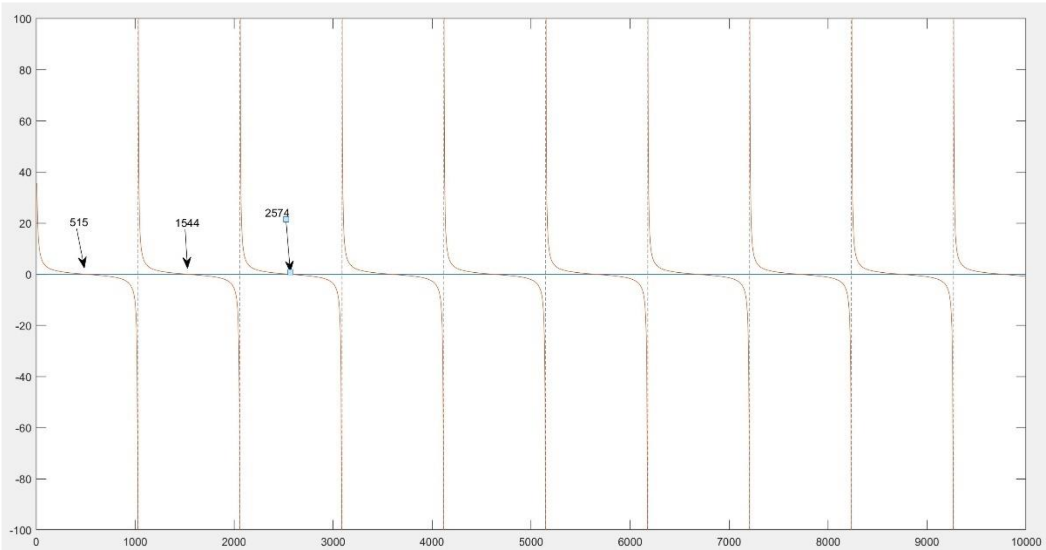
$$\boxed{\frac{A_1}{A_2} \tan(\Omega T_2) = \cos(\Omega T_1)}$$

where $T_1 = l_1/c$ $\quad T_2 = l_2/c$

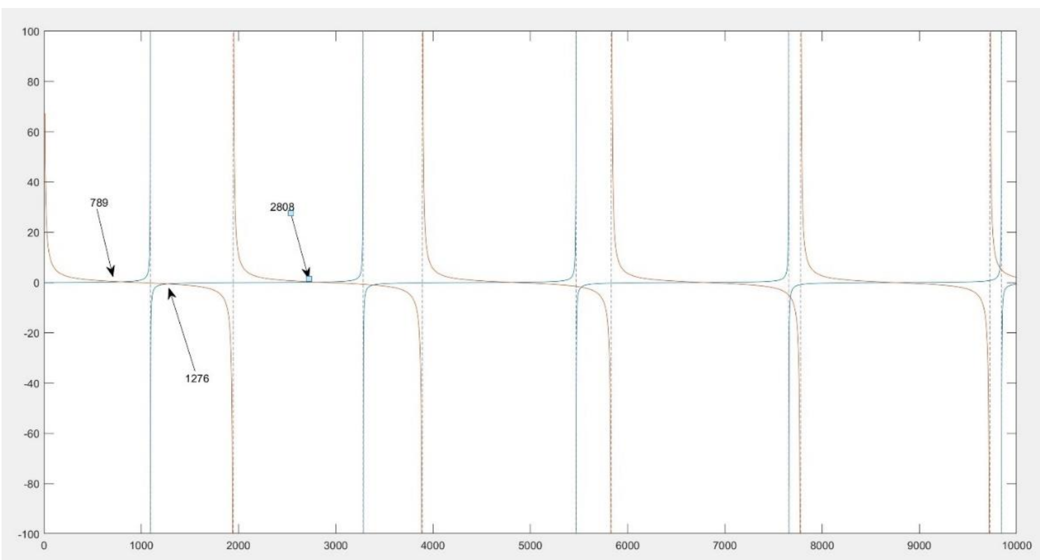
c = velocity of sound.

Que 1b)

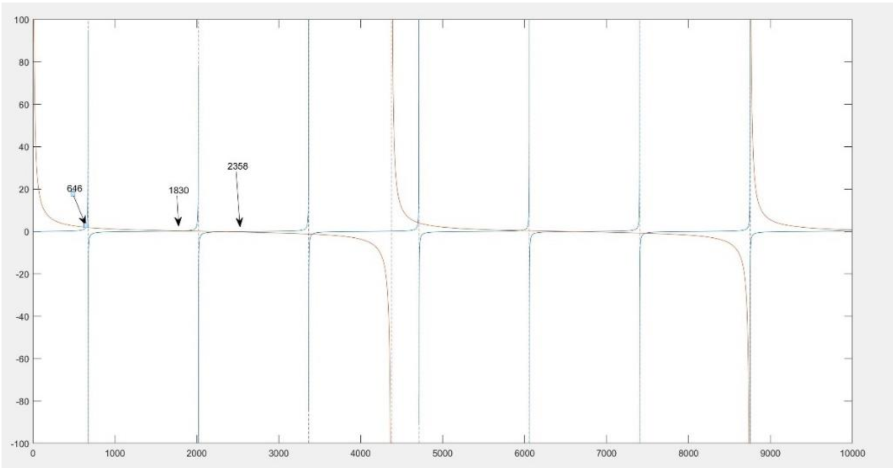
Vowel / Λ /



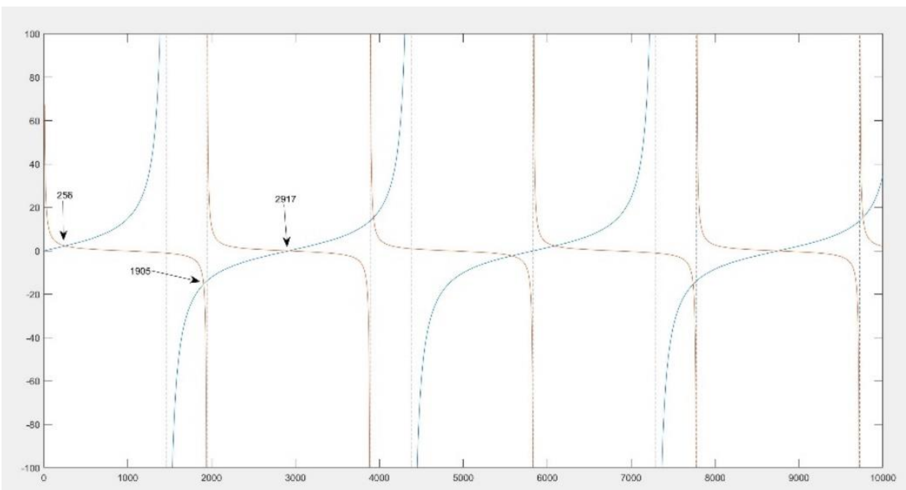
Vowel /a/

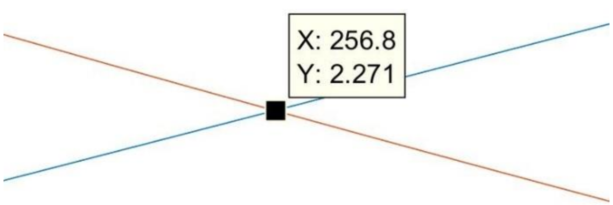


Vowel /ae/



Vowel /i/





Vowel	F1	F2	F3
/i/	256	1905	2917
/ae/	646	1830	2358
/a/	789	1276	2808
/ʌ/	515	1544	2574

Code –

```
clc;clear all; close all;

f1 = @(x) 8*tan((2*pi*x*6)/35000) %- cot(2*pi*x*9/35000);
f2 = @(x) cot(2*pi*x*9/35000);
figure();
fplot(f1);
axis([0 10000 -100 100]);
hold on;
fplot(f2);
% P=interX(f1,f2);

f1 = @(x) (1/8)*tan((2*pi*x*13)/35000) %- cot(2*pi*x*9/35000);
f2 = @(x) cot(2*pi*x*4/35000);
figure();
fplot(f1);
axis([0 10000 -100 100]);
hold on;
fplot(f2);

f1 = @(x) (1/7)*tan((2*pi*x*8)/35000) %- cot(2*pi*x*9/35000);
f2 = @(x) cot(2*pi*x*9/35000);
figure();
fplot(f1);
axis([0 10000 -100 100]);
hold on;
fplot(f2);

f1 = @(x) (1)*tan(0) %- cot(2*pi*x*9/35000);
f2 = @(x) cot(2*pi*x*17/35000);
figure();
fplot(f1);
axis([0 10000 -100 100]);
hold on;
fplot(f2);
```

2) $g(n) = \begin{cases} n a^n & 0 \le n \le N-1, \ |a|<1, \ a>0 \\ 0 & n<0, \ n>N \end{cases}$ (2)

a) $G(z) = \sum_{n=0}^{N-1} g(n) z^{-n} = \sum_{n=0}^{N-1} n a^n z^{-n}$

$= \sum_{n=0}^{N-1} n (az^{-1})^n$

By the z-tranform propeties

z tranform of $n x(n)$ is $-z \frac{dX(z)}{dz}$

z tranform of $a^n = \sum_{n=0}^{N-1} (az^{-1})^n = \frac{1-(az^{-1})^n}{1-az^{-1}}$

$$\frac{dX(z)}{dz} = \frac{d}{dz}\left[\frac{1}{1-az^{-1}} - \frac{(az^{-1})^N}{1-az^{-1}}\right]$$

$$= \frac{-1}{(1-az^{-1})^2}(+az^{-2}) - \left[\frac{-(az^{-1})^N (az^{-2})}{(1-az^{-1})^2} + \frac{a^N(-n) z^{-N-1}}{(1-az^{-1})}\right]$$

$$= -\frac{az^{-2}}{(1-az^{-1})^2} + \frac{a^{N+1} z^{-N-2}}{(1-az^{-1})^2} + \frac{n a^N z^{-N-1}}{(1-az^{-1})}$$

$$= \frac{-az^{-2} + a^{N+1} z^{-N-2} + n a^N z^{-N-1}(1-az^{-1})}{(1-az^{-1})^2}$$

$$= \frac{az^{-2} + a^{N+1} z^{-N-2} + n a^N z^{-N-1} - n a^{N+1} z^{-N-2}}{(1-az^{-1})^2}$$

$$= \frac{az^{-2} + a^N z^{-N-1}[az^{-1} + N - Naz^{-1}]}{(1-az^{-1})^2}$$

$n x(n) \Rightarrow n a^n$ z Transform $= -z \times \left[\frac{az^{-2} + a^N z^{-N-1}[az^{-1} + N - Naz^{-1}]}{(1-az^{-1})^2}\right]$

$$= \frac{az^{-1} - a^N z^{-N}\left[az^{-1} + N - Naz^{-1}\right]}{(1-az^{-1})^2}$$

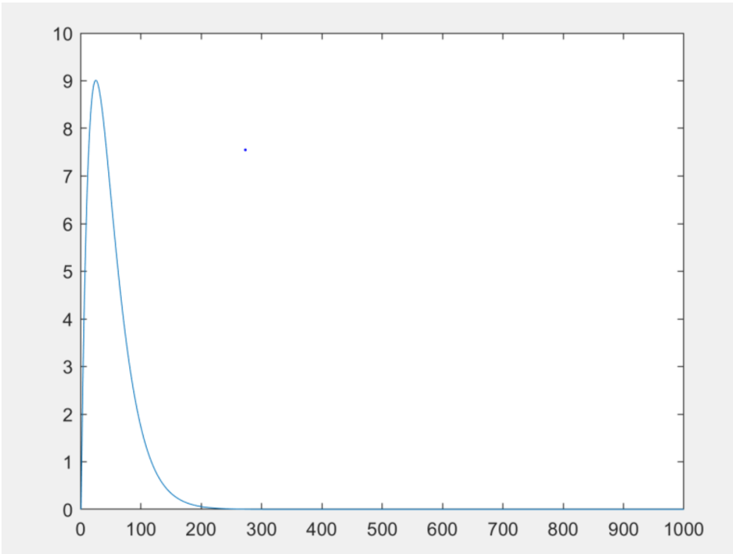
when N lies from 0 to ∞

$$\Rightarrow na^n \text{ z-transform } = \frac{az^{-1}}{(1-az^{-1})^2}$$

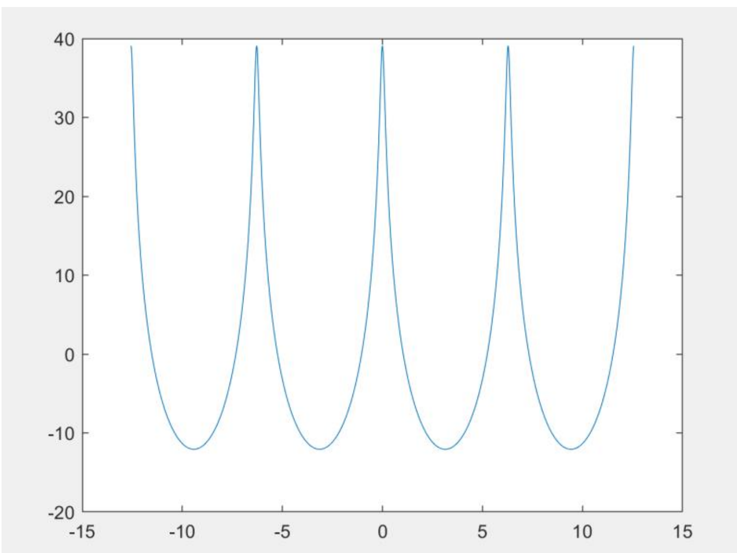
2e) on hearing the glottal pulse(n=80, m+n=160) excitation, we hear a fast buzzer type sound.

on hearing the glottal pulse(n=160, m+n=320) excitation, we hear a slower buzzer type sound compared to the above.The matlab code saves the files on which we verified.

Que 2a,b,c) Glottal Pulse.



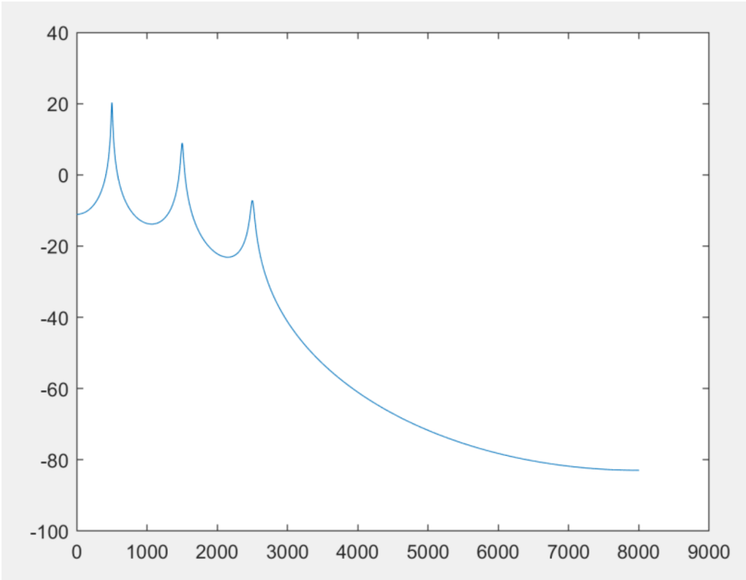
Frequency Response plot



Value of a

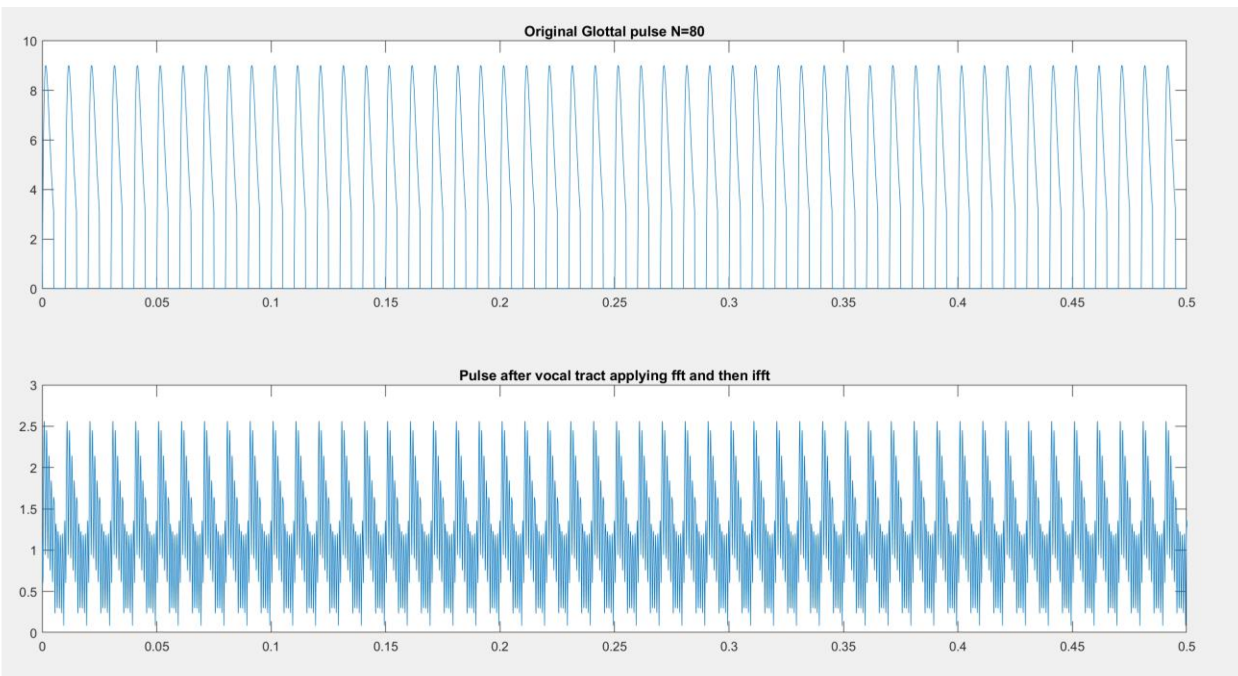
```
ans =

     0.9384

fx >>
```

2d) Frequency response

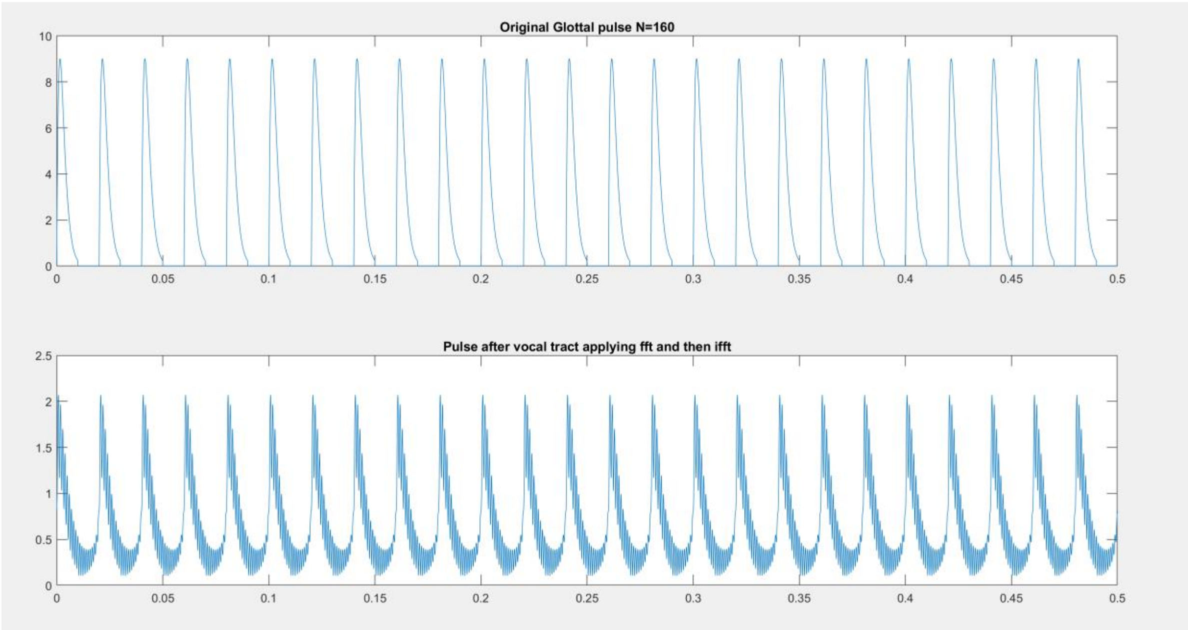


40
20
0
-20
-40
-60
-80
-100
0
1000
2000
3000
4000
5000
6000
7000
8000
9000

2e)

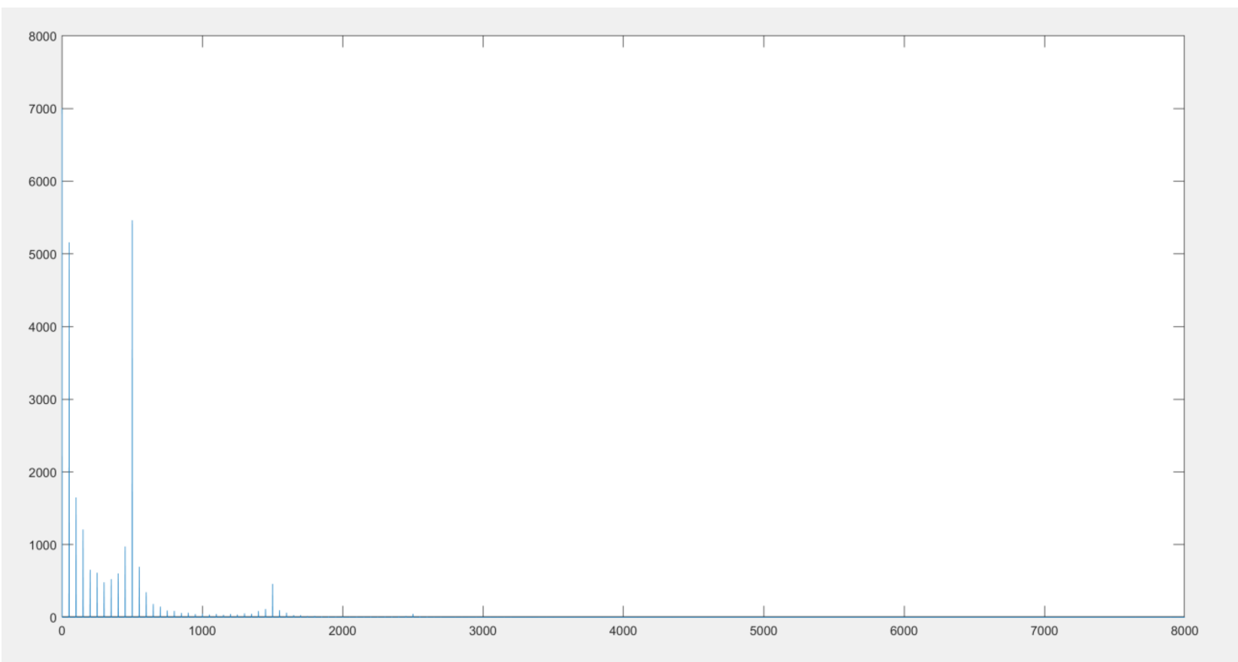


Original Glottal pulse N=80
Pulse after vocal tract applying fft and then ifft



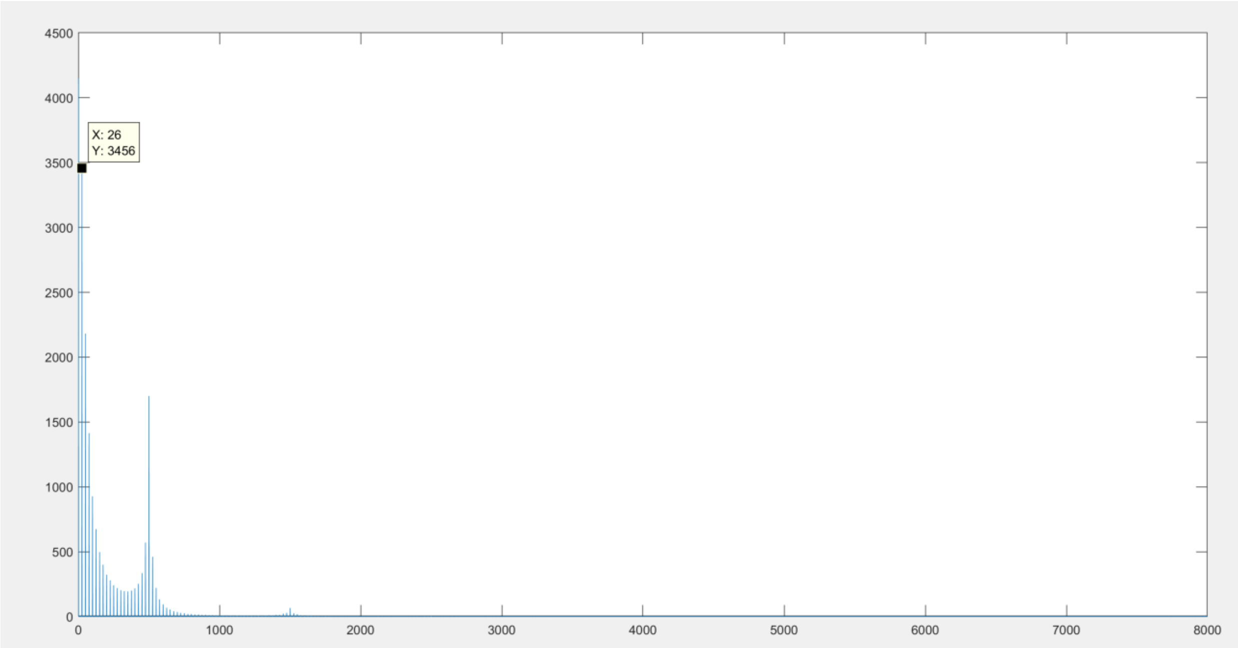
2e)

N=80



F1	51Hz
F2	501Hz
F3	1501Hz
Pitch	0.01 sec (time period) = 100Hz(frequency) =0.01*16000(Fs) = 160 samples/period

N=160



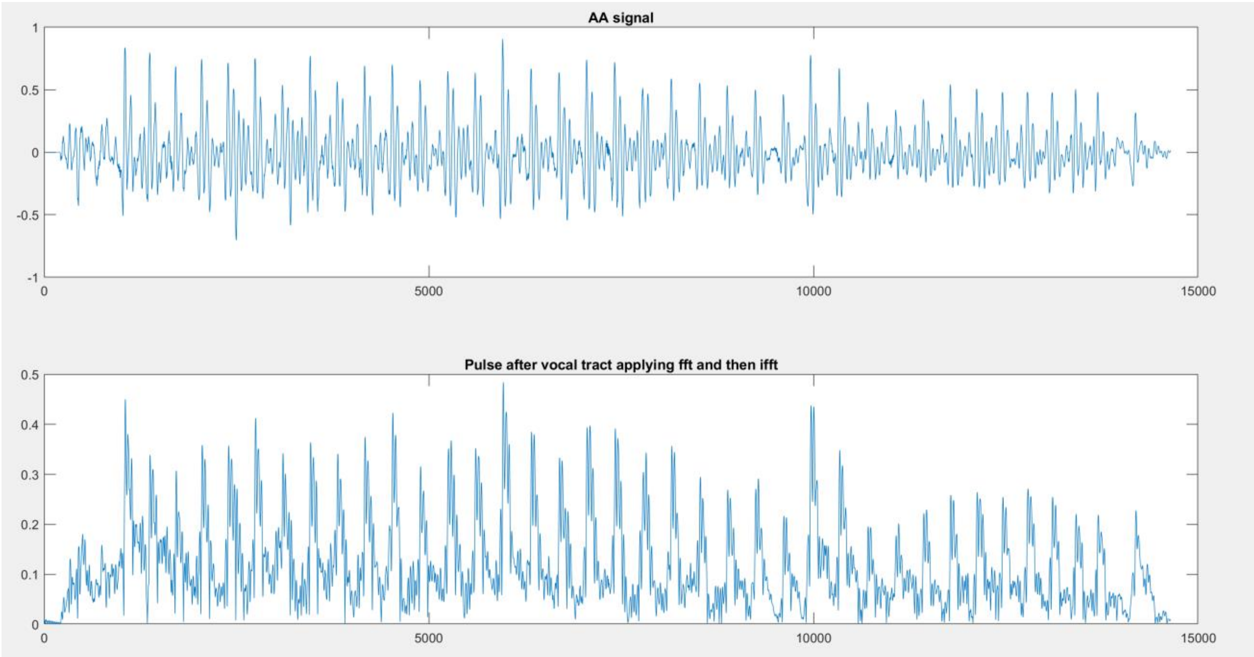
F1	26Hz
F2	501Hz
F3	1501Hz
Pitch	0.02sec (time period) = 50Hz(frequency) =0.02*16000(Fs) = 320 samples/period

Code-

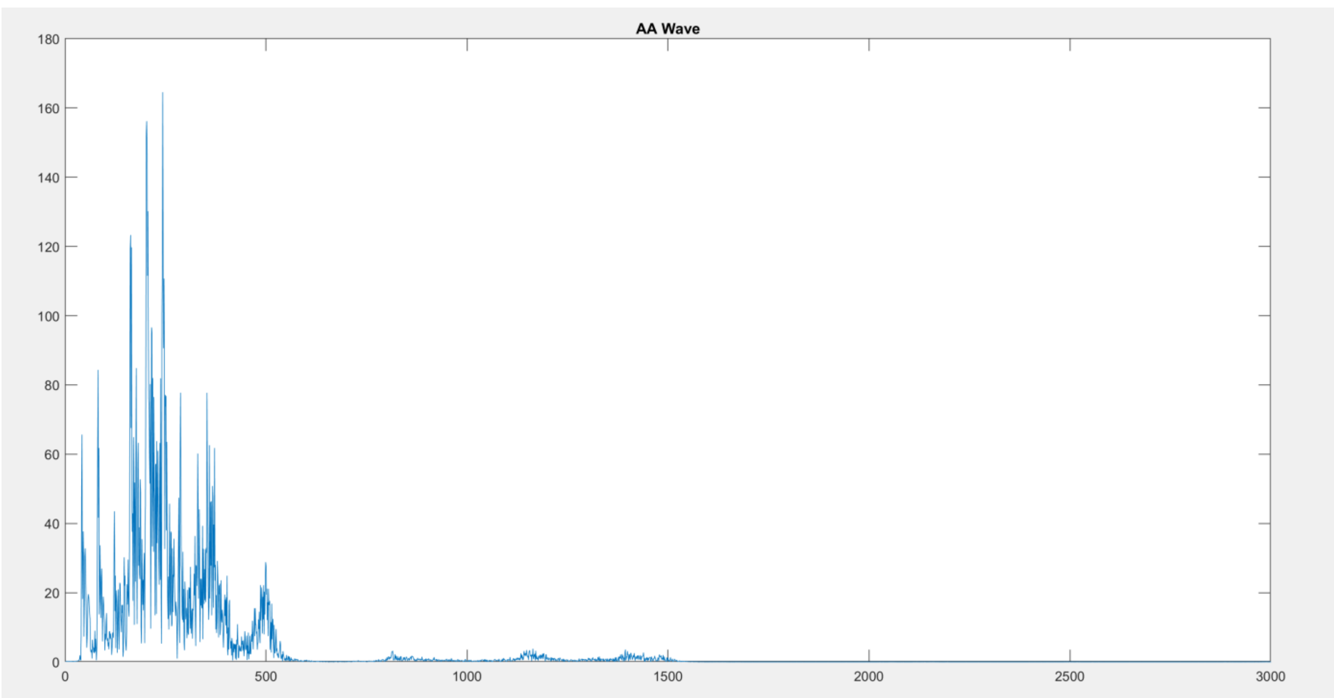
```
clear all; clc; close all;
Fk = [500 1500 2500];s
B = [200 400 600];
Fs = 16000;
%pole_magnitude_gain = [0.8 0.8 0.8];
pole_magnitude_gain = 0.08;

abs_vals = exp(-pi*pole_magnitude_gain.*B/Fs);
angles = exp(1j*2*pi*Fk/Fs);
conj_angles = conj(angles);
K = 10^(-2.5);
% freq_poly = zpk(Z, total_roots, K);

% sys = tf(1, polynomial);
% gpeak = getPeakGain(sys);

total_roots = [abs_vals.*angles abs_vals.*conj_angles];
polynomial = poly(total_roots);
Z = [];

for k =0:1:8000
   x = exp(1j*2*pi*k/Fs);
   value = abs(polyval(polynomial, x));
   mag = 20*log10(K/value);
   plot_val(k+1) = mag;
end
```

```
%Generate glottal pulse and feed into filter
g = @(x) rem(x,80).*(0.96.^rem(x,80)).*(rem(x,80)>=0).*(rem(x,160)<=80);
T = 0.5;
length = linspace(0,T,Fs*T); %Samples over half a second

g1 = @(x) rem(x,160).*(0.96.^rem(x,160)).*(rem(x,160)>=0).*(rem(x,320)<=160);
T1 = 0.5;
length1 = linspace(0,T1,Fs*T1);

freq_pulse = fft(g(linspace(0,7999,8000)));
y_z = K*freq_pulse./polyval(polynomial, exp(1j*2*pi*linspace(0,7999,8000)/Fs));

y_time = abs(ifft(y_z));

freq_pulse1 = fft(g1(linspace(0,7999,8000)));
y_z1 = K*freq_pulse1./polyval(polynomial, exp(1j*2*pi*linspace(0,7999,8000)/Fs));

y_time1 = abs(ifft(y_z1));

figure()
subplot(2,1,1);
plot(length, g(linspace(0,7999,8000)));
title('Original Glottal pulse N=80');
subplot(2,1,2);
plot(length, y_time);
title('Pulse after vocal tract applying fft and then ifft');

figure()
subplot(2,1,1);
plot(length, g1(linspace(0,7999,8000)));
title('Original Glottal pulse N=160');
subplot(2,1,2);
plot(length1, y_time1);
title('Pulse after vocal tract applying fft and then ifft');

figure()
plot(plot_val)

figure()
plot(abs(y_z))
%freqz(K,polynomial);
figure()
plot(abs(y_z1))
```

2g)

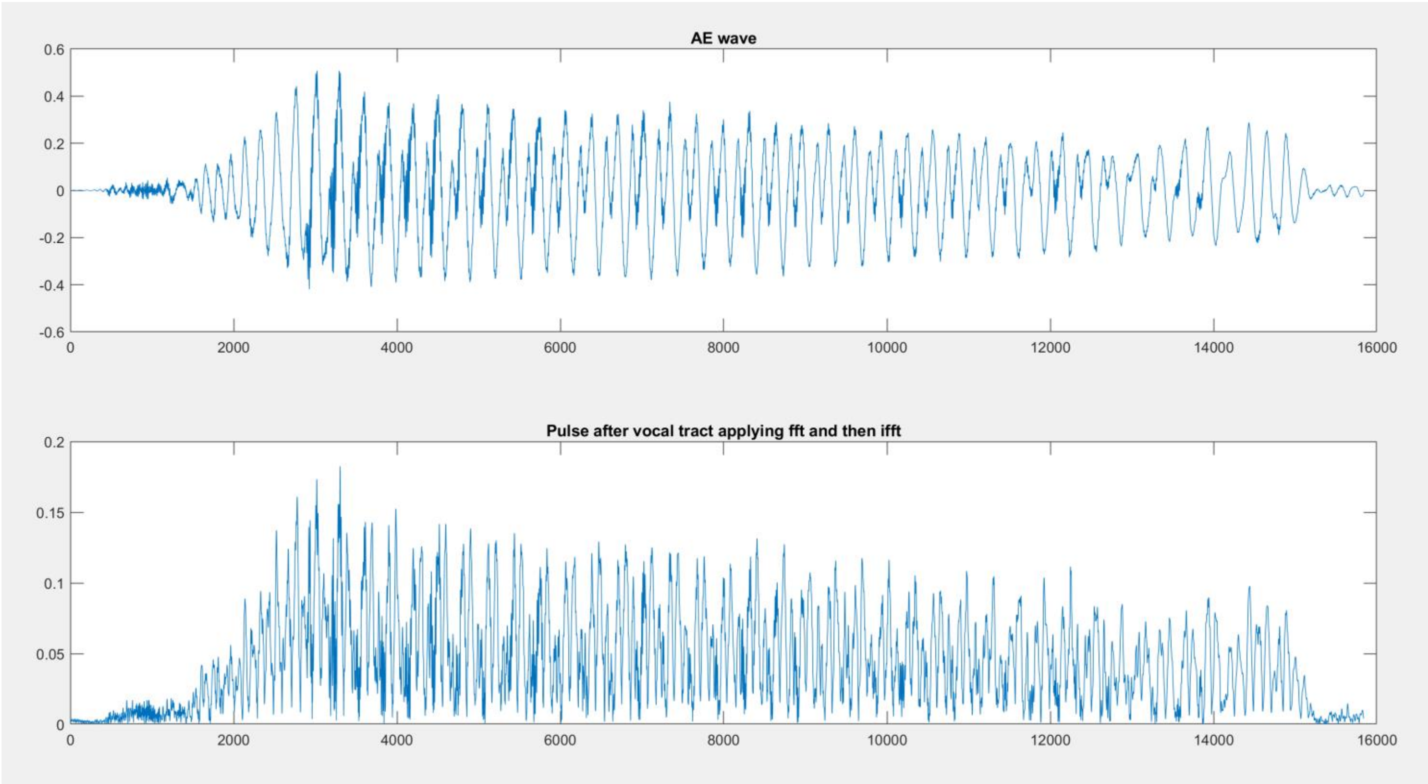


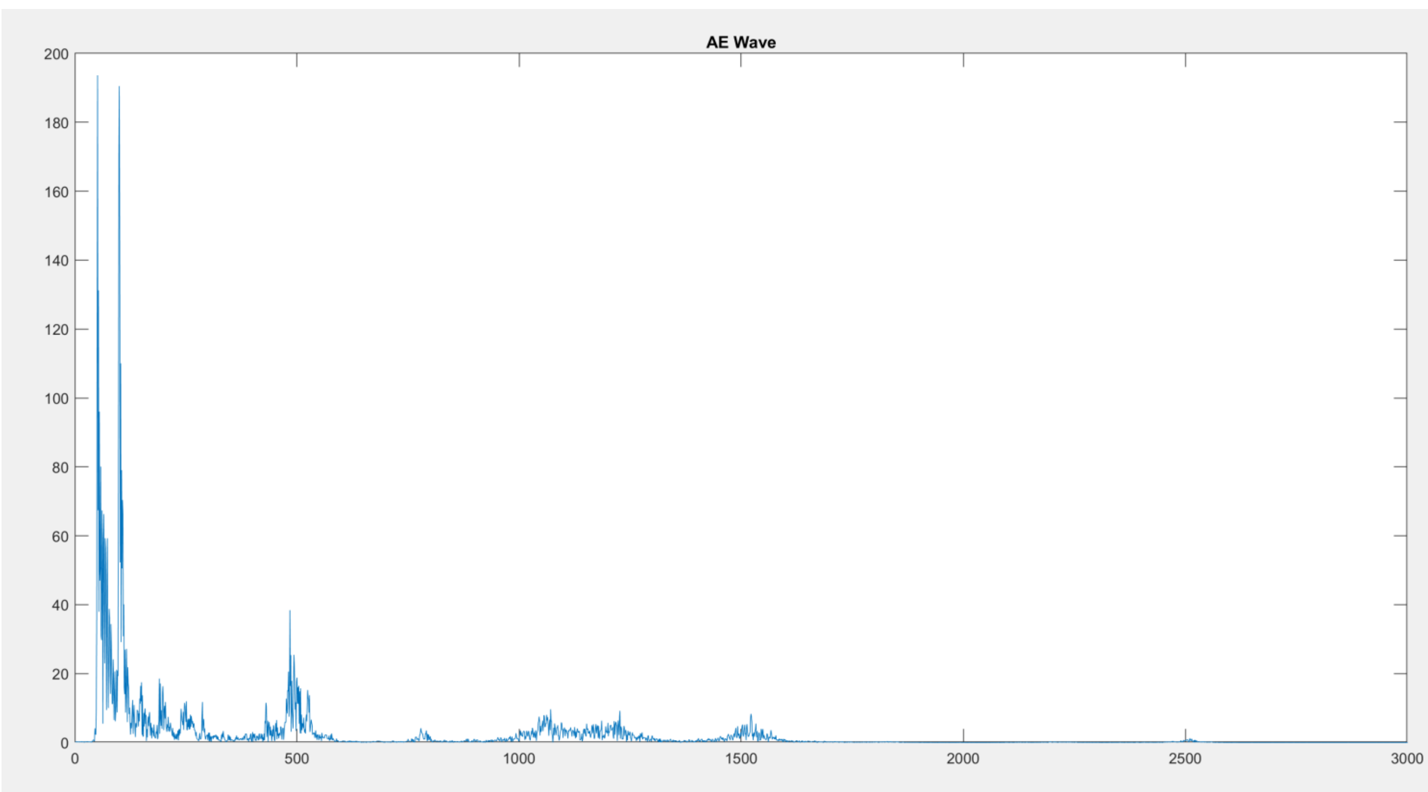
Frequency Response -



F1	813Hz
F2	1220Hz
F3	1400Hz
Pitch	322

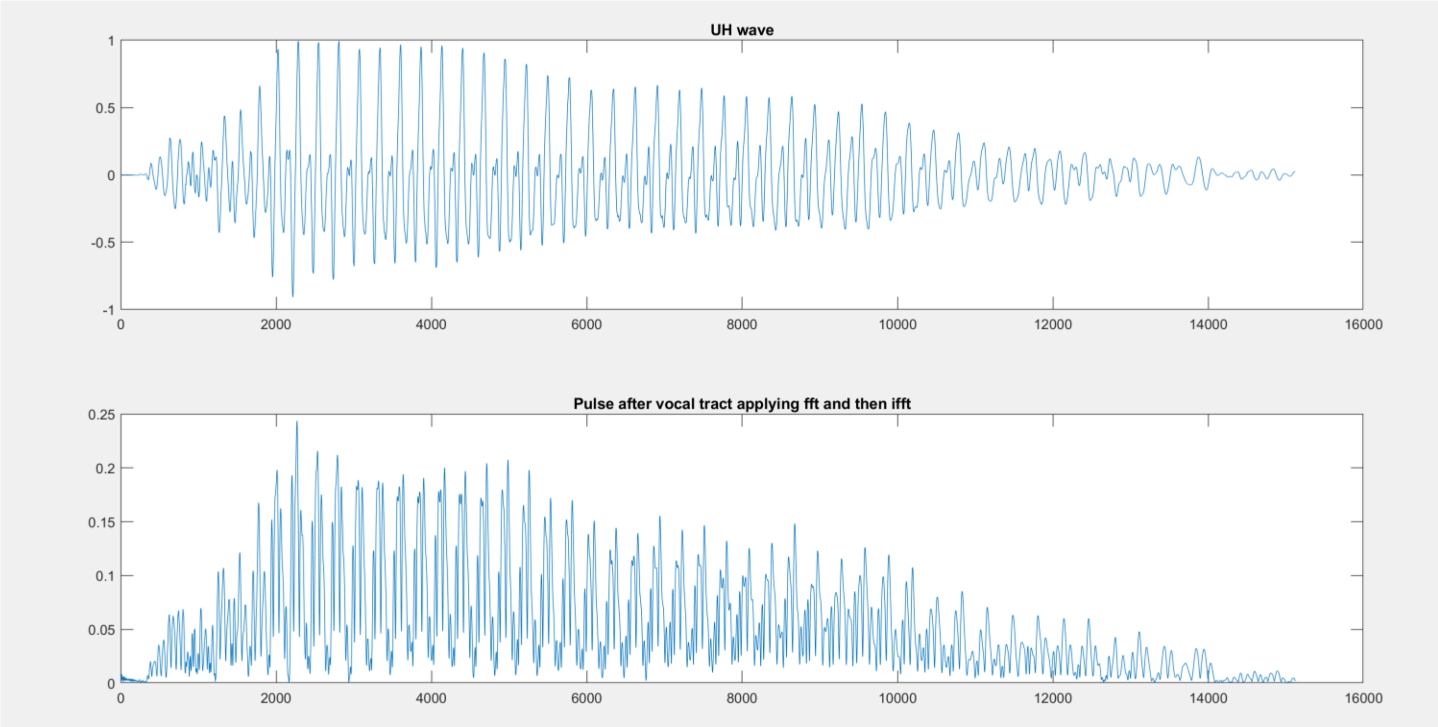
/AE/ Vowel



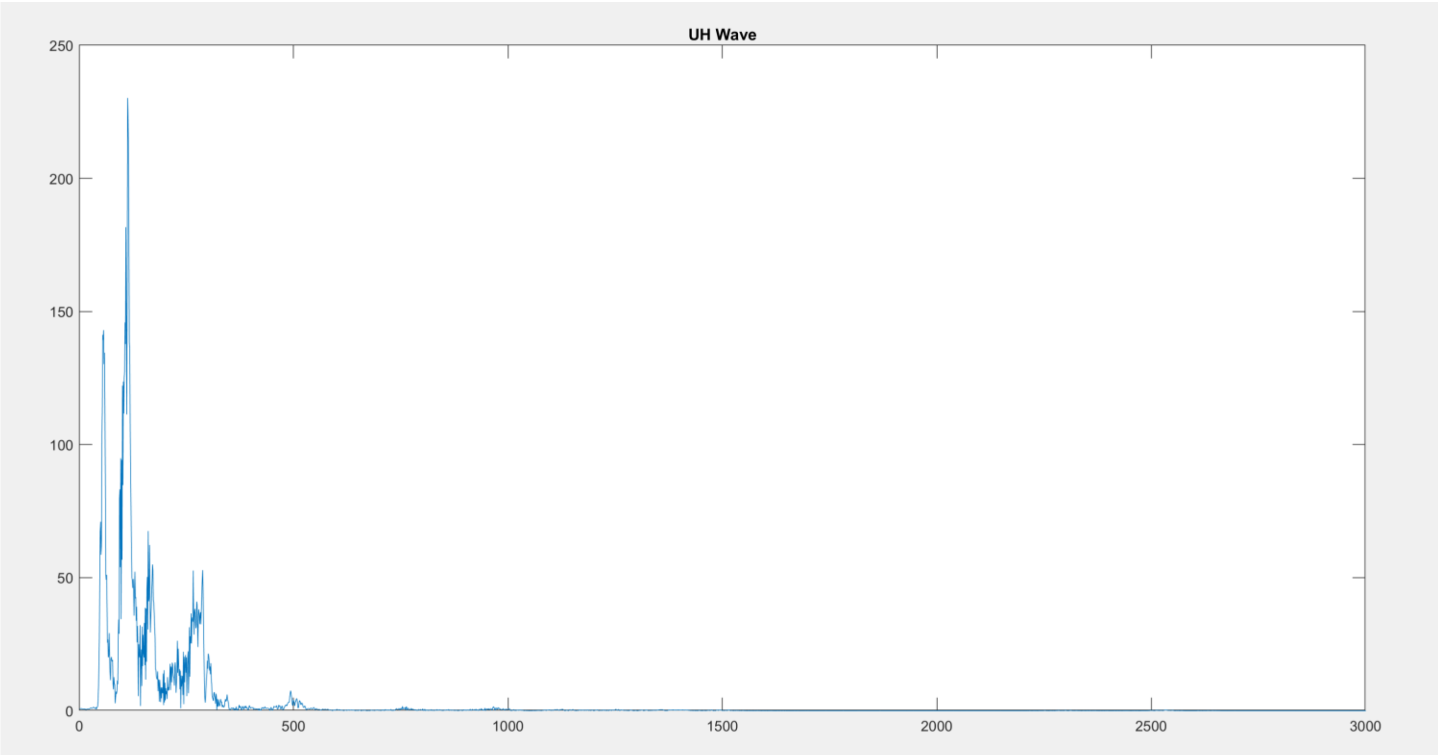


F1	500Hz
F2	1100Hz
F3	1509Hz
Pitch	280

/UH/ Wave



Frequency Response



F1	154Hz
F2	307Hz
F3	498hz
Pitch	236

③ Prob 6.2 ③

$$E_n(k) = \sum_{m=-\infty}^{\infty} \{x(m)\, w(n-m)\}^2$$

$$w[m] = \begin{cases} a^m & m \geq 0 \\ 0 & m < 0 \end{cases}$$

$\sum_{m=-\infty}^{\infty} x(m)^2\, w^2(n-m)$ is convolution in time domain

$$E_n(k) = \underbrace{x^2(n)}_{m(n)} * \underbrace{w^2(n)}_{\tilde{w}(n)}$$

Let $m[n] = x^2(n)$ and $\tilde{w}(n) = w^2(n)$

$E_n(k) = m[n] * \tilde{w}(n)$

convolution in time domain is multiplication frequency domain.

$$E_n(z) = m(z)\, \tilde{w}(z)$$

we know $w(n) = \begin{cases} a^m & m \geq 0 \\ 0 & \text{else} \end{cases}$

$$w^2[n] = \begin{cases} a^{2m} & m \geq 0 \\ 0 & \text{else} \end{cases}$$

$$w^2(z) = \frac{1}{1-a^2 z^{-1}}$$ from HW1

$$E_n(z) = m(z)\, \frac{1}{1-a^2 z^{-1}}$$

$$E_n(z)(1 - a^2(z^{-1})) = m(z)$$

$$E_n(z) - a^2 E_n(z) z^{-1} = m(z)$$

taking inverse

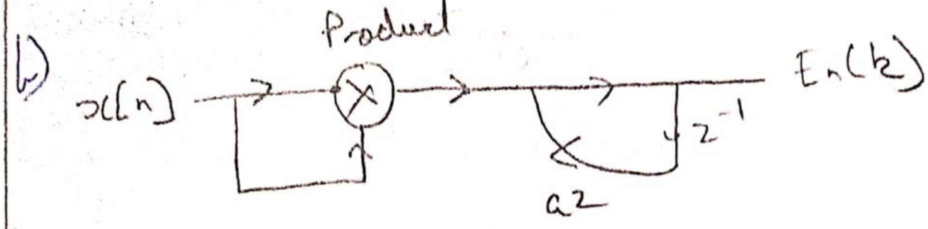
$$E_n(k) - a^2 E_{n-1}(k) = m(n)$$

$$E_n(k) - a^2 E_{n-1}(k) = \underline{x^2(n)}$$

let $\underline{n = \hat{n}}$

$$\boxed{E_{\hat{n}}(k) = x^2(\hat{n}) + a^2 E_{\hat{n}-1}(k)}$$

b)



c) We know $w[m] = \begin{cases} a^m & m \geq 0 \\ 0 & \text{else} \end{cases}$

z transform is $\dfrac{1}{1-az^{-1}}$

z transform of $w^2(m)$ is $\dfrac{1}{1-a^2z^{-1}}$ from previous que

To find a recursive implementation, $W(z)$ must be a rational function of z:

$$\tilde{w}(m) = w^2(m)$$

$$\hat{w}(z) = \frac{1}{1 - \sum_{k=1}^{N_p} a_k z^{-1}} \quad \text{or} \quad \hat{w}(z) = \frac{\sum_{k=1}^{N_z} b_k z^{-1}}{1 - \sum_{k=1}^{N_p} a_k z^{-1}}$$

where N_p or N_z are finite values and not infinite.

(4) Prob 6.9 (4)

long time autocorrelation

$$\phi(k) = \lim_{N\to\infty} \frac{1}{2N+1} \sum_{m=-N}^{N} x(m)\, x(m+k)$$

Short time autocorrelation

$$R_n(k) = \sum_{m=0}^{N-|k|-1} x(n+m)\, w'(m)\, x(n+m+k)\, w'(m+k)$$

modified short time autocorrelation function :-

$$\hat{R}_n(k) = \sum_{m=0}^{N-1} x(n+m)\, x(n+m+k)$$

$x(n+P) = x(n) \Rightarrow \underline{-\infty < n < \infty}$ given

a) i) check if $\phi(k) = \phi(k+p) \quad -\infty < k \leq \infty$

$$\phi(k+p) = \lim_{N\to\infty} \frac{1}{2N+1} \sum_{m=-N}^{N} x(m)\, \underline{x(m+k+p)}$$

we know $x(n+p) = x(n)$

$\Rightarrow x(m+k+p) = x(m+k)$ periodic

$$\Rightarrow \boxed{\phi(k) = \phi(k+p)}$$

ii) check if $R_n(k) = R_n(k+p) \quad -(N-1) < k < (N-1)$

$$R_n(k+p) = \sum_{m=0}^{N-(k+p)-1} x(m+n)\, w'(m)\, \underbrace{x(n+m+k+p)}_{\approx x(n+m+k)\ \text{periodic}}\, \underbrace{w'(m+k+n)}_{\text{we dont kow if this is periodic or not}}$$

$\Rightarrow R_n(k) \neq R_n(k+p)$

as we dont kow the window.

If window is rectangular

then $R_n(k) = R_n(k+p)$

(iii) $\hat{R}_n(k) = \hat{R}_n(k+p)$ $\quad -(N+1) < k < (N-1)$

$$\hat{R}_n(k+p) = \sum_{m=0}^{N-1} x(m+n)\, x(n+m+k+p)$$

$x(n+m+k+p) = x(n+m+k)$ periodic (given)

$$\Rightarrow \hat{R}_n(k) = \underline{\hat{R}_n(k+p)}$$

b) (i) $\phi(-k) = \phi(k)$ check

$$\phi(-k) = \lim_{N\to\infty} \frac{1}{2N+1} \sum_{m=-N}^{N} x(m)\, x(m-k)$$

$m-k=n$

$\Rightarrow m = \underline{n+k}$

$$= \lim_{N\to\infty} \frac{1}{2N+1} \sum_{n=-N-k}^{N-k} x(n+k)\, x(n)$$

$$\Rightarrow \boxed{\phi(-k) = \phi(k)}$$

(ii) $R_n(-k) = R_n(k)$ check $\quad -(N-1) < k < \underline{(N-1)}$

$$R_n(-k) = \sum_{n=0}^{N-|k|+1} x(n+m)\, w'(m)\, x(n+m-k)\, w'(m-k)$$

Let $m' = m-k$

$$R_n(-k) = \sum_{n=0}^{N-|k|+1} x(n+m'+k)\, w'(m'+k)\, x(n+m')\, w'(m')$$

$$\Rightarrow R_n(-k) = R_n(k)$$

(iii) $\hat{R}_n(-k) = \hat{R}_n(k) \quad -(N-1) < k < (N-1)$

$$\hat{R}_n(-k) = \sum_{m=0}^{N-1} x(n+m)\, x(n+m-k)$$

$$m-k = m'$$

$$= \sum_{m'=0}^{N-1-k} x(n+m'+k)\, x(n+m')$$

the limits have changed

$\Rightarrow \hat{R}_n(-k) \neq \hat{R}_n(k)$

c) (i) $\phi(k) \leq \phi(0)$

$$\phi(0) = \lim_{N\to\infty} \frac{1}{2N+1} \sum_{m=-N}^{N} x(m)\, x(m)$$

Let $\lim_{N\to\infty} \frac{1}{2N+1} \sum_{m=-N}^{N} \left(x(m+k) \pm x(m)\right)^2 \geq 0$

as this is square term

$$\Rightarrow \lim_{N\to\infty} \frac{1}{2N+1} \sum_{m=-N}^{N} \left[x(m+k)\,x(m+k) \pm 2\,x(m)\,x(m+k) + x(m)\,x(m) \right) \geq 0$$

$$\Rightarrow 2\,\phi(0) \pm 2\,\phi(k) \geq 0$$

$$\phi(0) \pm 2\phi(k) \geq 0$$

$x^2(m) = \phi(0)$
$x^2(m+k) = \phi(0)$
$\phi(k) = x(m)\,x(m+k)$

$$\Rightarrow -\phi(0) \leq \phi(k) \leq \phi(0)$$

(ii) $\sum_{m=-\infty}^{\infty} \left(x(n+m+k)\, w'(m+k) \pm x(n+m)\, w'(m) \right)^2 \geq 0$

$$\Rightarrow 2\left[R_n(0) \pm R_n(k)\right) \geq 0$$

$$\Rightarrow \boxed{R_n(k) \leq R_n(0)}$$

$x^2(n+m)\, w^{2'}(m) = R_n(0)$
$x^2(n+m+k)\, w^{2'}(m+k) = R_n(0)$
$x(n+m+k)\, w'(m+k)$
$x(n+m)\, w'(m) = R_n(k)$

(iii) Let $x[n] = \begin{cases} 2 & n=0 \\ 0 & 0 < n \leq L-1 \\ 3 & n=L \\ 0 & \text{otherwise} \end{cases}$

$$\hat{R}_n(0) = \sum_{m=0}^{\cancel{N}-1} x^2(m) = (2)^2 = \underline{\underline{4}}$$

$$\hat{R}_n(L) = \sum_{m=0}^{L-1} x(m)\,x(m+L) = 3 \times 2 = \underline{\underline{6}}$$

$$\hat{R}_n(L) > \hat{R}_n(0)$$

$$\Rightarrow \hat{R}_n(L) \not\leq \underline{\underline{\hat{R}_n(0)}}$$

d)(i) $\phi(0)$ is power of signal

$$\phi(0) = \lim_{N \to \infty} \frac{1}{2N+1} \sum_{m=-N}^{N} x(m)x(m)$$

$$= \lim_{N \to \infty} \frac{1}{2N+1} \sum_{m=-N}^{N} x^2(m)$$

This is $\frac{\text{energy}}{\text{total samples}}$ = power

(ii) $R_n(0)$ is short-time energy

$$R_n(0) = \sum_{m=0}^{N-1} x(n+m)w'(m)\, x(n+m)\, w'(m)$$

$$= \sum_{m=0}^{N-1} \left(x(n+m)\, w'(m)\right)^2$$

$w'(m)$ is causal window $\Rightarrow w'(m) = w'(-m)$

$$= \sum_{m=-\infty}^{\infty} \left(x(n+m)\; w'[m]\right)^2$$

$n+m = m'$

$$R_n(0) = \sum_{m=-\infty}^{\infty} \left(x(m')\; w'(n-m')\right)^2$$

$\Rightarrow R_n(0)$ is short time energy.

(iii) $\hat{R}_n(0)$ is short time energy

$$\hat{R}_n(0) = \sum_{n=0}^{N-1} \left(x(n+m)\right)^2$$

$$n+m = m'$$

$$= \sum_{m'=\hat{n}}^{L-1+\hat{n}} \left(x(m')\right)^2$$

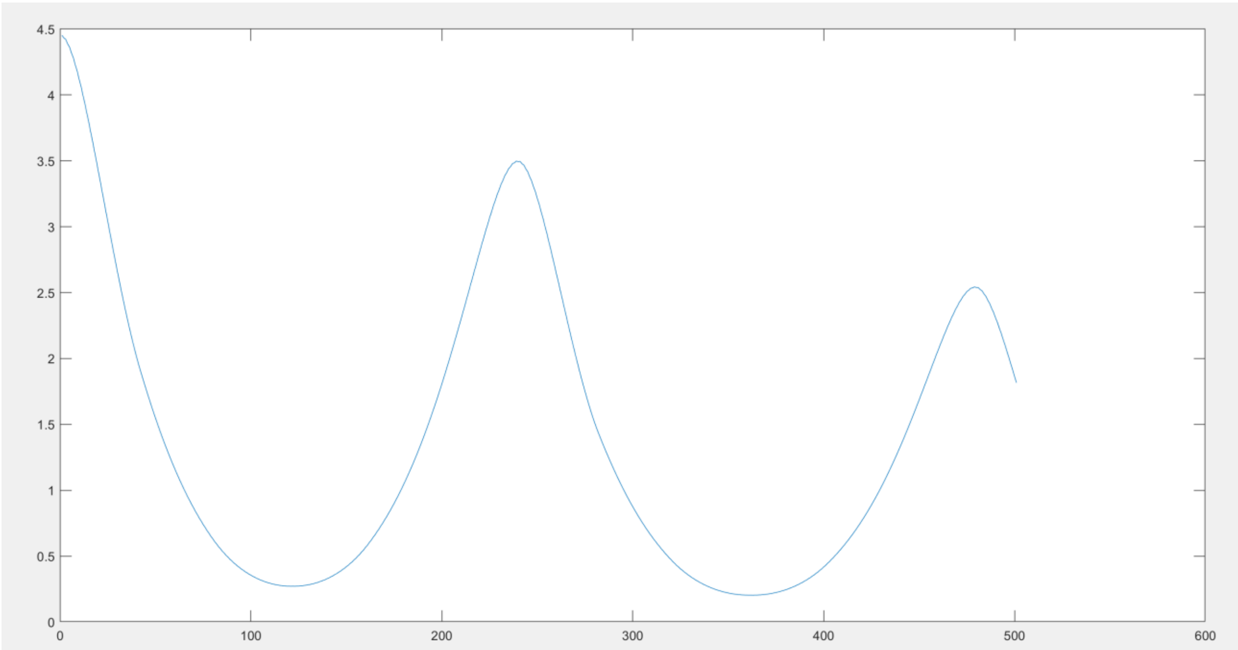
Since this is bounded, even window is bounded.

$\Rightarrow \hat{R}_n(0)$ does not give short time energy.

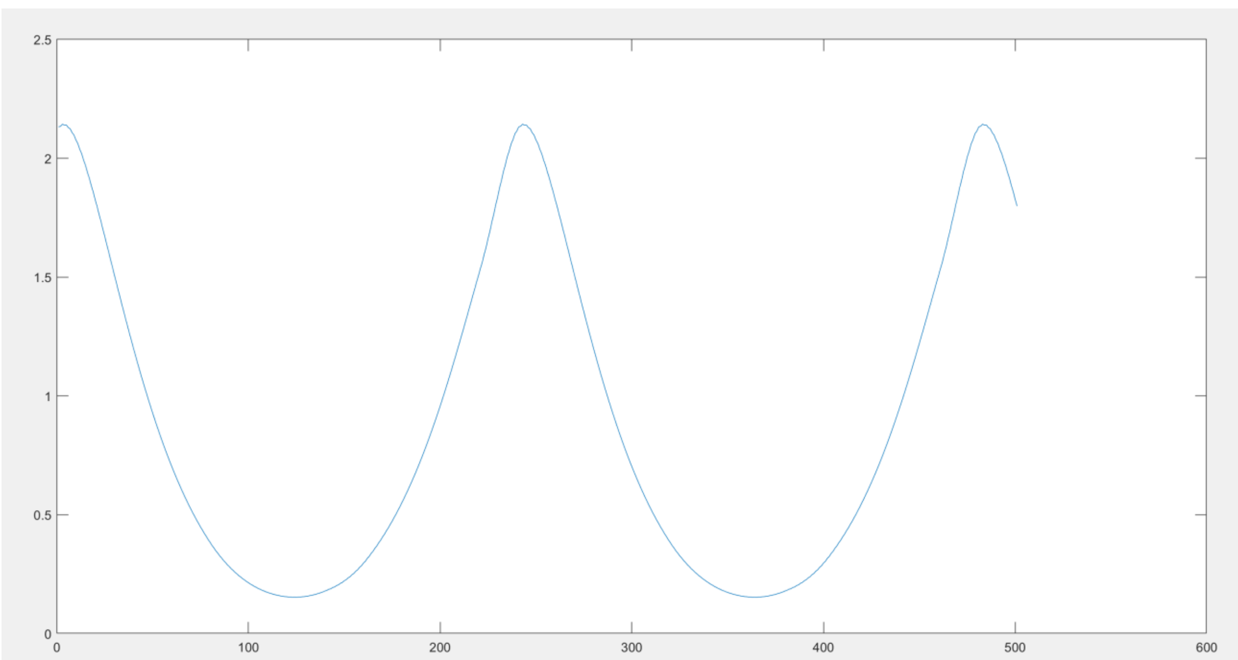
5a)

N=1000

Short time autocorrelation

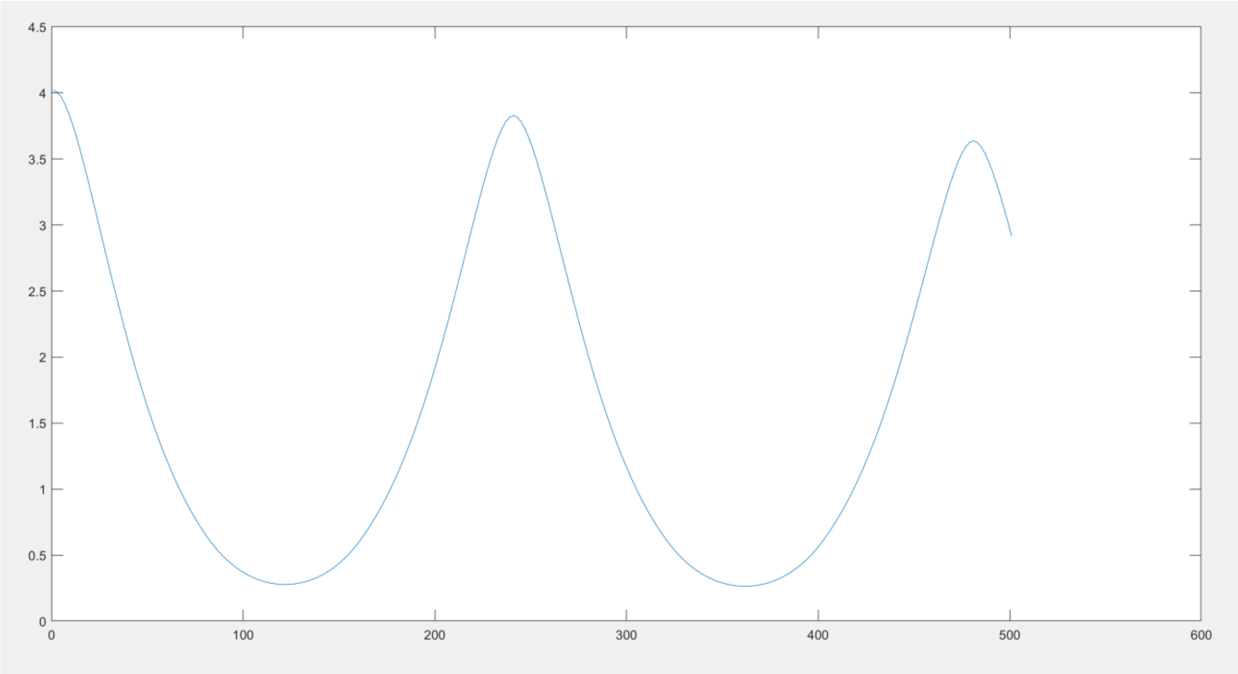


Modified

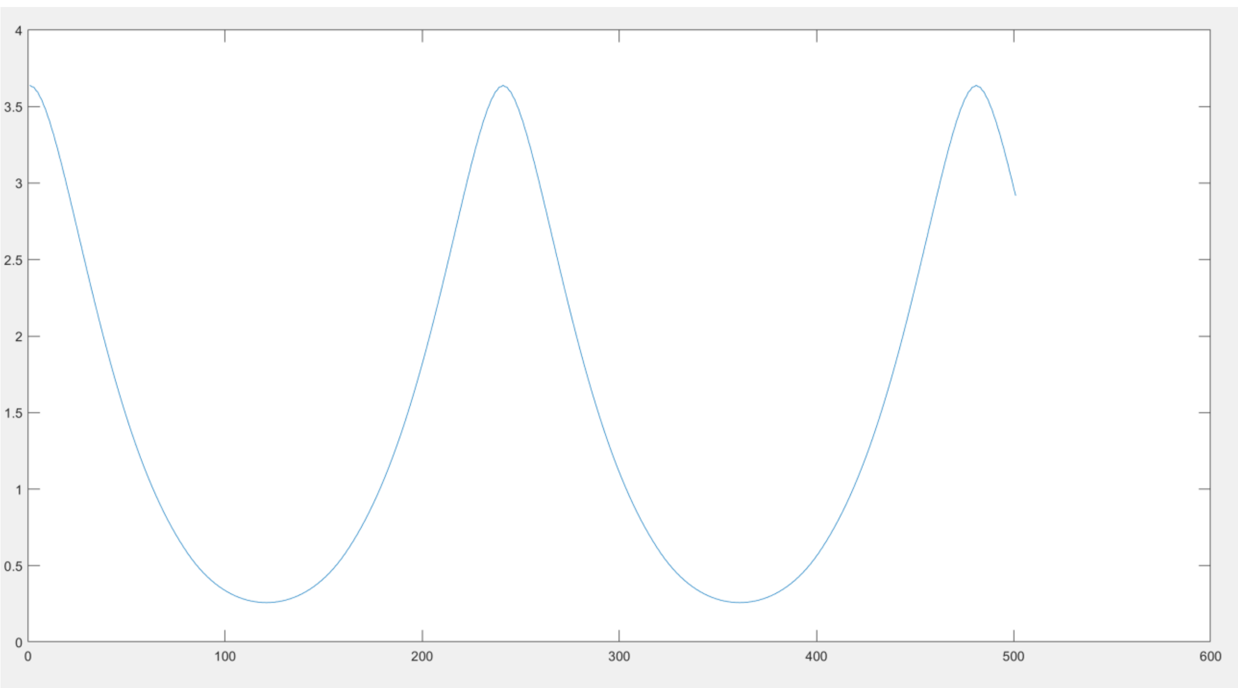


N=5000

Short time autocorrelation



Modified

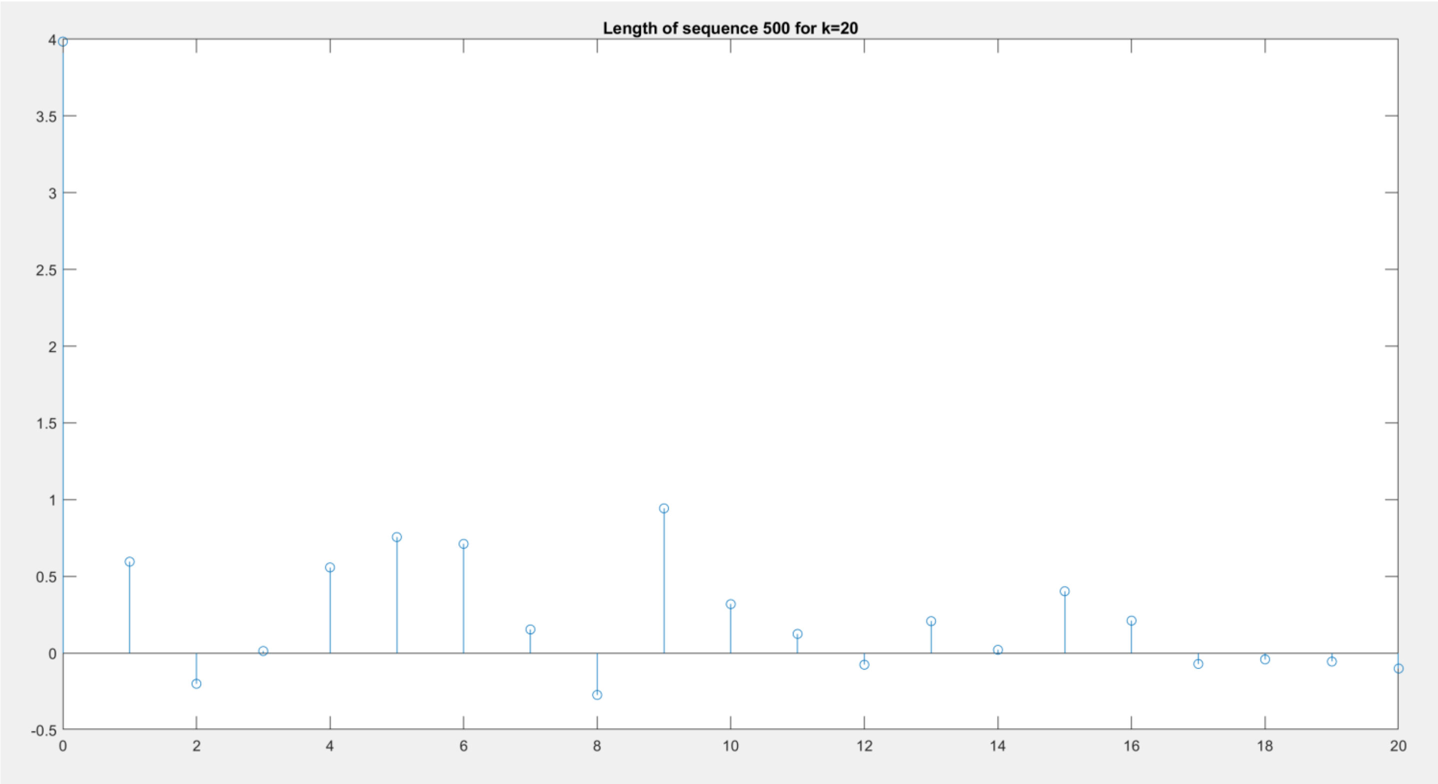


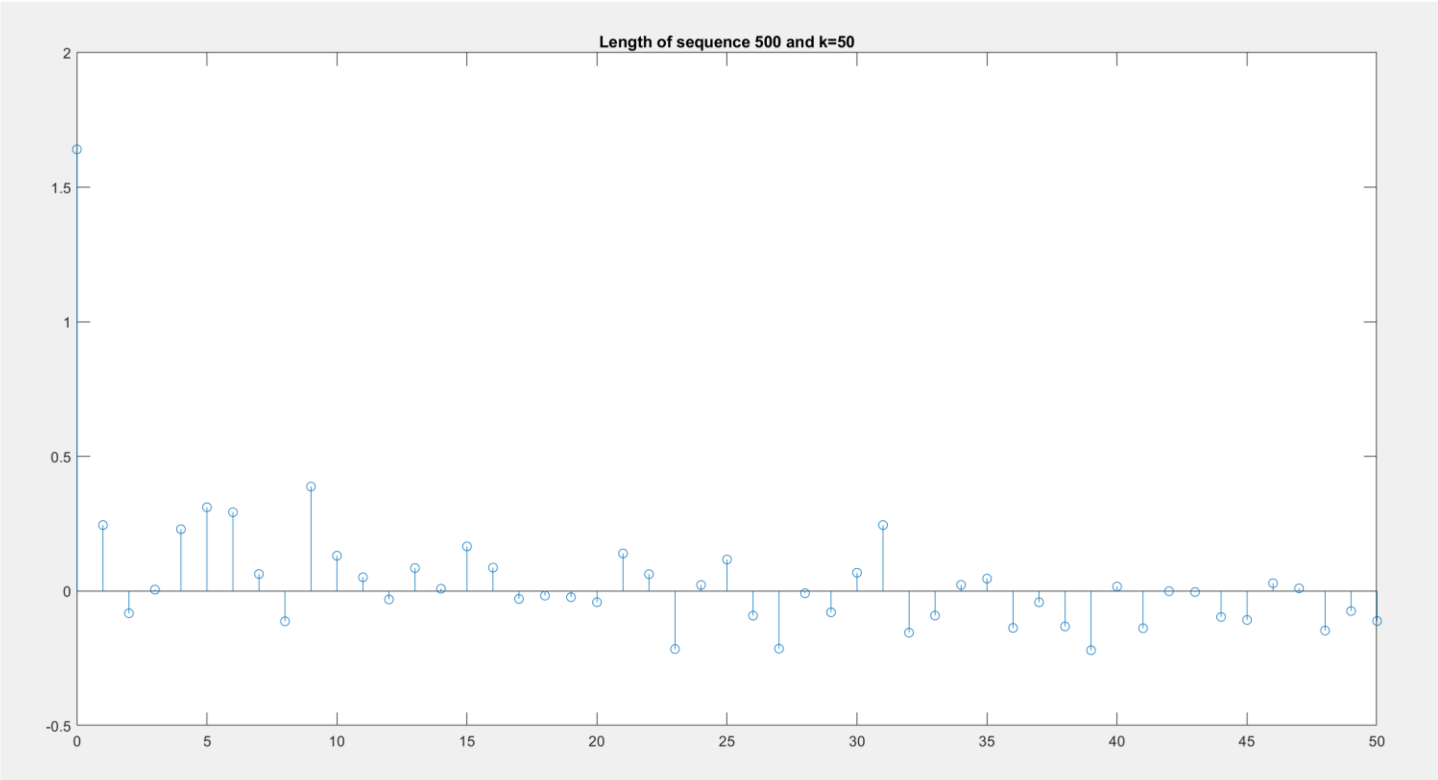
In case of N=1000, the magnitude of short time autocorrelation is reducing when k reaches 500 but remains constant in case of modified short time autocorrelation. This is because it reaches the original autocorrelation in case of modified autocorrelations.

In case of N=5000, the magnitude of short time autocorrelation and modified short time autocorrelation remains constant.This is because at higher N, it reaches the long autocorrelation.

An important issue is how N should be chosen to give a good indication of periodicity. Again we face conflicting requirements. Because the pitch period of voiced speech changes with time, N should be as small as possible. On the other hand, it should be clear that to get any indication of periodicity in the autocorrelation function, the window must have a duration of at least two periods of the waveform.

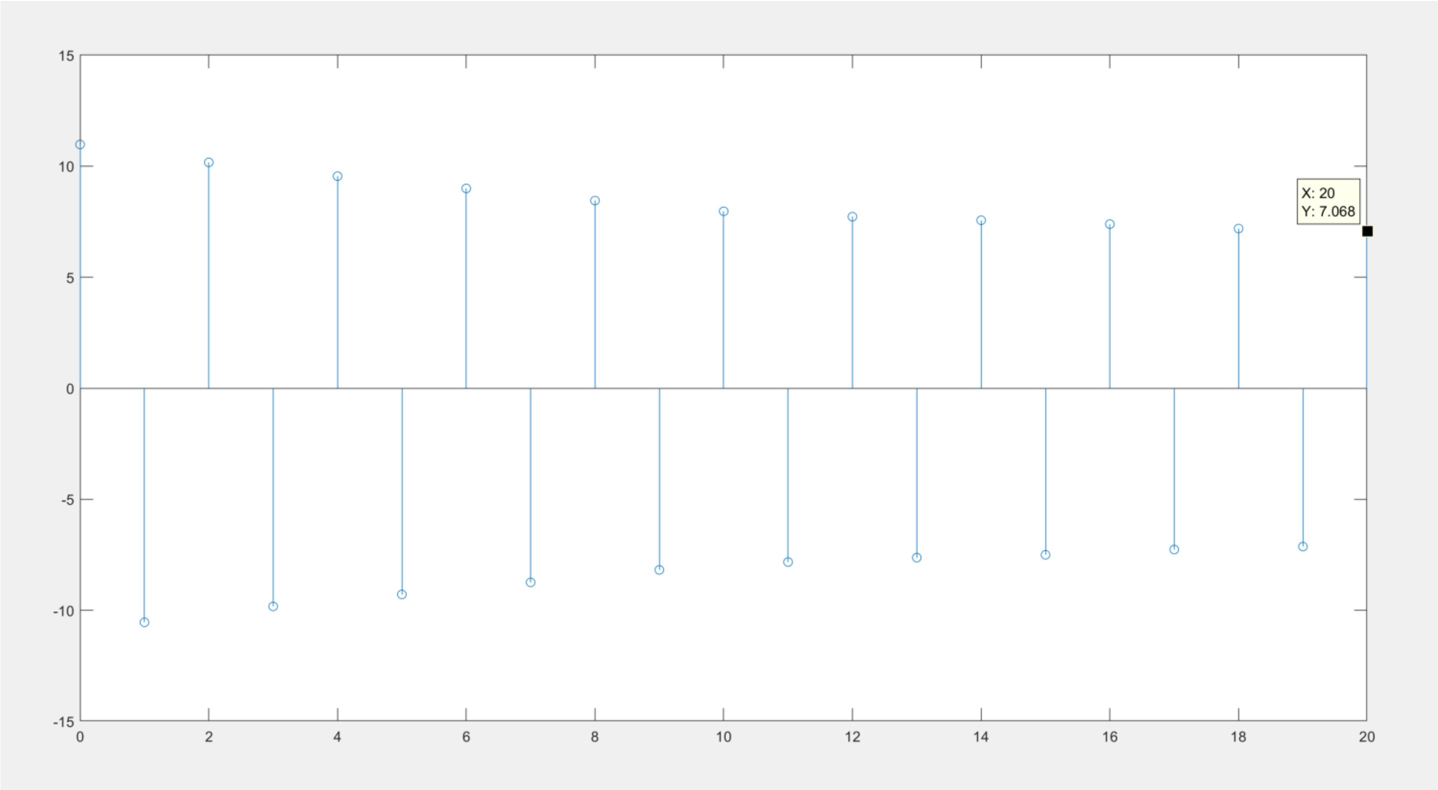
5b)



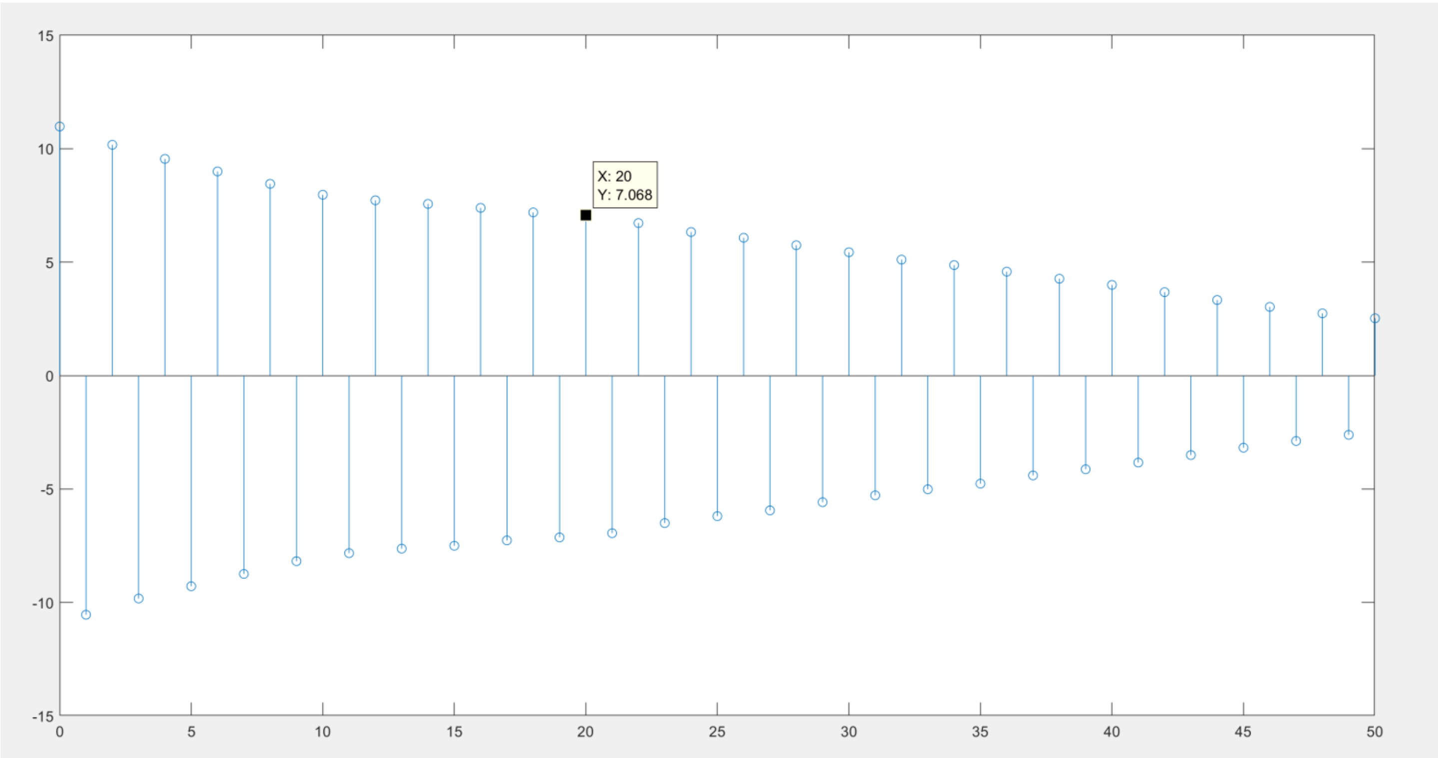


Since the window is constant, there is no difference when k=20 and k=50. The magnitude had a difference as k value has increased and lesser number of terms are used. WE can see that at the initial point the energy is high due to white noise energy. Going ahead it is very clear that the energy goes on decreasing, and it converges to 0 eventually. The covariance also tends to 0.

5c) K=20



K=50

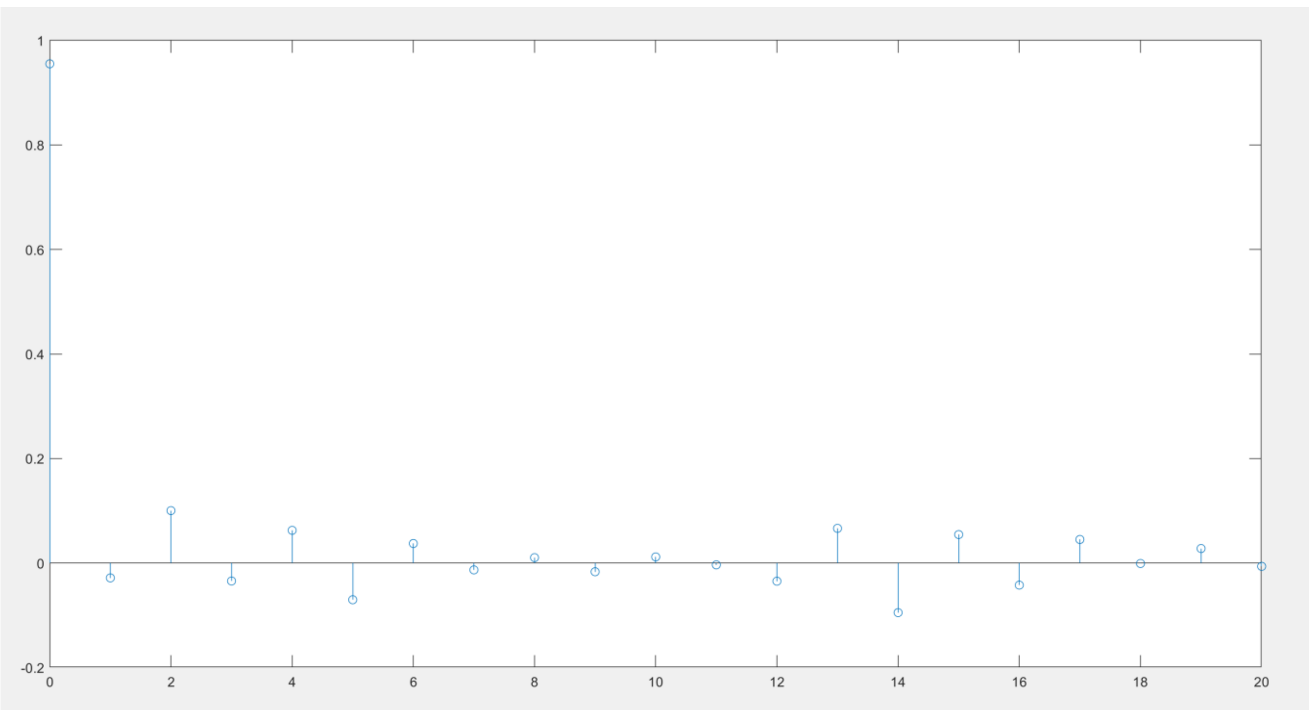


Similar reasoning here as well. Here the noise is no longer white noise. We correlate it with each of the previous sequence. The magnitude is same as we can see in the above graph. So, the value of energy eventually converges as k increases.

```
>> abs(R(2)/R(1))

ans =

    0.9407
```

The value of a and R(1)/R(0) are almost the same.

5d)



We can see a dual sinusoid here. We have done cross correlation here with white noise and other sequence. Outside the white noise region the energy is 0. Again at 0^{th} position it is the white noise energy. But as we scroll through the k value, the value of energy eventually converges to 0.

Q6) Energy-

Wave 2

Element = p --Energy 0.029196
Element = er --Energy 4.019818
Element = s --Energy 0.111790
Element = en --Energy 0.084740
Element = el --Energy 1.419667
Element = p --Energy 0.010848
Element = r --Energy 0.835690
Element = iy --Energy 0.504544
Element = d --Energy 0.014158
Element = ih --Energy 0.786404
Element = s --Energy 0.041916
Element = p --Energy 0.004330
Element = ix --Energy 0.121989
Element = z --Energy 0.012634
Element = ih --Energy 0.759254
Element = sh --Energy 0.407397
Element = ix --Energy 0.061391
Element = n --Energy 0.017139
Element = s --Energy 0.090307
Element = t --Energy 0.024787
Element = eh --Energy 0.667935
Element = n --Energy 0.049159
Element = t --Energy 0.022226
Element = ix --Energy 0.121530
Element = b --Energy 0.005712
Element = l --Energy 0.797925
Element = ah --Energy 4.362905
Element = n --Energy 0.028414
Element = dh --Energy 0.003634
Element = ix --Energy 0.602788
Element = ey --Energy 0.571412
Element = ah --Energy 0.901017
Element = eh --Energy 1.260192
Element = n --Energy 0.036184
Element = ih --Energy 0.241893
Element = n --Energy 0.014633
Element = t --Energy 0.050575
Element = er --Energy 2.398641
Element = n --Energy 0.024072
Element = ax --Energy 0.100558
Element = v --Energy 0.018189
Element = oy --Energy 2.917097
Element = s --Energy 0.053252
Element = ix --Energy 0.114545
Element = z --Energy 0.038347
Element = w --Energy 0.467094
Element = eh --Energy 0.648640
Element = l --Energy 0.196858

Wave 6

Element = w --Energy 1.628676
Element = ax --Energy 1.875170
Element = dx --Energy 0.510434
Element = ix --Energy 0.074907
Element = d --Energy 0.248177
Element = ah --Energy 2.367198
Element = z --Energy 0.922102
Element = ey --Energy 0.684882
Element = z --Energy 0.068281
Element = ix --Energy 0.004337

Element = n --Energy 0.003097
Element = p --Energy 0.055682
Element = er --Energy 0.029530
Element = v --Energy 0.045516
Element = eh --Energy 0.670390
Element = n --Energy 0.031423
Element = t --Energy 0.001105
Element = iy --Energy 0.018471
Element = ng --Energy 0.125379
Element = f --Energy 0.007813
Element = ow --Energy 2.813825
Element = m --Energy 2.282542
Element = iy --Energy 0.082603

Vowel	*Nasal*	*Unvoiced Fricative*	*Voiced Fricative*	*Dipthongs*	*V/Unvoiced Stop*	*Glide*
'ih','iy' 'uw','aa'	*'m','n'*	*'f','th' 'sh','s'*	*'v','dh' 'z','zh'*	*'oy','ey'*	*'b','d'/ 't','k'*	*'w','l' 'r','y'*
'iy'=0.018471	*'m'=2.282542*	*'f'=0.007813*	*'z'=0.922102*	*'ow'=2.813825*	*'d'=0.248177*	*'l'=0..453921*
'ah'=2.367198	*'n'=0.031423*	*'f'=0.007813*	*'v'=0.045516*	*'ow'=0.589503*	*'t'=0.083137*	*'w'=1.628676*

Element = b --Energy 0.000013
Element = l --Energy 0.453921
Element = ow --Energy 0.589503
Element = t --Energy 0.083137

Q7)

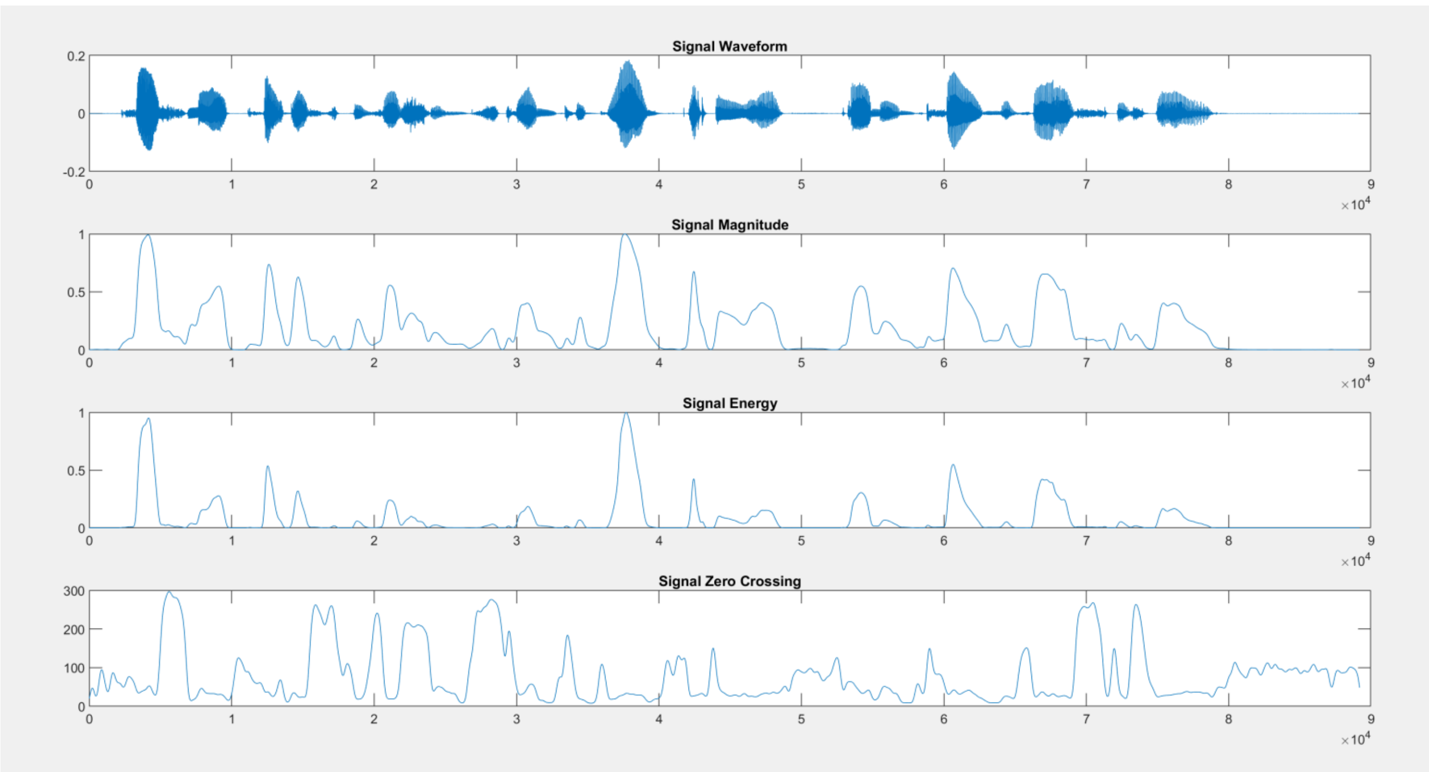
Larger the window size, we get narrow band frequency response. The shorter the window size, we get wide band frequency response.

Window size = 1000

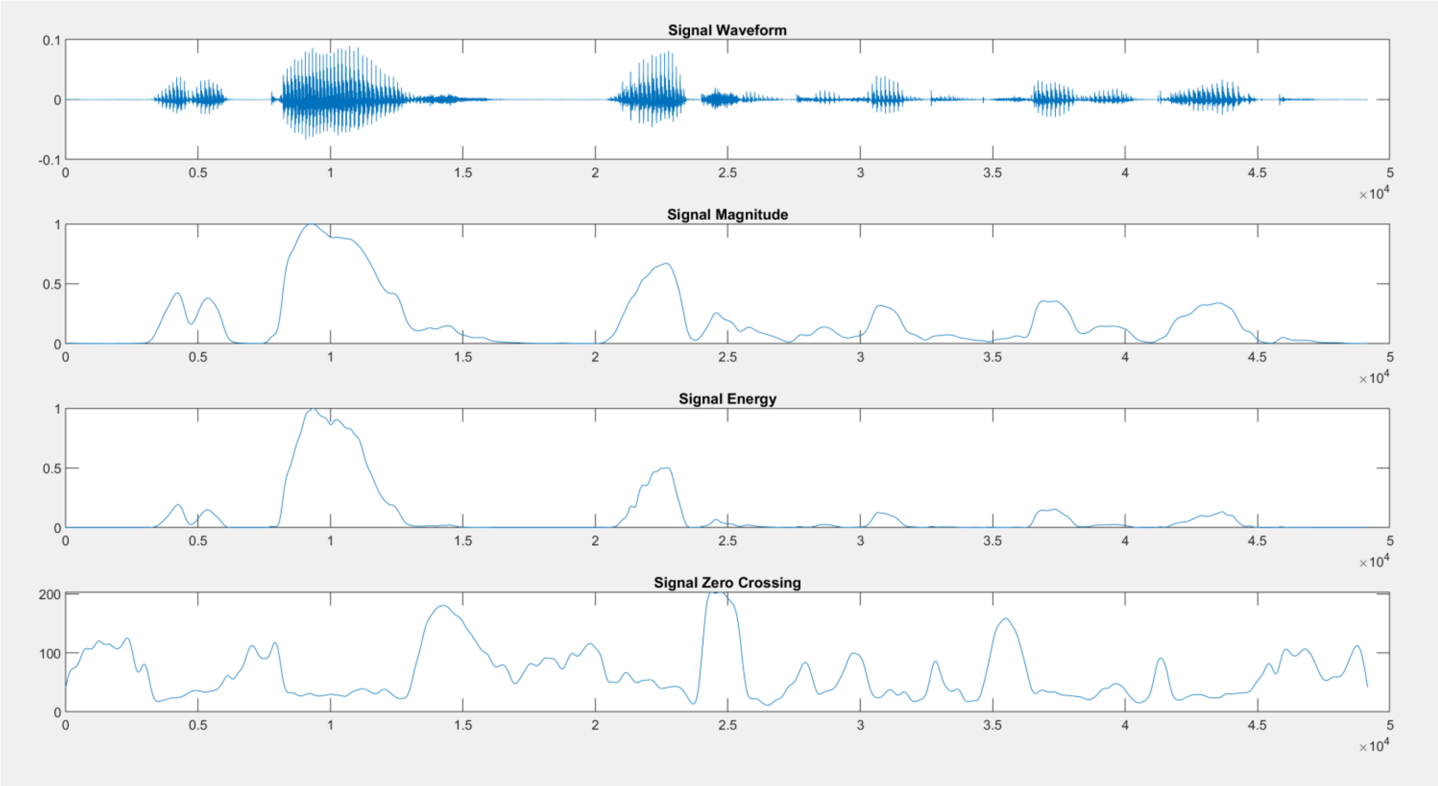
Shift = delaying it by 1 sample(we try to move by 1 shift and we get the best response.)

Window- BlackMan(any window can be preferred, I did not use rectangular window as it has a constant magnitude.)

Wave – 2.wav



Wave- 6.wav



Signal Waveform
0.1
0
-0.1
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
×10^4
Signal Magnitude
1
0.5
0
Signal Energy
1
0.5
0
Signal Zero Crossing
200
100
0