EEE321 - Signals & Systems

Lab Assignment VI

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Part 1:

-The solution of the analytical part is provided in a separate pdf.

Code for the function

```
function [y]=DTLTI(a,b,x,Ny)
N = length(a);
M = length(b) - 1;
y = zeros(1, Ny);
for n = 0:Ny-1
    for l = 1:N
    if (n+1-l) < 1
    y(n+1) = y(n+1);
    else
    y(n+1) = a(l)*y(n+1-l) + y(n+1);
    end
    end
    for k = 0:M
    if (n+1-k) < 1
```

```
y(n+1) = y(n+1);
else
y(n+1) = b(k+1)*x(n+1-k) + y(n+1);
end
end
end
end
```

Part 2:

a)

```
D = [21903608];
D4 = mod(D,4);
N = 1;
M = 5 + D4;
b = exp(-(0:M-1));

Ny = 11; % For 0 ≤ n ≤ 10
x = [1, zeros(1, Ny-1)]; % Impulse signal

h = DTLTI(zeros(1, N), b, x, Ny);

figure;
```

```
stem(0:Ny-1, h);

xlabel('n');

ylabel('h[n]');

title('Impulse Response h[n] of the Filter');
```

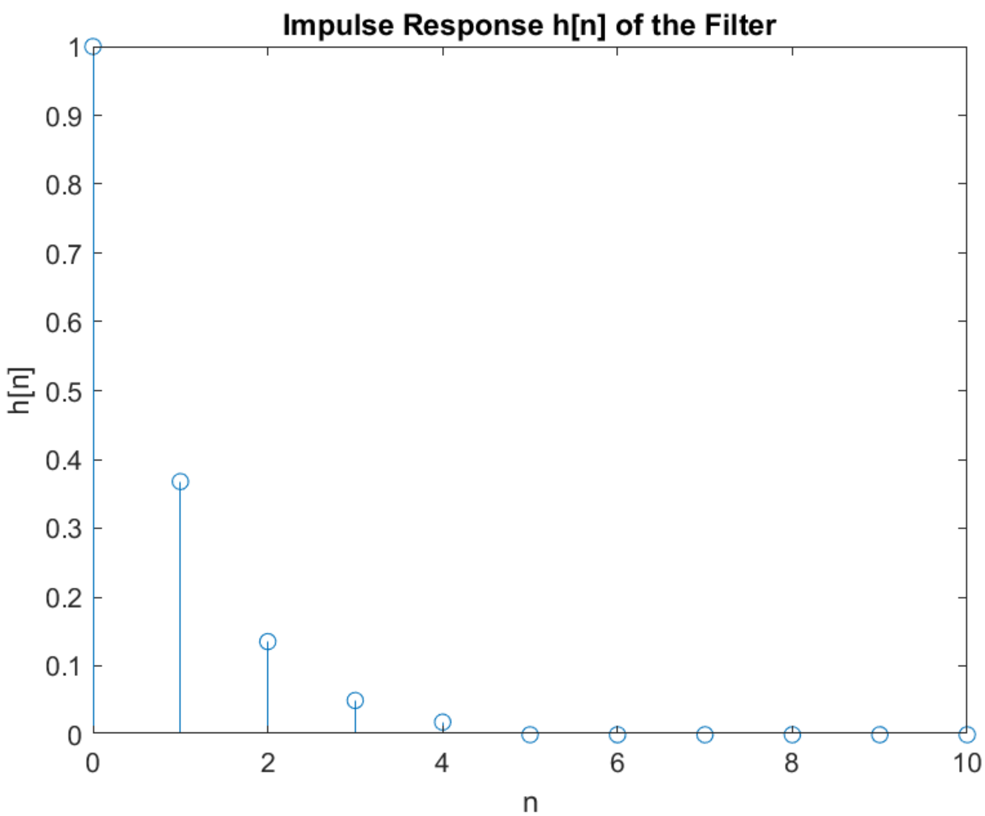

Figure 1: The Impulse Response of the Filter

b) Solution is attached in the separate pdf

c) Solution is attached in the separate pdf

e)

```
omega = linspace(-pi, pi, 1000);
```

```
H_w = (1-(exp(-5*(1+1j*omega)))).(1-(exp(-(1+1j*omega))));

figure;

plot(omega, abs(H_w));

title('Magnitude of the Frequency Response of the System');

xlabel('\omega');

ylabel('Magnitude');

xlim([-pi pi]);
```

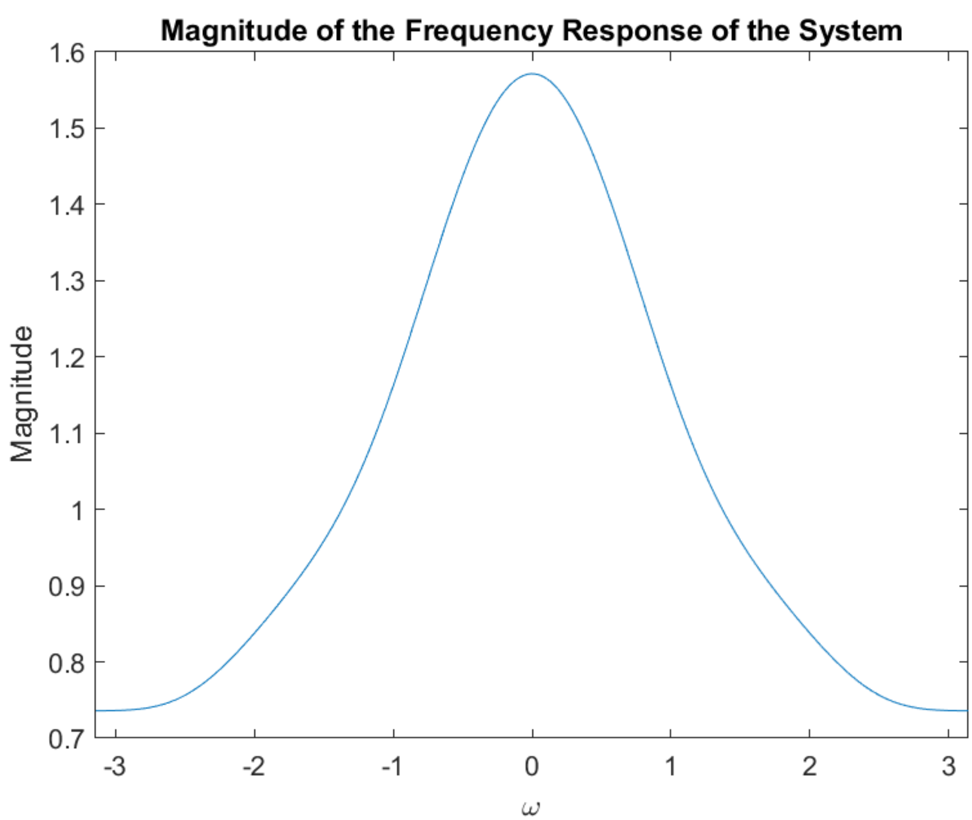

Figure 2: The Magnitude of the Frequency Response of the Filter

Inspecting the shape of the graph, this is a low pass filter as it permits low frequencies (frequencies around 0 of passing), and it attenuates high frequencies.

The cutoff frequency of the system is the frequency at which the magnitude drops to $\frac{1}{\sqrt{2}}$ of its maximum value:

$$\omega_c = H^{-1}(H(0)\frac{1}{\sqrt{2}}) = H^{-1}(1.571) = 1.123\, rad/sec$$

The 3 dB bandwidth is the frequency range where the magnitude of the filter's frequency response is no more than 3 dB below the maximum magnitude ($\frac{1}{\sqrt{2}}$ of maximum magnitude). The 3 dB bandwidth of this LPF is the distance between ω_c and $-\omega_c$ which is 2.220 rad/sec.

f)

```
D4 = 0;

a = [1];

M = 5 + D4;

b = exp(-[0:M-1]);

fS = 1400;

f0 = 0;

f_end = 700;

t_intervals = [1, 10, 1000];


k1 = (f_end - f0) / t_intervals(1);

k2 = (f_end - f0) / t_intervals(2);

k3 = (f_end - f0) / t_intervals(3);

t1 = linspace(0, t_intervals(1), fS * t_intervals(1));
```

```
t2 = linspace(0, t_intervals(2), fS * t_intervals(2));

t3 = linspace(0, t_intervals(3), fS * t_intervals(3));


phi_t1 = f0 .* t1 + 0.5 .* k1 .* t1.^2;

phi_t2 = f0 .* t2 + 0.5 .* k2 .* t2.^2;

phi_t3 = f0 .* t3 + 0.5 .* k3 .* t3.^2;

chirpSignal_1 = cos(2 * pi * phi_t1);

chirpSignal_2 = cos(2 * pi * phi_t2);

chirpSignal_3 = cos(2 * pi * phi_t3);


y1 = DTLTI(a, b, chirpSignal_1, length(chirpSignal_1));

y2 = DTLTI(a, b, chirpSignal_2, length(chirpSignal_2));

y3 = DTLTI(a, b, chirpSignal_3, length(chirpSignal_3));


subplot(3,1,1);

plot(linspace(0, pi, length(y1)), y1);

xlabel('\omega')

ylabel('Magnitude')

title('Chirp Signal Output for 0 \leq t \leq 1')

subplot(3,1,2);

plot(linspace(0, pi, length(y2)), y2);
```

```
xlabel('\omega')

ylabel('Magnitude')

title('Chirp Signal Output for 0 \leq t \leq 100')

subplot(3,1,3);

plot(linspace(0, pi, length(y3)), y3);

xlabel('\omega')

ylabel('Magnitude')

title('Chirp Signal Output for 0 \leq t \leq 1000')
```

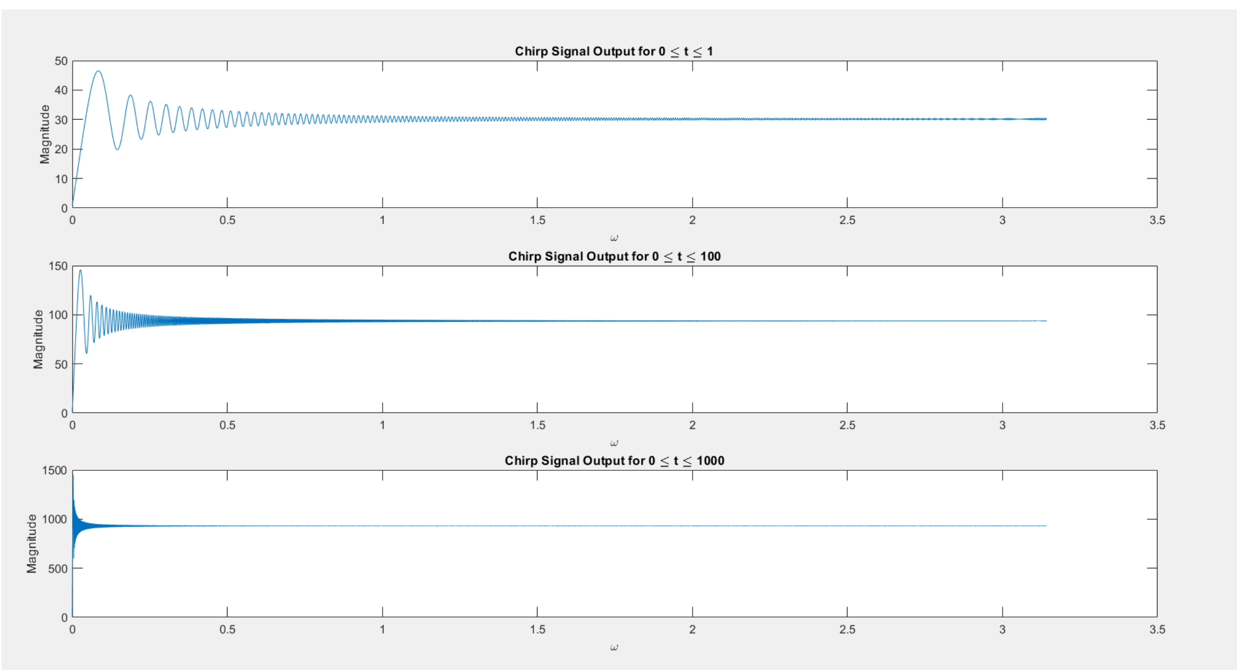

Figure 3: Chirp Signal Outputs for Different Time Intervals Shown using Subplot Command

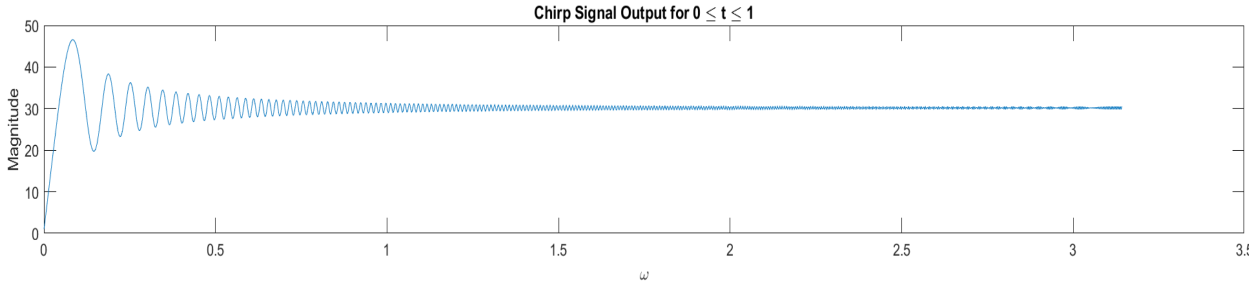

Figure 4: Chirp Signal Output for $0 \leq t \leq 1$

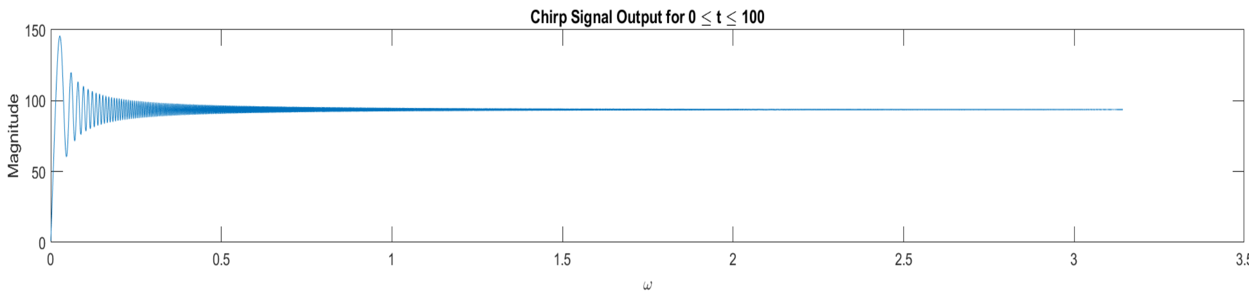

Figure 5: Chirp Signal Output for $0 \leq t \leq 100$

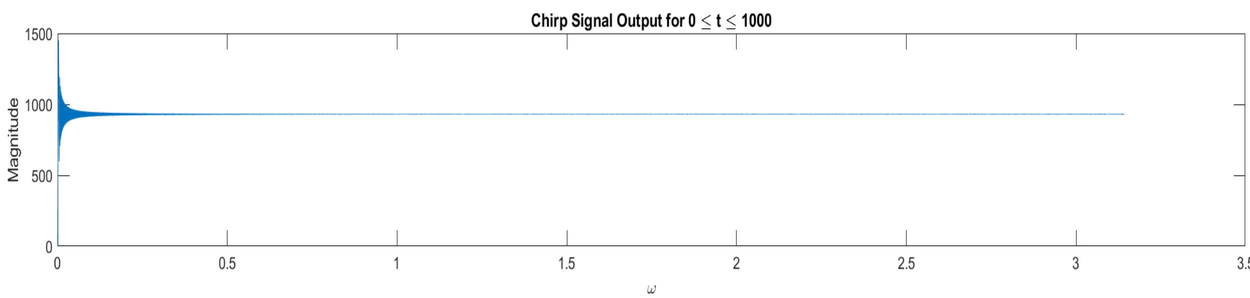

Figure 6: Chirp Signal Output for $0 \leq t \leq 1000$

Part 3:

a,b,c,d,e,f) analytical answers are provided in the separate pdf.

g)

```
ni = [ 2 1 9 0 3 6 0 8 ];

ni = ni +2;

z1 = (ni(2)+1i*ni(3))/((ni(2)^2+ni(2)^2)^(1/2));

p1 = (ni(1)+1i*ni(5))/((1 + ni(1)^2+ni(5)^2)^(1/2));

p2 = (ni(8)+1i*ni(6))/((1 + ni(8)^2+ni(6)^2)^(1/2));


a = [ (p1+p2), -p1*p2];

b = [1 , -z1];

dw = 0.001;

w = [0:dw:2*pi-dw];


x = (exp(1i*w) - z1)./((exp(1i*w)-p1).*(exp(1i*w)-p2));

figure;

plot(w,abs(x));

xlabel('\omega'); ylabel('amplitude');

title('Frequency Response');
```

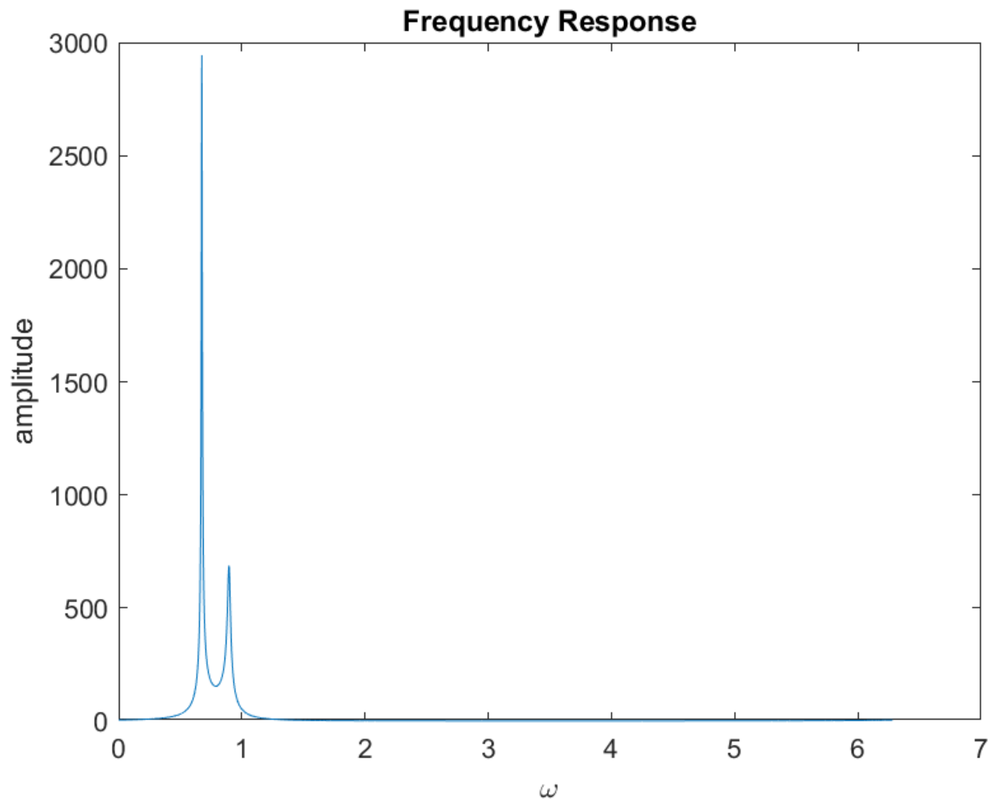

Figure 7: Frequency Response of the Filter

This is a Band-pass Filter.

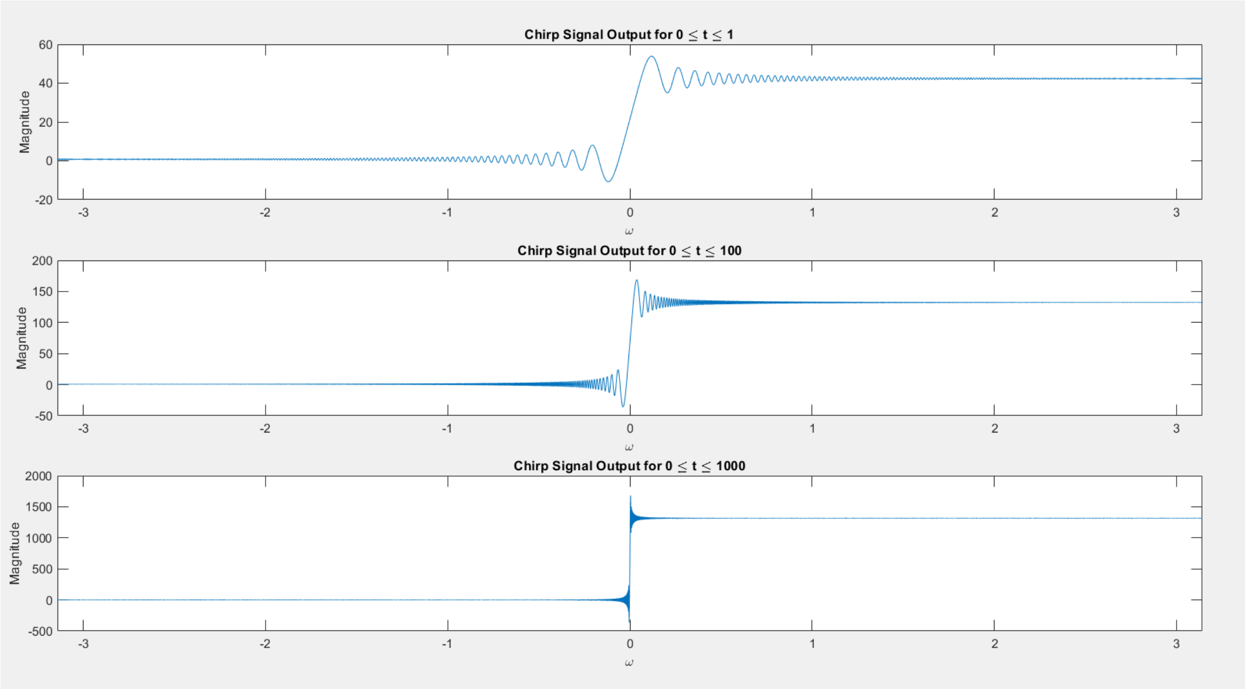

Figure 8: Chirp Signal Outputs for Different Time Intervals Shown using Subplot Command

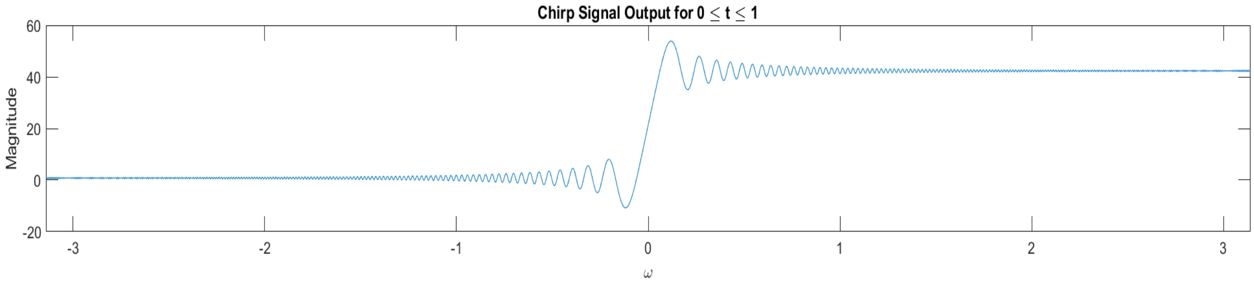

Figure 9: Chirp Signal Output for $0 \leq t \leq 1$

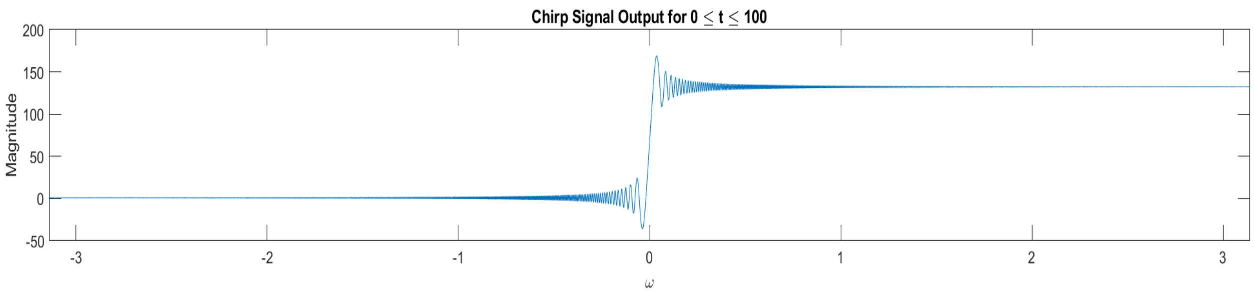

Figure 10: Chirp Signal Output for $0 \leq t \leq 100$

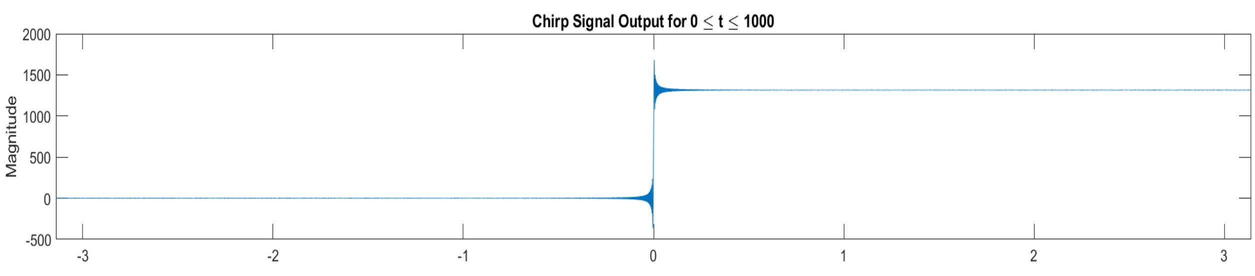

Figure 11: Chirp Signal Output for $0 \leq t \leq 1000$