Atahan İyiekici
21801985
EEE321-001
Lab Report 6

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Part 2

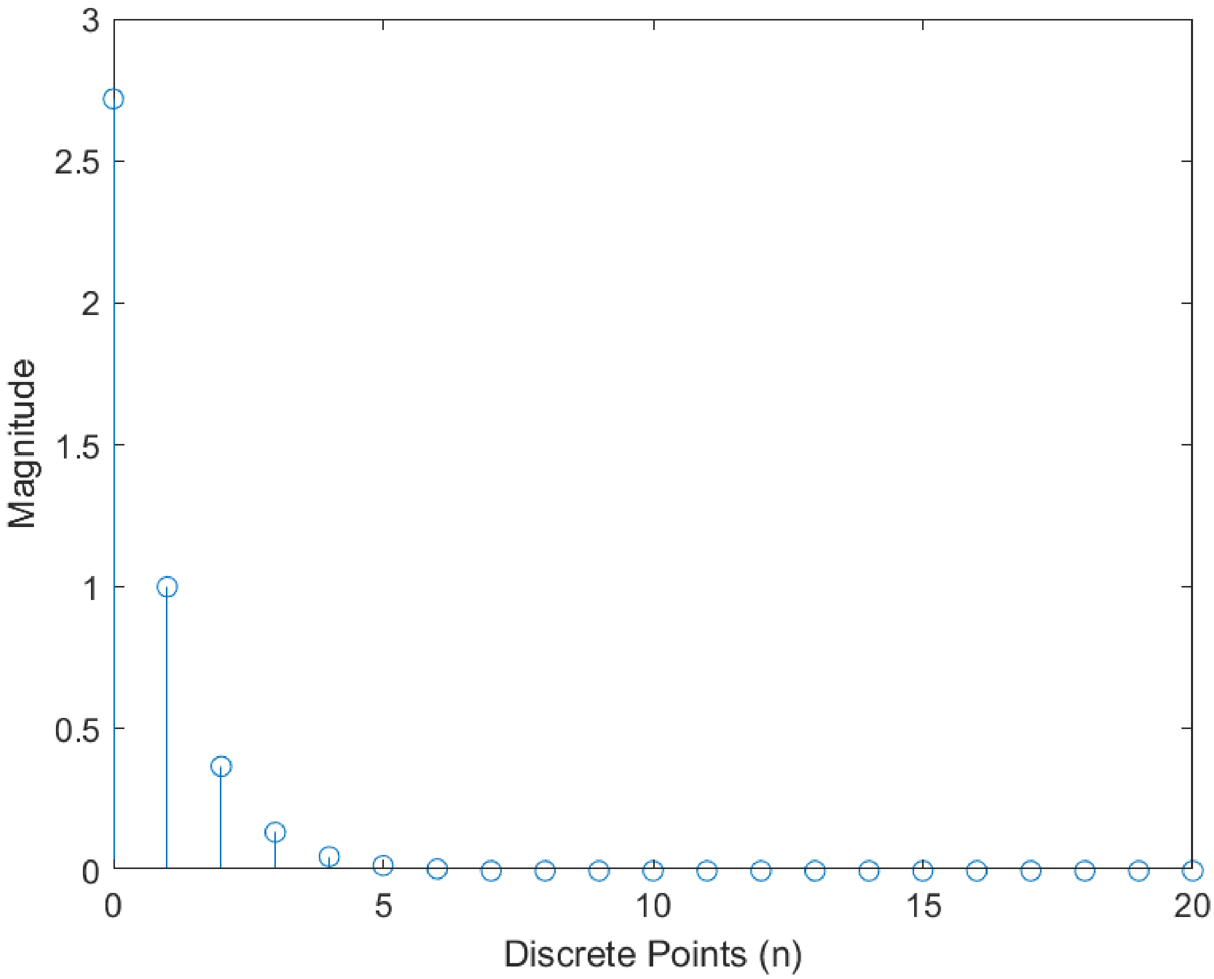

Figure 1: Plot of Impulse Response

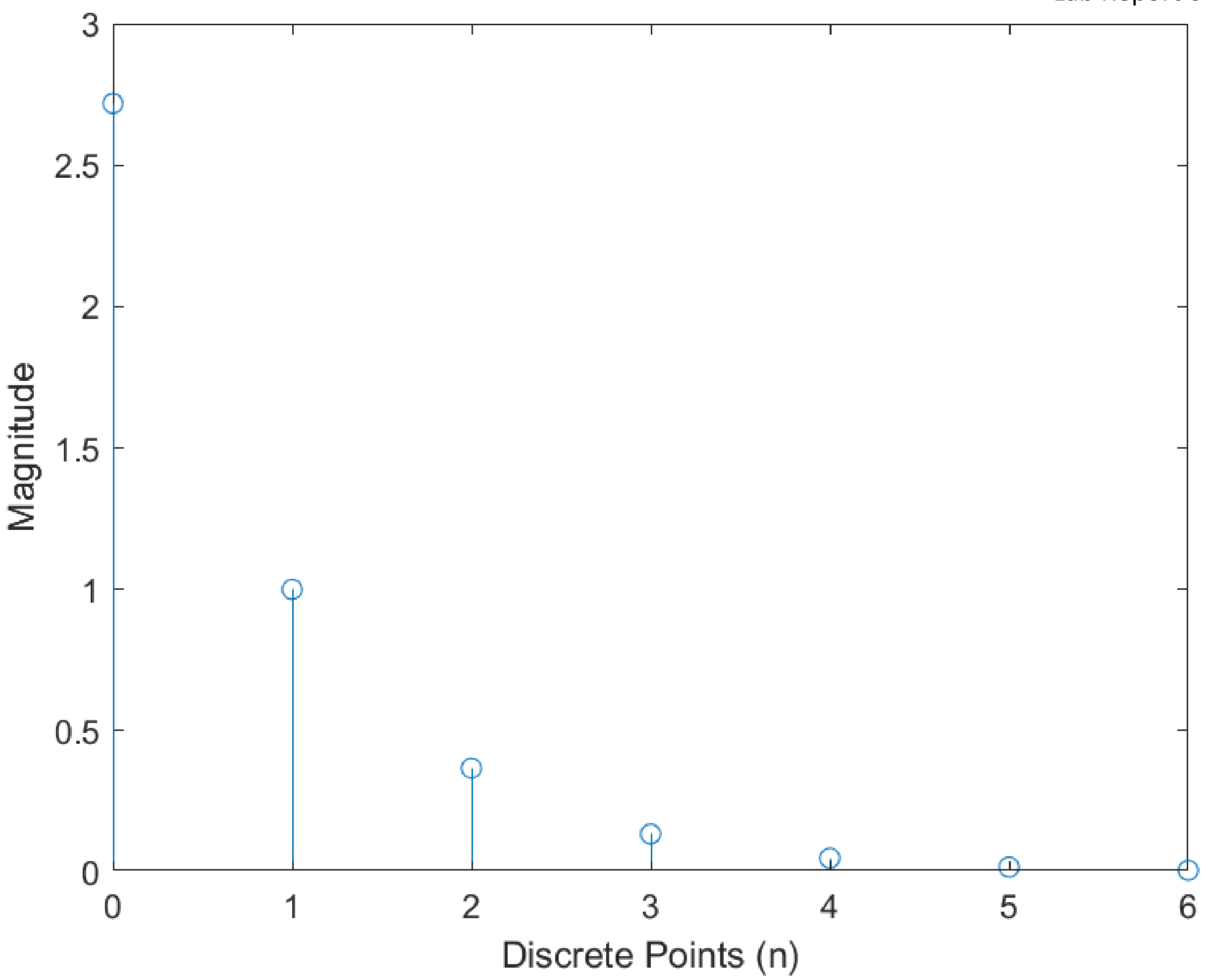

Figure 2: Plot of b[k] (Coefficient Plot of b[k])

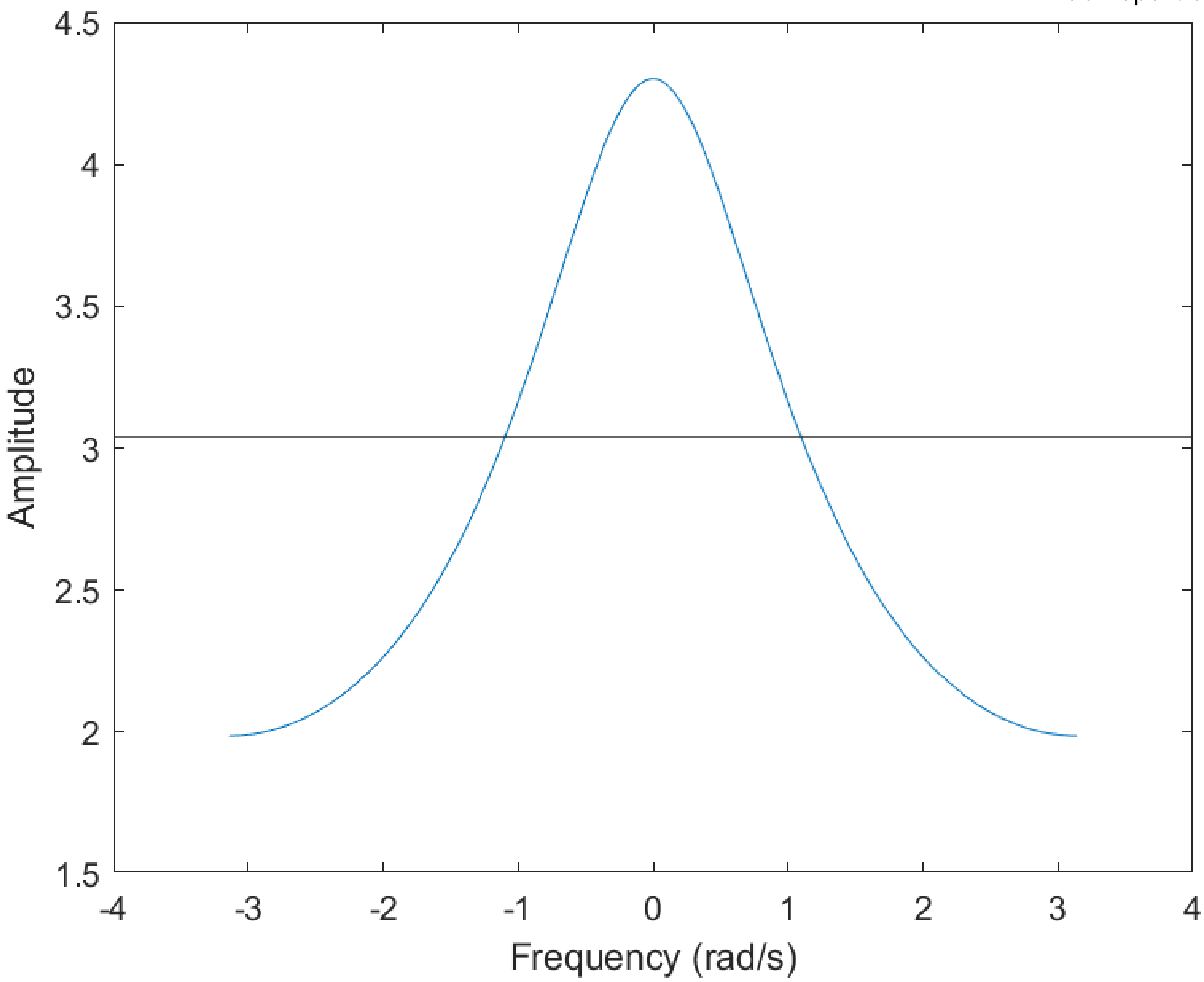

Figure 3: Magnitude Plot of Impulse Response

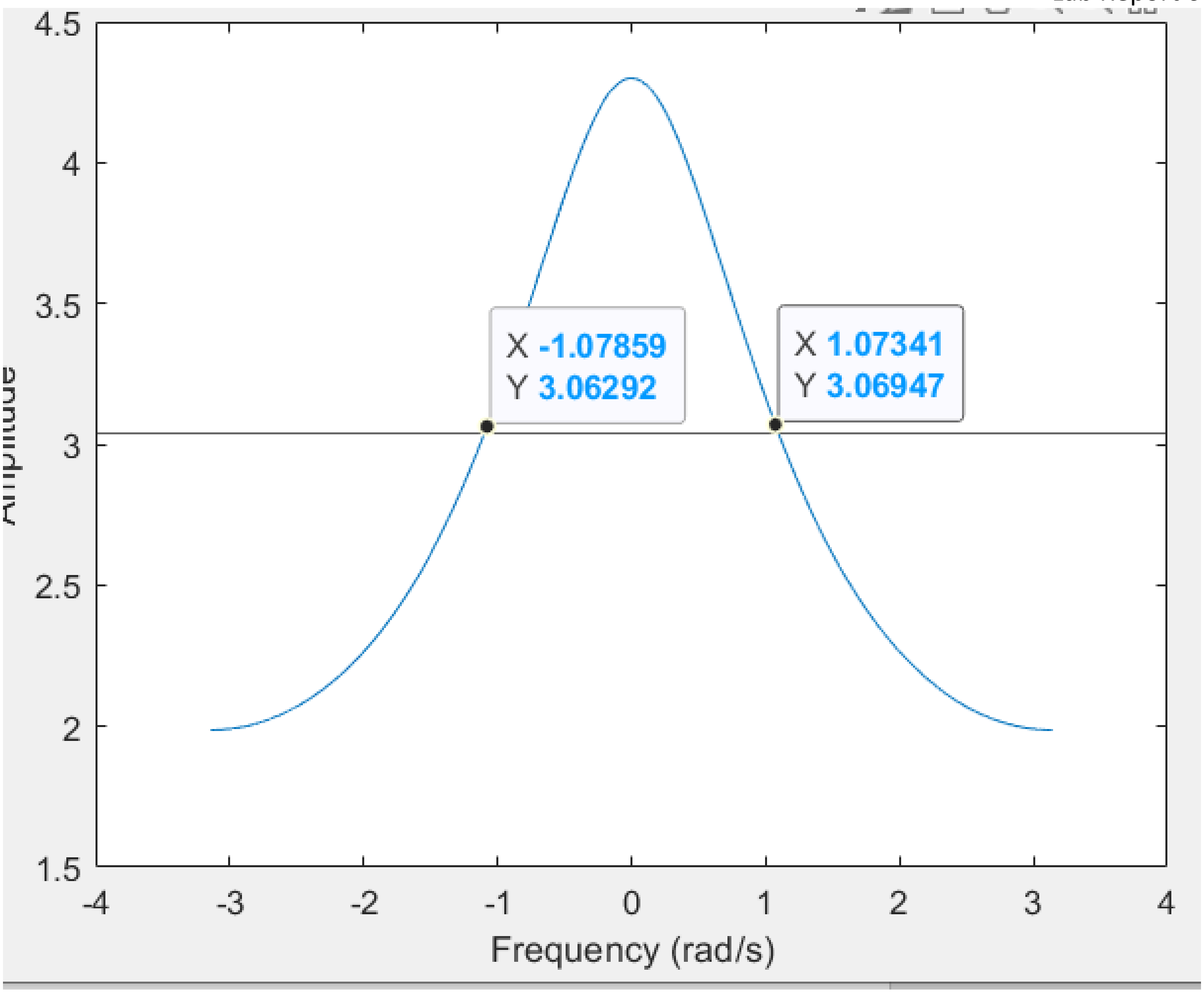

Figure 4: Cut-Off Frequency Values of Impulse Response

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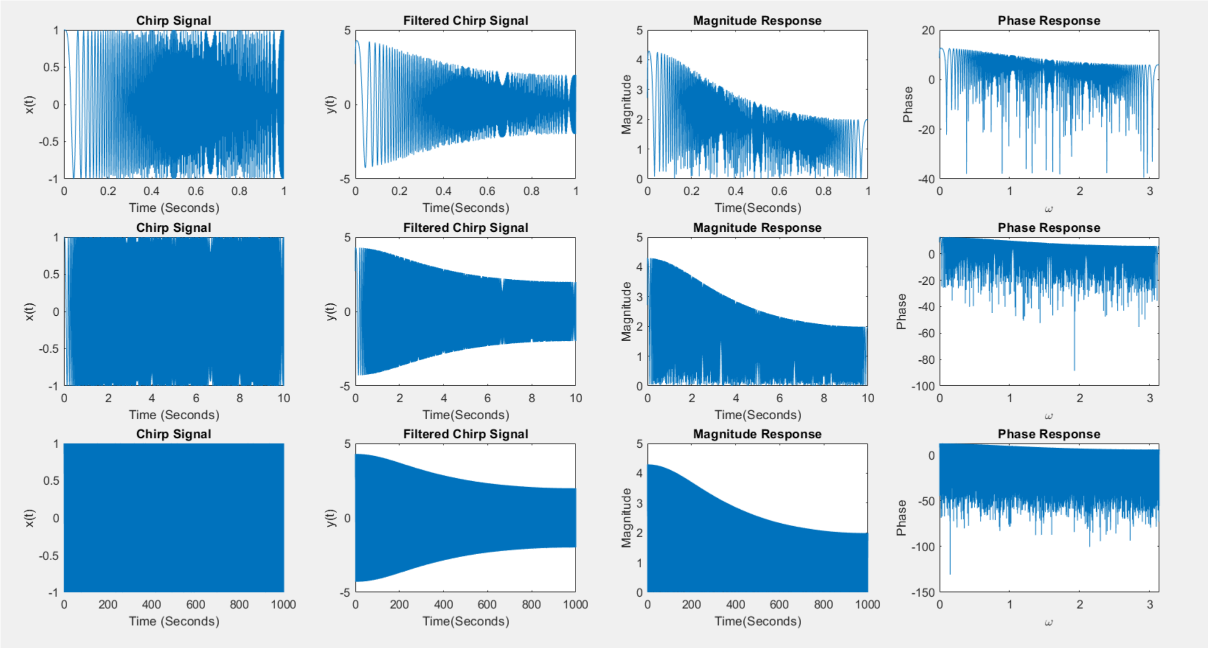

Figure 5: Subplot of x(t), y(t), Magnitude Response

Part 4

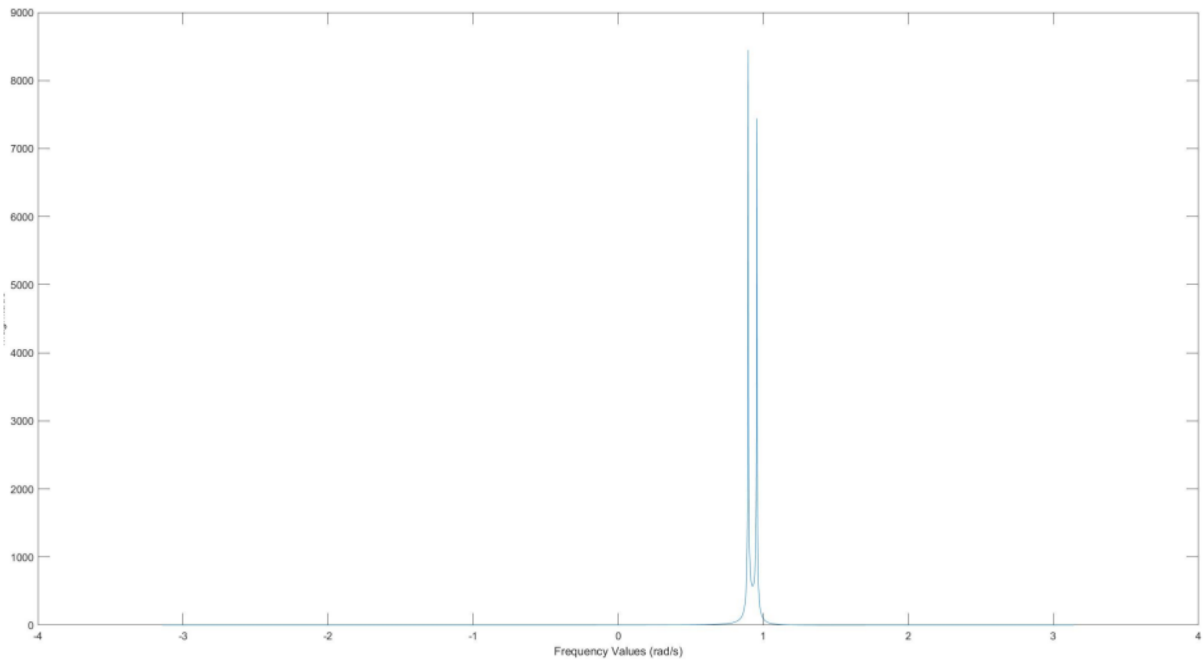

Figure 6: Magnitude Response of Filter After Finding DTFT

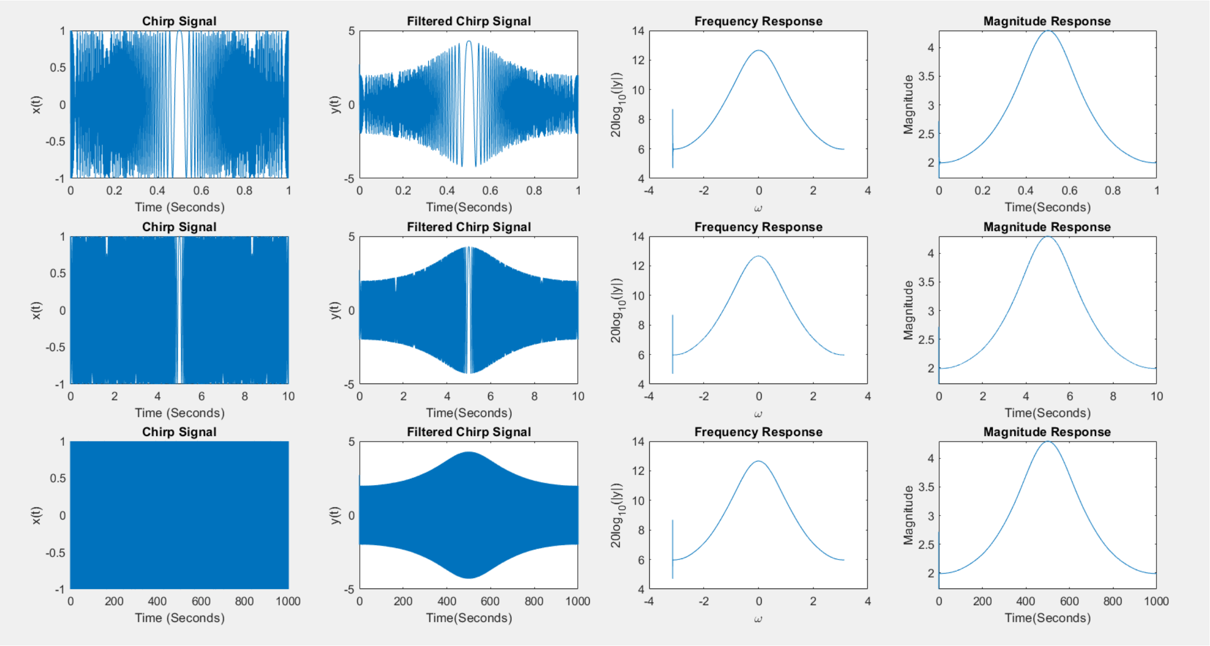

Figure 7: Subplot of x(t), y(t), Magnitude Response

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MATLAB CODES

```
%% PART 2 %%
D = mod(21801985, 7);
M = 5 + D;
discrete_points = 0 : 1 : M - 1;
a_l = 0;
b_k = exp(-1 * discrete_points + 1);
figure; stem(discrete_points, b_k); xlabel('Discrete Points
(n)');ylabel('Magnitude');
impulse_response = DTLTI(a_l, b_k, 1, 21);
figure; stem(0 : 20, impulse_response); xlabel('Discrete Points
(n)');ylabel('Magnitude');
freq_interval = -pi : 0.001 : pi - 0.001;
ZT_2_DTFT = exp(1) * (1 - exp(-10 * (1 + 1i * freq_interval))) ./ (1- exp(-1* (1 +
1i * freq_interval)));
figure; plot(freq_interval, abs(ZT_2_DTFT)); xlabel('Frequency
(rad/s)');ylabel('Magnitude');
fq = -pi : 0.001 : pi - 0.001;
trans_z = exp(1) * (1 - exp(-10 * (1 + 1i * fq))) ./ (1- exp(-1* (1 + 1i * fq)));
figure; plot(fq, abs(trans_z)); xlabel('Frequency (rad/s)'); ylabel('Amplitude');
yline((max(abs(trans_z))/sqrt(2)));
t = 0 : 1 / 1000 : 1;
t_freq = 0 : pi / 1000 : pi;
phi = 250 .* (t .^2);
x = cos(2 * pi .* phi);
y = DTLTI(a_l, b_k, x, 1001);
subplot(3, 4, 1); plot(t, x); title('Chirp Signal'); xlabel('Time
(Seconds)');ylabel('x(t)');
subplot(3, 4, 2); plot(t, y);title('Filtered Chirp Signal');
xlabel('Time(Seconds)'); ylabel('y(t)');
subplot(3, 4, 3); plot(t, abs(y)); title('Magnitude Response');
xlabel('Time(Seconds)'); ylabel('Magnitude');
subplot(3, 4, 4); plot(t_freq, 20 * log10(abs(y))); title('Phase
Response');xlabel('\omega'); ylabel('Phase');
t = 0 : 1 / 1000 : 10;
t_freq = 0 : pi / 10000 : pi;
phi = 25 .* (t .^ 2);
x = cos(2 * pi .* phi);
y = DTLTI(a_l, b_k, x, 10001);
subplot(3, 4, 5); plot(t, x); title('Chirp Signal'); xlabel('Time (Seconds)');
ylabel('x(t)');
```

```
subplot(3, 4, 6); plot(t, y); title('Filtered Chirp Signal');
xlabel('Time(Seconds)'); ylabel('y(t)');
subplot(3, 4, 7); plot(t, abs(y)); title('Magnitude Response');
xlabel('Time(Seconds)'); ylabel('Magnitude');
subplot(3, 4, 8); plot(t_freq, 20 * log10(abs(y))); title('Phase
Response');xlabel('\omega'); ylabel('Phase');
t = 0 : 1 / 1000 : 1000;
t_freq = 0 : pi / 1000000 : pi;
phi = 0.25 .* (t .^ 2);
x = cos(2 * pi .* phi);
y = DTLTI(a_l, b_k, x, 1000001);
subplot(3, 4, 9); plot(t, x); title('Chirp Signal'); xlabel('Time
(Seconds)');ylabel('x(t)');
subplot(3, 4, 10);plot(t, y); title('Filtered Chirp Signal');
xlabel('Time(Seconds)'); ylabel('y(t)');


subplot(3, 4, 11); plot(t, abs(y)); title('Magnitude Response');
xlabel('Time(Seconds)'); ylabel('Magnitude');
subplot(3, 4, 12); plot(t_freq, 20 * log10(abs(y))); title('Phase
Response');xlabel('\omega'); ylabel('Phase');


%% PART 4 %%
for i = 1 : 8
    n(i) = (2 * i + i * mod(21801985, 5)) * mod(21801985, 7);
end
z1 = (n(1) + (1i) * n(8)) / sqrt(n(1)^2 + n(8)^2);
p1 = (n(4) + (1i) * n(5)) / sqrt(1 + n(4)^2 + n(5)^2);
p2 = (n(5) + (1i) * n(7)) / sqrt(1 + n(5)^2 + n(7)^2);
omega = -pi : 0.001 : pi;
h = (exp(1i * omega) - exp(1i * 1.4465)) ./ ((exp(1i * omega) - 0.999 * exp(1i*
0.8960)) .* (exp(1i * omega) - 0.999 * exp(1i * 0.9560)));
plot(omega, abs(h)); xlabel('Frequency Values (rad/s)'); ylabel('Magnitude');
t = 0 : 1 / 1000 : 1;
t_freq = -pi : pi / 500 : pi;
phi = -500 * t + 500 * (t .^ 2);
x = exp(1i * 2 * pi * phi);
y = DTLTI(a_l, b_k, x, 1001);
subplot(3, 4, 1); plot(t, x); title('Chirp Signal'); xlabel('Time
(Seconds)');ylabel('x(t)');
subplot(3, 4, 2); plot(t, y); title('Filtered Chirp Signal');
xlabel('Time(Seconds)'); ylabel('y(t)');
subplot(3, 4, 3); plot(t_freq, 20 * log10(abs(y))); title('Frequency
Response');xlabel('\omega'); ylabel('20log_1_0(|y|)');
subplot(3, 4, 4); plot(t, abs(y)); title('Magnitude Response');
xlabel('Time(Seconds)'); ylabel('Magnitude');
t = 0 : 1 / 1000 : 10;
t_freq = -pi : pi / 5000 : pi;
phi = -500 * t + 50 * (t .^ 2);
x = exp(1i * 2 * pi * phi);
y = DTLTI(a_l, b_k, x, 10001);
subplot(3, 4, 5); plot(t, x); title('Chirp Signal'); xlabel('Time
(Seconds)');ylabel('x(t)');
subplot(3, 4, 6); plot(t, y); title('Filtered Chirp Signal');
xlabel('Time(Seconds)'); ylabel('y(t)');
subplot(3, 4, 7); plot(t_freq, 20 * log10(abs(y))); title('Frequency
```

```
Response');xlabel('\omega'); ylabel('20log_1_0(|y|)');
subplot(3, 4, 8); plot(t, abs(y)); title('Magnitude Response');
xlabel('Time(Seconds)'); ylabel('Magnitude');
t = 0 : 1 / 1000 : 1000;
t_freq = -pi : pi / 500000 : pi;
phi = -500 * t + 0.5 * (t .^ 2);
x = exp(1i * 2 * pi * phi);
y = DTLTI(a_l, b_k, x, 1000001);
subplot(3, 4, 9); plot(t, x); title('Chirp Signal'); xlabel('Time
(Seconds)');ylabel('x(t)');
subplot(3, 4, 10);plot(t, y); title('Filtered Chirp Signal');
xlabel('Time(Seconds)'); ylabel('y(t)');
subplot(3, 4, 11); plot(t_freq, 20 * log10(abs(y))); title('Frequency
Response');xlabel('\omega'); ylabel('20log_1_0(|y|)');
subplot(3, 4, 12); plot(t, abs(y)); title('Magnitude Response');
xlabel('Time(Seconds)'); ylabel('Magnitude');

%% FUNCTIONS %%
function [y] = DTLTI(a, b, x, Ny)
y = zeros(1, Ny);
for n = 0 : Ny - 1
    for l = 0 : min([length(a) n]) - 1
    y(n + 1) = y(n + 1) - a(l + 1) * y(n - l);
    end
    for k = max([0 (n - length(x) + 1)]) : min([(length(b) - 1) n])
    y(n + 1) = y(n + 1) + b(k + 1) * x(n - k + 1);
    end
end
end
```

Part 1

Atahan İyiekici
21801985

• $y[0] = \underbrace{\sum_{l=1}^{N} a[l]\,y[-l]}_{0} + \sum_{k=0}^{m} b[k]\,x[-k] = \underbrace{b[0]\,x[0]}_{*}$ as $y[-l]=0$ in this case

• $y[1] = \sum_{l=1}^{N} a[l]\,y[1-l] + \sum_{k=0}^{m} b[k]\,x[1-k] = a[1]\,y[0] + b[0]\,x[1] + b[1]\,x[0]$

from $*$ $\Rightarrow a[1]b[0]x[0] + b[0]x[1] + b[1]x[0]$

$$\Rightarrow Y(z) = \sum_{n=0}^{\infty}\sum_{l=1}^{N} a[l]\,y[n-l]\,z^{-n} + \sum_{n=0}^{\infty}\sum_{k=0}^{m} b[k]\,x[n-k]\,z^{-n}$$

$$= \sum_{l=1}^{N} a[l] \sum_{n=0}^{\infty} y[n-l]\,z^{-n} + \sum_{k=0}^{m} b[k] \sum_{n=0}^{\infty} x[n-k]\,z^{-n}$$

$$= \sum_{l=1}^{N} a[l]\,z^{-l}\,Y(z) + \sum_{k=0}^{m} b[k]\,z^{-k}\,X(z)$$

$$Y(z) = \left(1 - \sum_{l=1}^{N} a[l]\,z^{-l}\right) = X(z)\left(\sum_{k=0}^{m} b[k]\,z^{-k}\right)$$

$$\frac{Y(z)}{X(z)} = \frac{\sum_{k=0}^{m} b[k]\,z^{-k}}{1 - \sum_{l=1}^{N} a[l]\,z^{-l}} = \frac{\sum_{k=0}^{m} b[k]\,z^{-k}}{\sum_{l=0}^{N} -a[l]\,z^{-l}} \quad \text{where } a[0] = 1$$

Part 2

b) non-zero impulse response values and $b[k]$ are same. As $x[n] = \delta[n]$ they matched.

c) impulse response has finite length that converges 0 therefore it is also FIR. the length of impulse response is 7 for my ID.

d) $y[n] = \sum_{k=0}^{m-1} e^{-k+1} \cdot x[n-k] \rightarrow y(z) = \sum_{k=0}^{m-1} e^{-k+1} z^{-k} X(z)$

$$\frac{Y(z)}{X(z)} = H(z) = \sum_{k=0}^{m-1} e^{-k+1} z^{-k} = e \sum_{k=0}^{m-1} (ez)^{-k} = e \sum_{k=0}^{m-1} (e^{-1} \cdot z^{-1})^{k}$$ let denote $e^{-1} \cdot z^{-1} = A$

$$\Rightarrow e\,\frac{1-A^m}{1-A} = e\,\frac{1-((ez)^{-1})^m}{1-(ez)^{-1}} \Rightarrow H(e^{j\Omega}) = e\,\frac{1-((e^{1+j\Omega})^{-1})^m}{1-(e^{1+j\Omega})^{-1}}$$

$$= e\,\frac{1-(e^{1+j\Omega})^{-m}}{1-(e^{1+j\Omega})^{-1}} = e\,\frac{1-e^{(1+j\Omega)^{-7}}}{1-(e^{1+j\Omega})^{-1}}$$ where $M=7$

e) output attenuates in high frequencies, It is LPF. 3dB is the mag. of $\frac{\text{max value}}{\sqrt{2}}$

$w_{cut-off} = \pm 1.07341$. Bandwith is approximately 1.99606.

f) general trend of this signal is narrowing in Magnitude

Part 4

a) $H(z) = \frac{z - z_1}{(z-p_1)(z-p_2)}$ c) $z_1 = 0.1240 + 0.9923i$

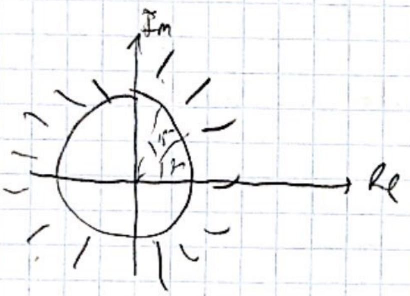
$p_1 = 0.6262 + 0.7803i$ $p_2 = 0.5810 + 0.8134i$

b) $H(z) = \frac{Y(z)}{X(z)} = \frac{z-(0.1240+0.9923i)}{z-(0.6262+0.7803i))(z-0.5810+0.8134i)}$

$\Rightarrow y[n] = y[n-1]\left(1.97682\, e^{j(0.9377)} + y[n-2](0.9899 e^{j(1.42)}\right) /$
$x[n-1] - x[n-2]\left(1.1177\, e^{j(1.3665)}\right)$

c) to compute impulse response, $h[n] = h[n-1](1.97682 e^{j(0.93377)}) + h[n-2]$
$+ \delta[n-1] - \delta[n-2] \cdot e^{j(1.3665)}$ $(0.9899 e^{j1.42})$

d)



ROC is outer side of the unit circle

poles and zeros are inside circle

Magnitude response

the sketch should look like this

e) All poles are inside the circle, therefore, the system is stable.

f) System is IIR. because it doesn't become zero as finite time passes

g) To find DTFT, use $z = e^{j\Omega}$ in $H(z)$

$H(z) \Rightarrow H(e^{j\Omega}) = \frac{(e^{j\Omega} - 0.1240 - j\,0.91)}{(e^{j\Omega} - 0.625 - j\,0.831)(e^{j\Omega} - 0.61 - j\,0.858)}$

this is a Band Pass filter

h) if we change sweep in the interval $-600\,Hz$ to $600\,Hz$ f_s must be at least $1200\,Hz$. because $(f_s > 2f_B)$