Signals and Systems
Matlab Homework #3

Table of Contents

Introduction

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- Class: ESE 351
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Initialize Variables

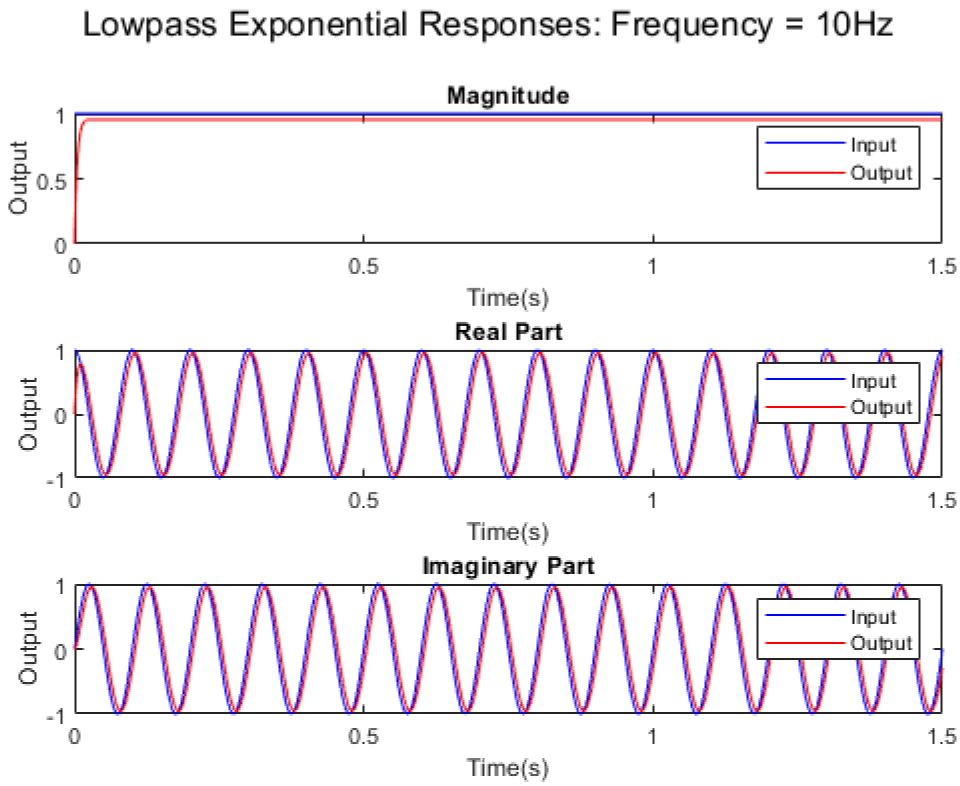
```
close all
R = 1e3; %Resistance in ohms
C = 5e-6; %Capacitence in Farads
tau = R*C;
sampleFreq = 44.1e3;
samplePeriod = 1/sampleFreq;
```

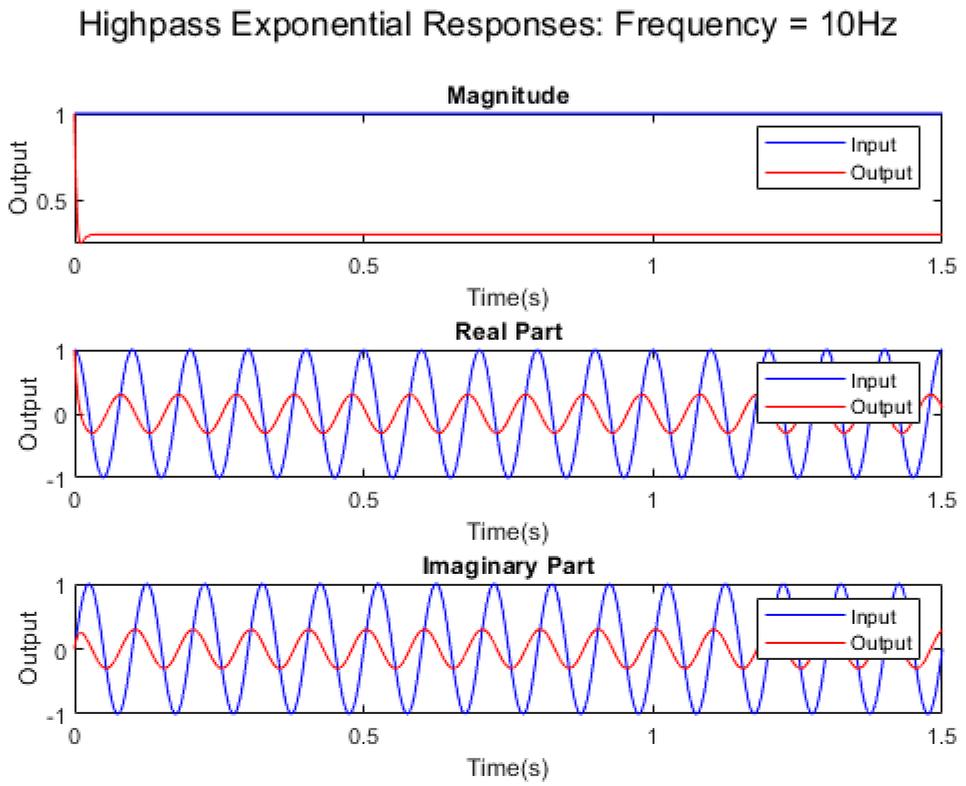
Part 1: Complex Exponential Input

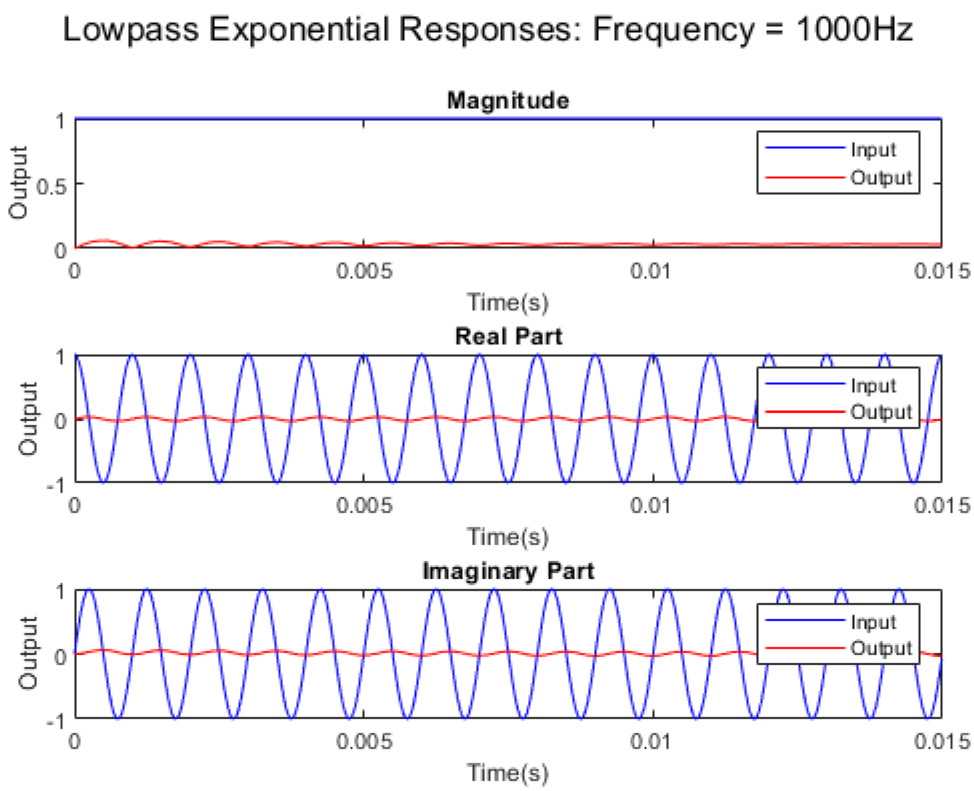
```
freqVals = [10, 1000];

for i = 1:2
freq = freqVals(i);
angularFreq = 2*pi*freq;

sampleTimes = 0:samplePeriod:15*(1/freq);
%inputFunct = zeros(1,length(timePoints));
inputFunct = exp(1j*angularFreq*sampleTimes);
```

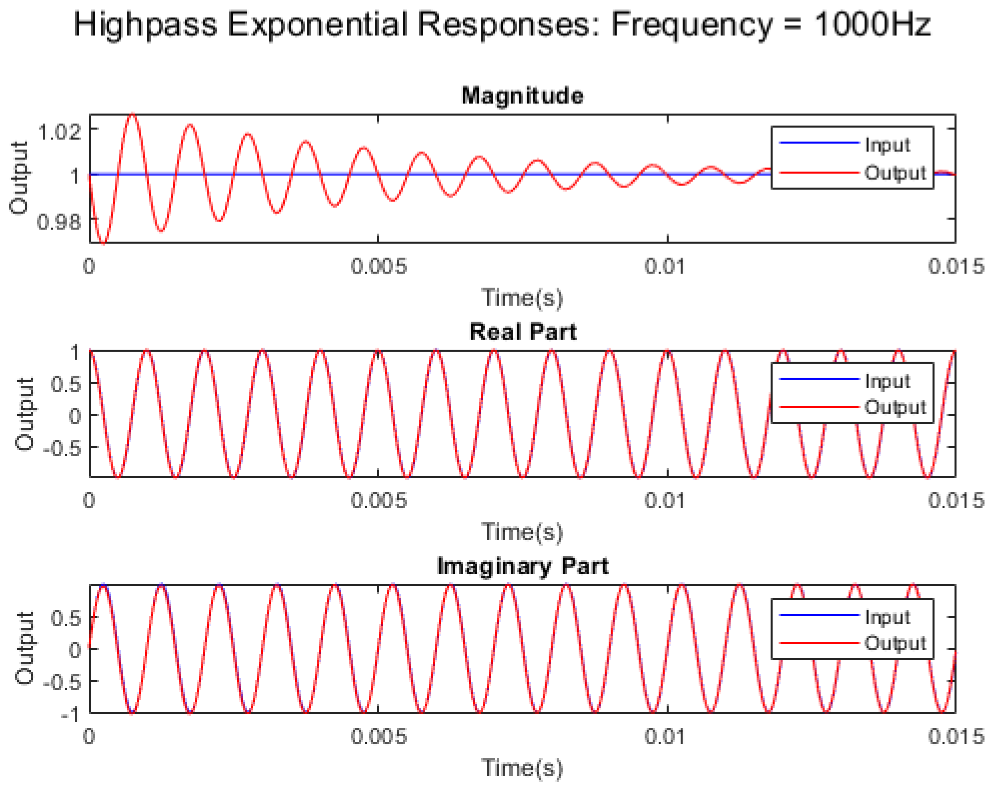
```
%LCCDE Lowpass

lsim_Lo = lsim(1/tau , [1 ,1/tau], inputFunct,sampleTimes);

%LCCDE Highpass

lsim_Hi = lsim([1 0] , [1 ,1/tau], inputFunct,sampleTimes);

 % Create subplots
 %plot lowpass
    figure;
    hold on
    subplot(3, 1, 1);
    plot(sampleTimes, abs(inputFunct), 'b', sampleTimes, abs(lsim_Lo), 'r');
    title('Magnitude');
    xlabel('Time(s)');
    ylabel('Output');
    legend('Input', 'Output');

    subplot(3, 1, 2);
    plot(sampleTimes, real(inputFunct), 'b', sampleTimes, real(lsim_Lo), 'r');
    title('Real Part');
    xlabel('Time(s)');
    ylabel('Output');
    legend('Input', 'Output');

    subplot(3, 1, 3);
    plot(sampleTimes, imag(inputFunct), 'b', sampleTimes, imag(lsim_Lo), 'r');
    title('Imaginary Part');
    legend('Input', 'Output');
    xlabel('Time(s)');
    ylabel('Output');
    sgtitle(['Lowpass Exponential Responses: Frequency = ',
 num2str(freq), 'Hz']);

    hold off
    % plot highpass
    figure;
    hold on
    subplot(3, 1, 1);
    plot(sampleTimes, abs(inputFunct), 'b', sampleTimes, abs(lsim_Hi), 'r');
    title('Magnitude');
    xlabel('Time(s)');
    ylabel('Output');
    legend('Input', 'Output');

    subplot(3, 1, 2);
    plot(sampleTimes, real(inputFunct), 'b', sampleTimes, real(lsim_Hi), 'r');
    title('Real Part');
    xlabel('Time(s)');
    ylabel('Output');
    legend('Input', 'Output');

    subplot(3, 1, 3);
```

```
    plot(sampleTimes, imag(inputFunct), 'b', sampleTimes, imag(lsim_Hi), 'r');
    title('Imaginary Part');
    xlabel('Time(s)');
    ylabel('Output');
    legend('Input', 'Output');
    sgtitle(['Highpass Exponential Responses: Frequency = ',
 num2str(freq), 'Hz']);
end
```




Highpass Exponential Responses: Frequency = 10Hz
Magnitude
Real Part
Imaginary Part
Output
Time(s)
Input
Output
0
0.5
1
1.5
-1

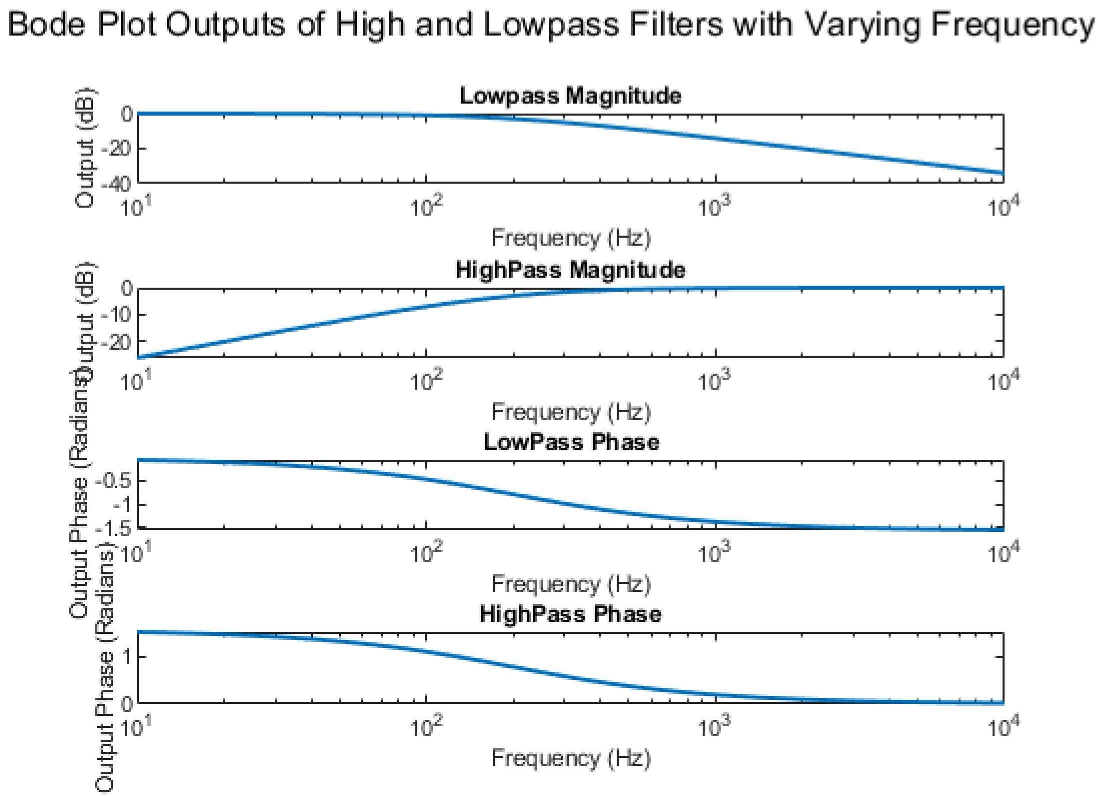

Lowpass Exponential Responses: Frequency = 1000Hz
Magnitude
Real Part
Imaginary Part
Output
Time(s)
Input
Output
0
0.5
1
-1
0.005
0.01
0.015



Part 2 Bode Plot

```
freqRange = logspace(1,4,100);
sampleTimes = 0:samplePeriod:2; %Sim to 2s for bettter steady state

H_Hi = zeros(length(freqRange),1);
H_Lo = zeros(length(freqRange),1);

for i = 1:length(freqRange)
    angularFreq = freqRange(i);
    inputFunct = exp(1j*angularFreq*sampleTimes);

    %Lsim Lowpass
    lsim_Lo = lsim(1/tau , [1 ,1/tau], inputFunct,sampleTimes);

    %Lsim Highpass
    lsim_Hi = lsim([1 0] , [1 ,1/tau], inputFunct,sampleTimes);

    % Compute H, assume steady state at index 660
    H_Lo(i) =  lsim_Lo(end) / inputFunct(end);
    H_Hi(i) =  lsim_Hi(end) / inputFunct(end);
    % Compute magnitude in dB and phase normalized by pi

end
```

```
%Calc for Highpass
mag_Hi = 20*log10(abs(H_Hi));
phase_Hi = angle((H_Hi)/pi);

%Calc for Lowpass
mag_Lo = 20*log10(abs(H_Lo));
phase_Lo = angle((H_Lo)/pi);

%Plot
figure;
hold on
subplot(4, 1, 1);
semilogx(freqRange, mag_Lo, LineWidth=1.5);
title('Lowpass Magnitude');
xlabel('Frequency (Hz)');
ylabel('Output (dB)');

subplot(4, 1, 2);
semilogx(freqRange, mag_Hi, LineWidth=1.5);
title('HighPass Magnitude');
xlabel('Frequency (Hz)');
ylabel('Output (dB)');

subplot(4, 1, 3);
semilogx(freqRange, phase_Lo, LineWidth=1.5);
title('LowPass Phase');
xlabel('Frequency (Hz)');
ylabel('Output Phase (Radians)');

subplot(4, 1, 4);
semilogx(freqRange, phase_Hi, LineWidth=1.5);
title('HighPass Phase');
xlabel('Frequency (Hz)');
ylabel('Output Phase (Radians)');
sgtitle('Bode Plot Outputs of High and Lowpass Filters with Varying
 Frequency');
hold off
```

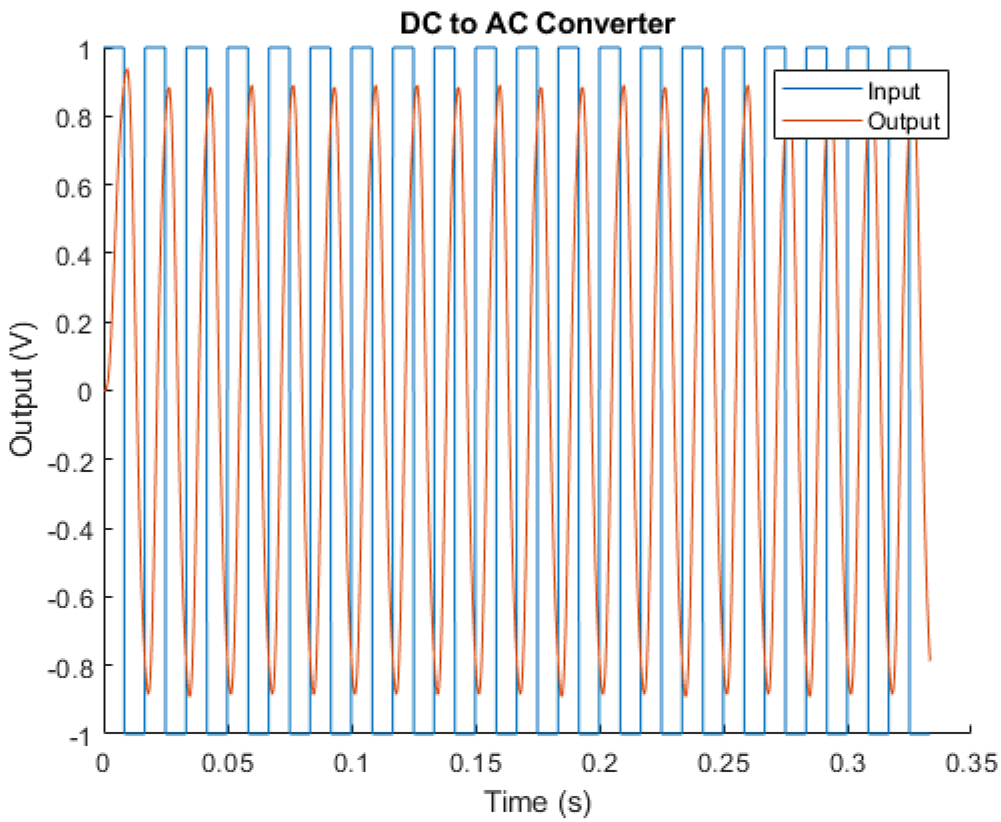


Part 3: DC to AC Converter

Define parameters

```
sampleFreq = 10e3;
samplePeriod = 1/sampleFreq;
frequency = 60;       % Desired frequency in Hz

cutoff = 160;
C = 10e-6;
R = 1/(2*pi*cutoff*C);
tau = R*C;

sampleTimes = 0:samplePeriod:20 *(1/frequency);

% Generate square wave
sq = square(2*pi*frequency*sampleTimes);
inputFunct = sq;

%Filter Coeffs
a = [1, samplePeriod/tau-1];
b = samplePeriod/tau;

% Pass signal through RC Lowpass filter 6 separate times
output = zeros(size(inputFunct));
for i = 1:6
```

```
output = filter(b, a, inputFunct);

inputFunct = output;
end

% Plot the output
figure()
hold on
plot(sampleTimes, sq);
plot(sampleTimes, output);
xlabel('Time (s)')
ylabel('Output (V)')
title('DC to AC Converter')
legend('Input', 'Output');
hold off
```



Part 3C: Power Efficiency

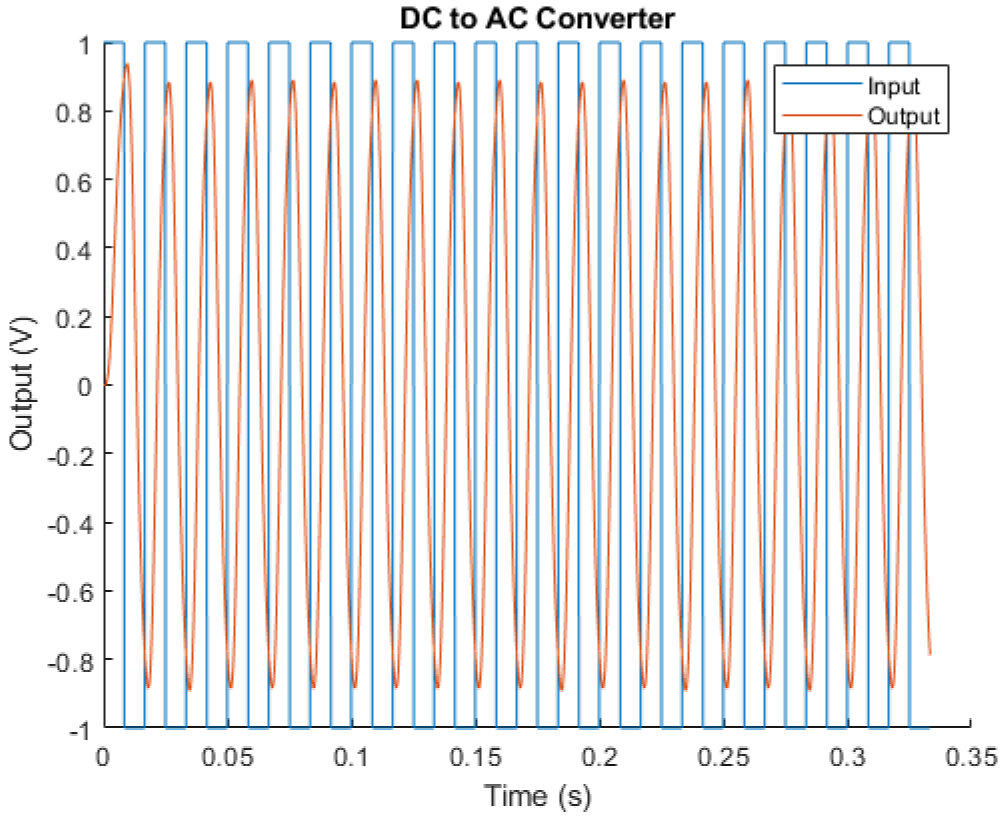
```
%Cut off first initial spike of the power, only interested in steady state
sq = sq(1000:end);
output = output(1000:end);
Pin = sum(sq(1:end).^2);
Pout = sum(output(1:end).^2);

efficiency = Pout/Pin;
fprintf('Efficiency Via Integral: %f\n', efficiency*100)
```

```
% a1 for the sinc function is
% power efficiency = (2a1)^2/Pin
% Pin = 1
a = 7/6*pi;
fprintf('Theoretical Max Efficiency Via Fourier Series: %f\n', (2*a)^2)
```

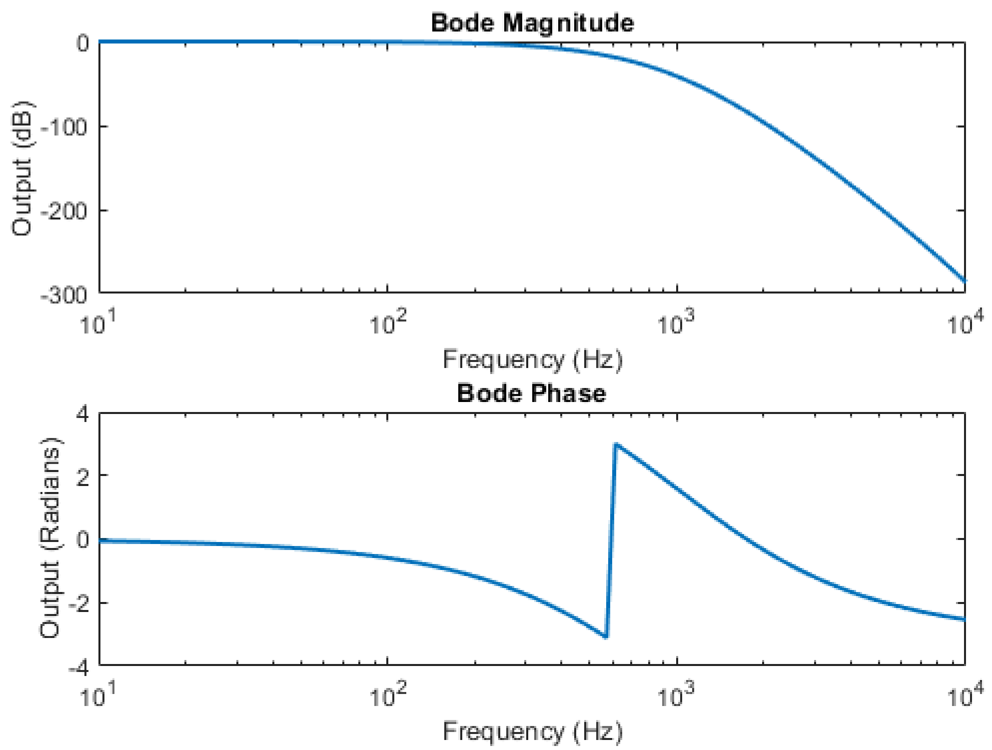
Efficiency Via Integral: 39.781441
Theoretical Max Efficiency Via Fourier Series: 53.734513

Part 3B : Bode Plot

```
sampleTimes = 0:samplePeriod:0.5; %2 seconds

frequencyRange = logspace(1,4,100);

H = zeros(size(frequencyRange));
for i = 1:length(frequencyRange)

    squareInput = exp(1i*frequencyRange(i)*sampleTimes);

    outputForBode = squareInput;
    for n = 1:6 % 6 low pass fiters
        outputForBode = lsim(1/tau,[1 1/tau],outputForBode,sampleTimes);
    end

    H(i) = outputForBode(end)/squareInput(end);

end
mag = 20*log(abs(H));

ang = angle(H/pi);

figure;
hold on
subplot(2, 1, 1);
semilogx(freqRange, mag, LineWidth=1.5);
title('Bode Magnitude');
xlabel('Frequency (Hz)');
ylabel('Output (dB)');

subplot(2, 1, 2);
semilogx(freqRange, ang, LineWidth=1.5);
title('Bode Phase');
xlabel('Frequency (Hz)');
ylabel('Output (Radians)');
sgtitle('Bode Plot Output of DC to AC Converter with Varying Frequency');
hold off
```



Bode Plot Output of DC to AC Converter with Varying Frequency



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