<table>
<tr><td colspan="3">Name: M NAGA TEJA
Lab Section: 1A</td><td colspan="2">Branch: AI & DS
Id No: 2000080061</td></tr>
<tr><td>Pre-lab Session work (15M)</td><td>In-Lab Session work (15M)</td><td>Post Lab session work (10M)</td><td>Viva (10M)</td><td>Total Marks 50M</td></tr>
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Signal Processing-Lab (20AD3107)

Lab 5: Frequency Analysis: The Fourier Transform

Lab Report

Introduction: The frequency representation of signals as well as the frequency response of systems are tools of great significance in signal processing, communi-cations, and control theory. In this lab we will explore the Fourier representation of signals by extending it to aperiodic signals. By a limiting process the harmonic represe-ntation of periodic signals is extended to the Fourier transform, a frequency-dense representation for non-periodic signals. The concept of spectrum introduced for periodic signals is generalized for both finite-power and finite-energy signals. Thus, the Fourier transform measures the frequency content of a signal, and unifies the representation of periodic and aperiodic signals.

Basic theory: An aperiodic, or nonperiodic, signal $x(t)$ can be thought of as a periodic signal $x_p(t)$ with an infinite period. Using the Fourier series representation of this signal and a limiting process we obtain a pair

$$x(t) \overset{\text{F.T}}{\longleftrightarrow} X(j\Omega)$$

where the signal $x(t)$ is transformed into a function $X(j\Omega)$ in the frequency domain by

the Fourier transform: $X(j\Omega) = \int_{-\infty}^{\infty} x(t)\, e^{-j\Omega t} dt$: Analysis equation

while $X(j\Omega)$ is transformed into a signal $x(t)$ in the time domain by the

Inverse Fourier transform: $x(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} X(j\Omega)\, e^{j\Omega t} d\Omega$: Synthesis equation

There are two important parameters associated with FT, known as magnitude spectrum and phase spectrum.

The magnitude spectrum is represented by $|X(j\Omega)|$, and similarly

The phase spectrum is represented by $\angle X(j\Omega)$.

Examples:

Ex5.1: Find the FT of a signal $x(t) = e^{-at}u(t)$, where $a = 1$. Develop Matlab code to plot its magnitude and phase spectrum.

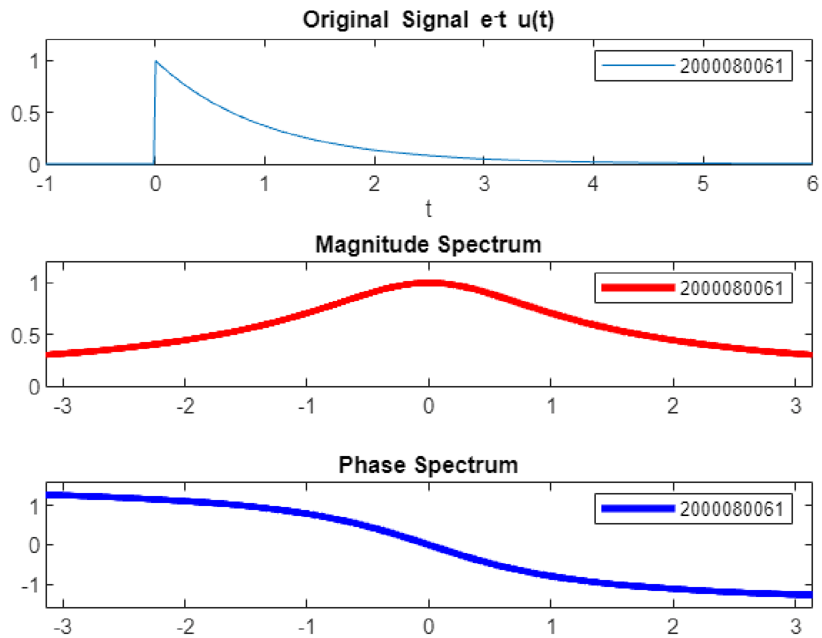
Solution:

CODE

```
clear all; close all; clc;
syms t;
x = exp(-t)*heaviside(t);

figure();
subplot(3,1,1);ezplot(x,[-1 6]); title('Original Signal e^-t u(t)');
axis([-1 6 0 1.2]);legend("2000080061");
X = fourier(x)

w = -pi:0.001:pi;
X = 1./(i*w + 1);
Xm = abs(X);
Xp = angle(X);

subplot(3,1,2);plot(w,Xm,'r','LineWidth',3);title('Magnitude Spectrum');
axis([-pi pi 0 1.2]);legend("2000080061");
subplot(3,1,3);plot(w,Xp,'b','LineWidth',3);title('Phase Spectrum');
axis([-pi pi -pi/2 pi/2]);legend("2000080061");
```

OUTPUT

```
X =

1/(1 + w*1i)
```



Ex5.2: Find the FT of a signal $x(t) = e^{-|t|}$. Develop Matlab code to plot its magnitude and phase spectrum.

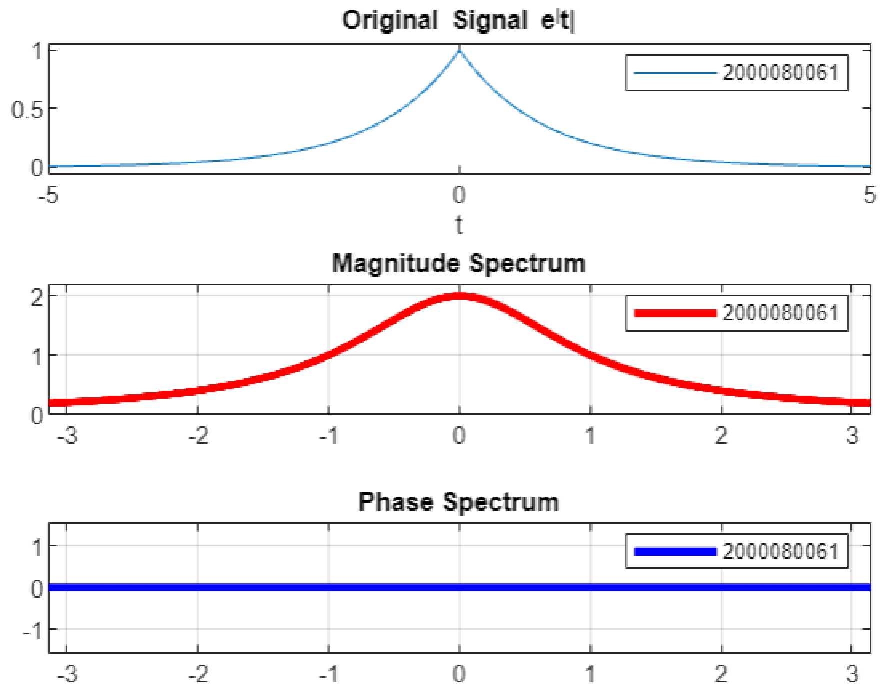
Solution:

CODE

```
clear all; close all; clc;
syms t;
x = exp(-abs(t));

figure();
subplot(3,1,1);ezplot(x,[-5 5]); title('Original Signal e^|t|');legend("2000080061");

X = fourier(x)

w = -pi:0.001:pi;
X = 2./(w.^2 + 1);
Xm = abs(X);
Xp = angle(X);

subplot(3,1,2);plot(w,Xm,'r','LineWidth',3);title('Magnitude Spectrum');
axis([-pi pi 0 2.2]);grid on;legend("2000080061");
subplot(3,1,3);plot(w,Xp,'b','LineWidth',3);title('Phase Spectrum');
axis([-pi pi -pi/2 pi/2]);grid on;legend("2000080061");
```

OUTPUT

```
X =
2/(w^2 + 1)
```



Ex5.3: Find the FT of a unit step function $x(t) = u(t)$. Develop Matlab code to plot its magnitude and phase spectrum.

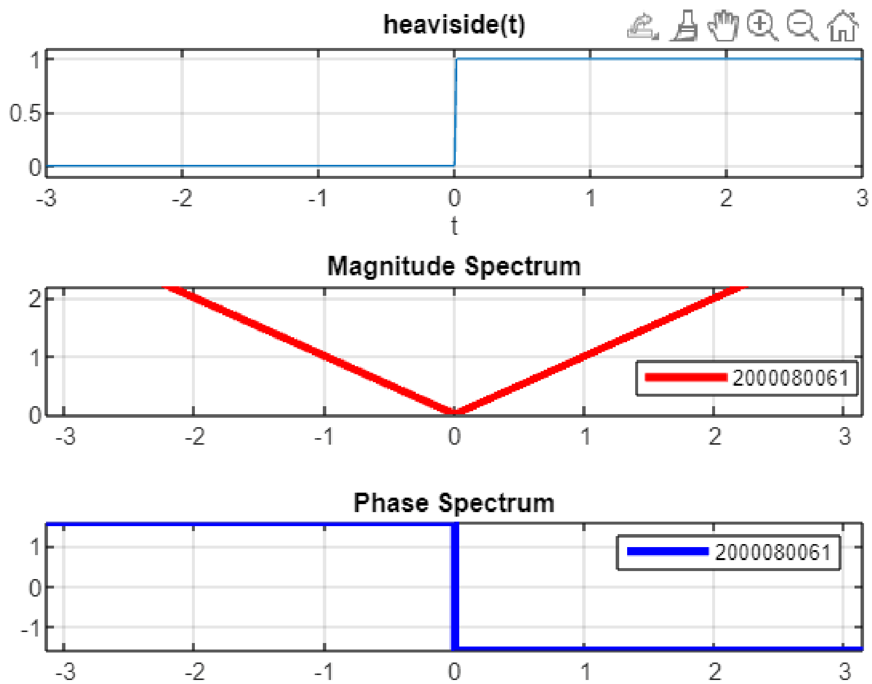
Solution:

CODE

```
clear all; close all; clc;
syms t;
x = heaviside(t);
figure();
subplot(3,1,1);ezplot(x, [-3 3]);axis([-3 3 -0.1 1.1]);grid
X = fourier(x)
disp(X);


w = -pi:0.001:pi;
X = pi*dirac(w)+(1./i*w);
Xm = abs(X);
Xp = angle(X);

subplot(3,1,2);plot(w,Xm,'r','LineWidth',3);title('Magnitude Spectrum');
axis([-pi pi 0 2.2]);grid on;legend("2000080061");

subplot(3,1,3);plot(w,Xp,'b','LineWidth',3);title('Phase Spectrum');
axis([-pi pi -pi/2 pi/2]);grid on;legend("2000080061");
```

OUTPUT

```
X =
pi*dirac(w) - 1i/w
```

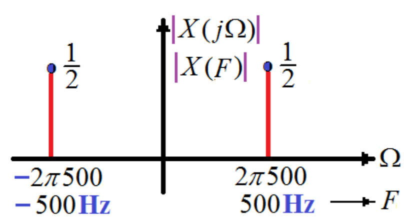


Ex5.4: Fourier Transform (FT) of periodic sinusoidal signals $x(t) = \cos(2\pi 500t)$. Find the FT analytically and sketch its magnitude response and phase response. Develop Matlab code and verify the results.

Solution: Given that $x(t) = \cos(2\pi 500t)$, with frequency $\Omega_0 = 2\pi 500$ rad/sec, or ($\Omega_0 = 2\pi F_0 \Rightarrow F_0 = 500$ Hz or Cycles / sec). This signal is represented as

$$x(t) = \cos(2\pi 500t)$$
$$= \frac{1}{2}\left\{e^{j2\pi 500t} + e^{-j2\pi 500t}\right\}$$

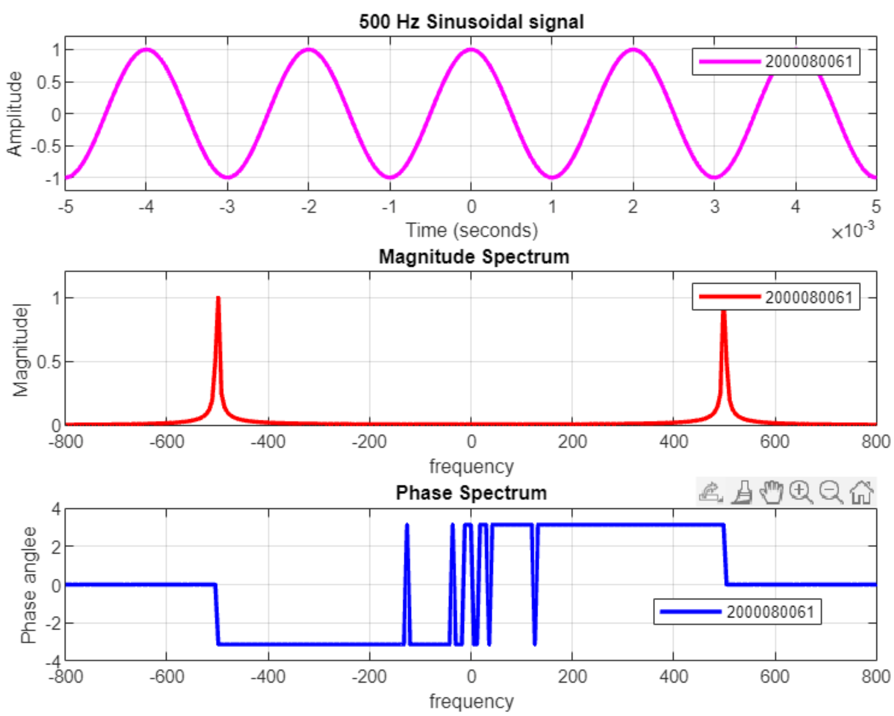
The Fourier series coefficients for this signal are $c_1 = c_{-1} = \frac{1}{2}$ and remaining co-efficients are zero. The Fourier representation is shown in figure.



CODE

```
clear all; close all; clc;
fs=30000;
N=5000;

Ts=1/fs;
t = -(N/2)*Ts:Ts:((N/2)-1)*Ts;

fm = 500;
m = cos(2*pi*fm*t);

f1 = (-N/2:1:N/2-1)*fs/N;
M = (2/N)*fftshift(fft(m));
Ma = abs(M);
Mp = angle(M);

figure();
subplot(3,1,1);
plot(t,m/max(m), 'm', 'LineWidth',2);axis([-0.005 0.005 -1.2 1.2]);
xlabel('Time (seconds)');ylabel('Amplitude');title('500 Hz Sinusoidal signal');grid on;legend("2000080061");

subplot(3,1,2);
plot(f1,Ma/max(Ma),'r','Linewidth',2); axis([-800 800 -0.001 1.2]);
xlabel('frequency'); ylabel('Magnitude|'); title(' Magnitude Spectrum');grid on;legend("2000080061");

subplot(3,1,3);
plot(f1,Mp,'b','Linewidth',2); axis([-800 800 -4 4]);
xlabel('frequency'); ylabel('Phase anglee'); title('Phase Spectrum');grid on;legend("2000080061");
```

OUTPUT



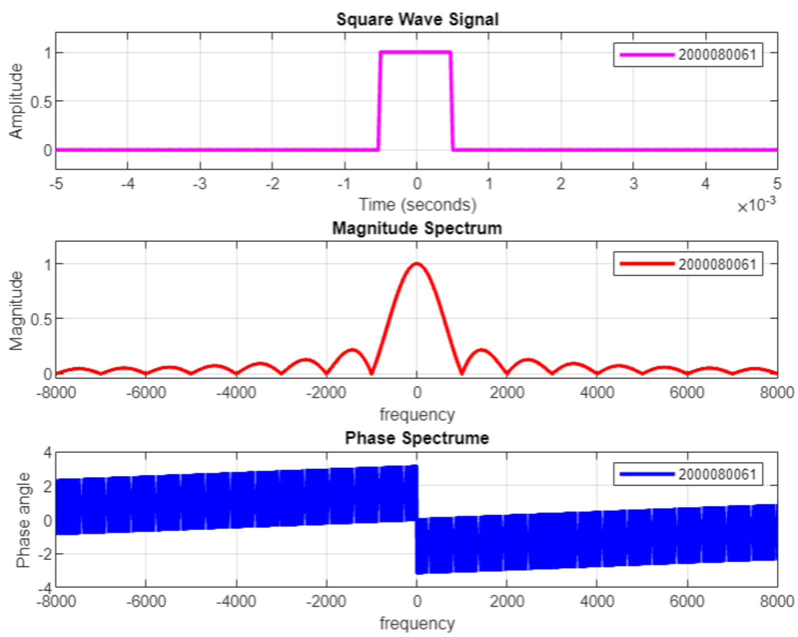
Ex5.5: Consider a symmetrical square wave pulse having unit height and I milli second width. Develop Matlab code to plot its magnitude and phase spectrum.

Solution:

CODE

```
clear all; close all; clc;
fs=30000;
N=5000;

Ts=1/fs;

t = (-N/2:1:(N/2)-1)*Ts;

m = rectpuls(t,1*10^-3);

f1 = (-N/2:1:N/2-1)*fs/N;
M = (2/N)*fftshift(fft(m));
Ma = abs(M);
Mp = angle(M);

figure();
subplot(3,1,1);
plot(t,m, 'm', 'LineWidth',2);axis([-0.005 0.005 -0.2 1.2]);
xlabel('Time (seconds)');ylabel('Amplitude');title('Square Wave Signal');grid on;legend("2000080061");

subplot(3,1,2);
plot(f1,Ma/max(Ma),'r','Linewidth',2); axis([-8000 8000 -0.04 1.2]);
xlabel('frequency'); ylabel('Magnitude'); title('Magnitude Spectrum');grid on;legend("2000080061");

subplot(3,1,3);
plot(f1,Mp,'b','Linewidth',2); axis([-8000 8000 -4 4]);
xlabel('frequency'); ylabel('Phase angle'); title('Phase Spectrume');grid on;legend("2000080061");
```

OUTPUT



Lab Exercise-5

Exercise 5.1: Develop Matlab code to determine and plot the magnitude and phase spectrum for the following signals

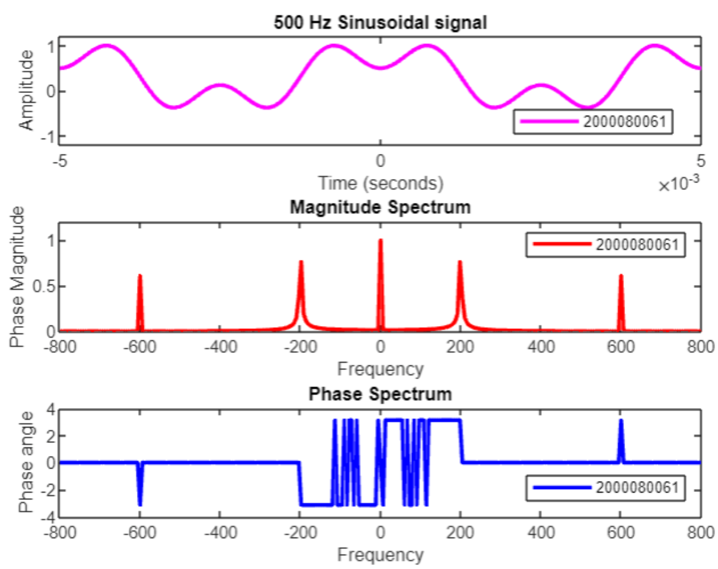
(a) $x(t) = 1 + 1.8\cos(2\pi 200t) - 1.2\cos(2\pi 600t)$ (b) $x(t) = e^{|t|}\cos(10t)$

(c) $x(t) = 2\cos(2\pi 500t)\cos(2\pi 5000t)$

CODE

```
clear all; close all; clc;
fs = 30000;
N = 5000;

Ts = 1/fs;

t = -(N/2)*Ts:Ts:((N/2)-1)*Ts;

fm = 600;
m = 1+1.8*cos(400*pi*t)-1.2*cos(1200*pi*t);
f1 = (-N/2:1:N/2-1)*fs/N;
M = (2/N)*fftshift(fft(m));
Ma = abs(M);
Mp = angle(M);

figure();
subplot(3,1,1);plot(t,m/max(m), 'm', 'LineWidth', 2);axis([-0.005 0.005 -1.2 1.2]);
xlabel('Time (seconds)');ylabel('Amplitude');title('500 Hz Sinusoidal signal');legend('2000080061')

subplot(3,1,2);plot(f1,Ma/max(Ma), 'r', 'LineWidth', 2);axis([-800 800 -0.001 1.2]);
xlabel('Frequency');ylabel('Phase Magnitude');title('Magnitude Spectrum');legend('2000080061');

subplot(3,1,3);plot(f1,Mp, 'b', 'LineWidth', 2);axis([-800 800 -4 4]);
xlabel('Frequency');ylabel('Phase angle');title('Phase Spectrum');legend('2000080061');
```

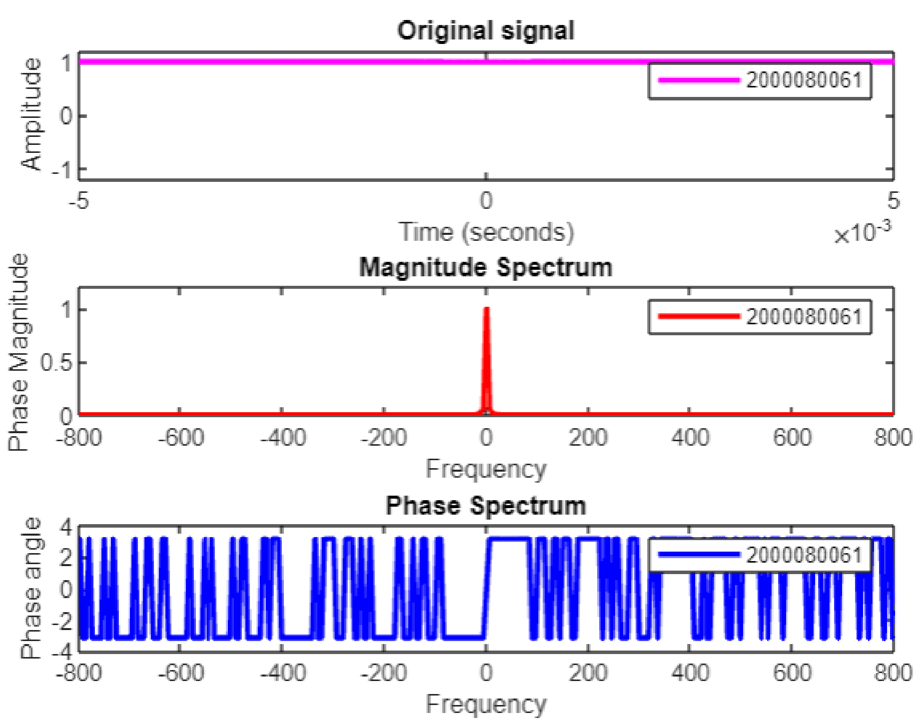
OUTPUT



CODE

```
clear all; close all; clc;
fs = 30000;
N = 5000;

Ts = 1/fs;

t = -(N/2)*Ts:Ts:((N/2)-1)*Ts;

fm = 600;
m = exp(abs(t)).*cos(10*t);
f1 = (-N/2:1:N/2-1)*fs/N;
M = (2/N)*fftshift(fft(m));
Ma = abs(M);
Mp = angle(M);

figure();
subplot(3,1,1);plot(t,m/max(m), 'm', 'LineWidth', 2);axis([-0.005 0.005 -1.2 1.2]);
xlabel('Time (seconds)');ylabel('Amplitude');title('500 Hz Sinusoidal signal');legend('2000080061');

subplot(3,1,2);plot(f1,Ma/max(Ma), 'r', 'LineWidth', 2);axis([-800 800 -0.001 1.2]);
xlabel('Frequency');ylabel('Phase Magnitude');title('Magnitude Spectrum');legend('2000080061');

subplot(3,1,3);plot(f1,Mp, 'b', 'LineWidth', 2);axis([-800 800 -4 4]);
xlabel('Frequency');ylabel('Phase angle');title('Phase Spectrum');legend('2000080061');
```

OUTPUT



CODE

```
clear all; close all; clc;
fs = 30000;
N = 5000;
Ts = 1/fs;
t = -(N/2)*Ts:Ts:((N/2)-1)*Ts;

fm = 600;
m = 2.*cos(2*pi*500*t).*cos(2*pi*5000*t);
f1 = (-N/2:1:N/2-1)*fs/N;
M = (2/N)*fftshift(fft(m));
Ma = abs(M);
Mp = angle(M);

figure();
subplot(3,1,1);plot(t,m/max(m), 'm', 'LineWidth', 2);axis([-0.005 0.005 -1.2 1.2]);
xlabel('Time (seconds)');ylabel('Amplitude');title('Original signal');legend('2000080061');

subplot(3,1,2);plot(f1,Ma/max(Ma), 'r', 'LineWidth', 2);axis([-800 800 -0.001 1.2]);
xlabel('Frequency');ylabel('Phase Magnitude');title('Magnitude Spectrum');legend('2000080061');

subplot(3,1,3);plot(f1,Mp, 'b', 'LineWidth', 2);axis([-800 800 -4 4]);
xlabel('Frequency');ylabel('Phase angle');title('Phase Spectrum');legend('2000080061');
```

OUTPUT