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Lab 1 Part 3

Signal Analysis in MATLAB

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Abstract— *For this portion of the lab we plotted a fourier series function, by first solving for the fourier series, then using spectrum we plotted the waveforms.*

Keywords—Frequency; Signals; Bandwidth

Introduction

We first begin our Lab 1 Part 3 by discovering one of the given plots functions using fourier series. After we solved for our function we then plotted the sinusoid and the spectrum for the wavelengths of one, five, ten, and one hundred.

A. What is Fourier Analysis

Fourier Analysis is a concept that any signal is made up of components at various frequencies, and each component is sinusoidal. By adding enough signals together, the appropriate frequency, amplitude, and phase any electromagnetic signal can be constructed.

B. Fourier Series Calculations

For the initial process of this lab we had to choose one of the four signals and using the provided figure, solve for the function using Fourier series. I choose to solve for the second figure that was provided, my calculations can be seen in figure one.

C. Plotting in MATLAB

Once we discovered the function for the given figure my group then had to develop code using MATLAB to graph the appropriate figure. Once we developed our initial code that graphed our Fourier series with the wavelength of one, we then had to alter our value of n which was a single line of code for the various wavelengths of five, ten, and one hundred.

D. Spectrum of our Signal

For the next step of the lab we had to graph the spectrum of our signal. Using the getSpectrum function that was provided in Part Two, we imputed the data into that function and then got the resulting plots.

E. Discoveries

Based on our plots that we created in MATLAB with the various wavelengths it appears to look exactly like what our expected results were supposed to be. The time and frequency domains for each plot were what was expected with the given wavelengths.

F. Appendix

```
fs = 1000;
f0= 0.5;
Ts= 1/fs;
dur = 1/f0 *1e3;
N= fs*dur;
t=0:Ts:(N-1)*Ts;
s1=0;
n=1;
for n = 1:1:n
    Aa=((1-(-1)^n)/((pi*n).^2));
    Ab=((((-1)^n)-2)/(pi*n));
    an= Aa.*cos(pi.*t*n);
    bn= Ab.*sin(pi.*t*n);
    s1=s1+an+bn;
end
a0 = -0.25;
s1=s1+a0;
xmin = 0;
xmax = 4;
ymin = -2;
ymax = 2;
figure
subplot(2,4,1);
plot(t,s1,'b-','linewidth',2)
axis([xmin xmax ymin ymax])
xlabel("Time(Ms)")
ylabel('Voltage (V)')
title("Time Domain Representation of Recreated Wave with n = 1")
grid on;
[freq, amp] = getSpectrum(s1,fs);
xmin = 0;
xmax = 7;
ymin = 0;
ymax = 1.5;
subplot(2,4,5);
plot(freq, amp,'b-','linewidth',2)
axis([xmin xmax ymin ymax])
xlabel("Frequency (kHz)")
ylabel("Voltage (V)")
title("Frequency Domain Representation of Recreated wave with n = 1")
grid on;
s1 = 0;
%subplot(2,4,2);
%plot(t,s1,'b-','linewidth',2);
```

Fig. 1. *MATLAB Code for signal with wavelength of one*

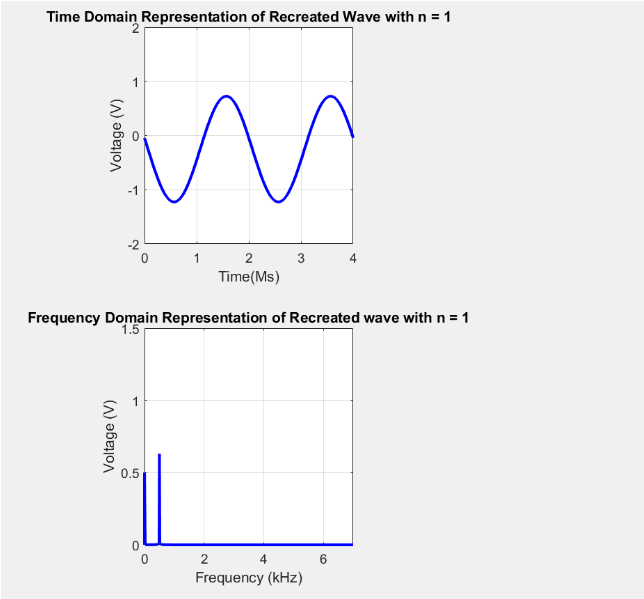


Fig. 2. Time and Frequency plots for wavelength of one

```
fs = 1000;
f0= 0.5;
Ts= 1/fs;
dur = 1/f0 *1e3;
N= fs*dur;
t=0:Ts:(N-1)*Ts;
s1=0;
n=5;
for n = 1:1:n
    Aa=((1-(-1)^n)/((pi*n).^2));
    Ab=((((-1)^n)-2)/(pi*n));
    an= Aa.*cos(pi.*t*n);
    bn= Ab.*sin(pi.*t*n);
    s1=s1+an+bn;
end
a0 = -0.25;
s1=s1+a0;
xmin = 0;
xmax = 4;
ymin = -2;
ymax = 2;
figure
subplot(2,4,1);
plot(t,s1,'b-','linewidth',2)
axis([xmin xmax ymin ymax])
xlabel("Time(Ms)")
ylabel('Voltage (V)')
title("Time Domain Representation of Recreated Wave with n = 1")
grid on;
[freq, amp] = getSpectrum(s1,fs);
xmin = 0;
xmax = 7;
ymin = 0;
ymax = 1.5;
subplot(2,4,5);
plot(freq, amp,'b-','linewidth',2)
axis([xmin xmax ymin ymax])
xlabel("Frequency (kHz)")
ylabel("Voltage (V)")
title("Frequency Domain Representation of Recreated wave with n = 1")
grid on;
s1 = 0;
%subplot(2,4,2);
%plot(t,s1,'b-','linewidth',2);
```

Fig. 3. MATLAB Code for signal with wavelength of five

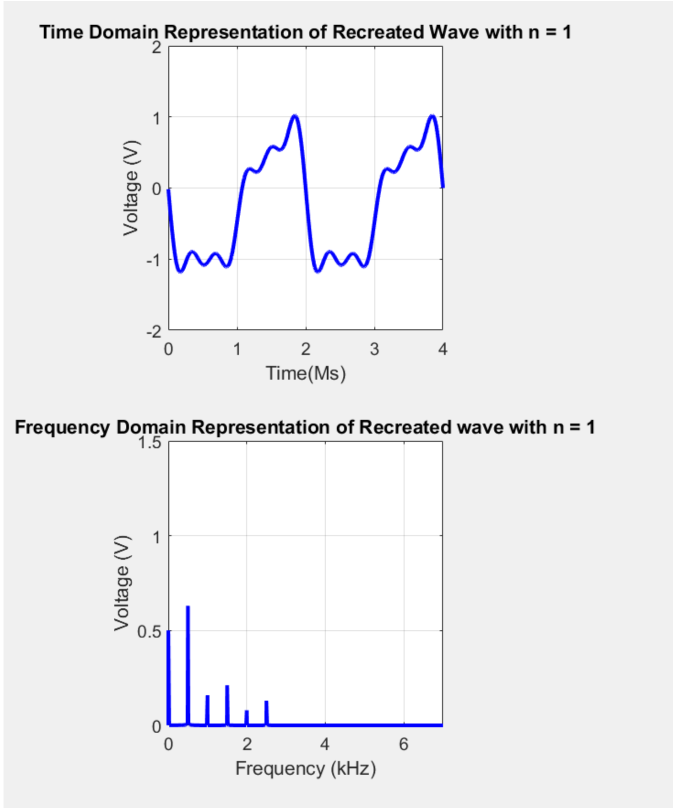


Fig. 4. Time and Frequency plots for wavelength of Five

```
fs = 1000;
f0= 0.5;
Ts= 1/fs;
dur = 1/f0 *1e3;
N= fs*dur;
t=0:Ts:(N-1)*Ts;
s1=0;
n=10;
for n = 1:1:n
    Aa=((1-(-1)^n)/((pi*n).^2));
    Ab=((((-1)^n)-2)/(pi*n));
    an= Aa.*cos(pi.*t*n);
    bn= Ab.*sin(pi.*t*n);
    s1=s1+an+bn;
end
a0 = -0.25;
s1=s1+a0;
xmin = 0;
xmax = 4;
ymin = -2;
ymax = 2;
figure
subplot(2,4,1);
plot(t,s1,'b-','linewidth',2)
axis([xmin xmax ymin ymax])
xlabel("Time(Ms)")
ylabel('Voltage (V)')
title("Time Domain Representation of Recreated Wave with n = 1")
grid on;
[freq, amp] = getSpectrum(s1,fs);
xmin = 0;
xmax = 7;
ymin = 0;
ymax = 1.5;
subplot(2,4,5);
plot(freq, amp,'b-','linewidth',2)
axis([xmin xmax ymin ymax])
xlabel("Frequency (kHz)")
ylabel("Voltage (V)")
title("Frequency Domain Representation of Recreated wave with n = 1")
grid on;
s1 = 0;
%subplot(2,4,2);
%plot(t,s1,'b-','linewidth',2);
```

Fig. 5. MATLAB Code for signal with wavelength of ten

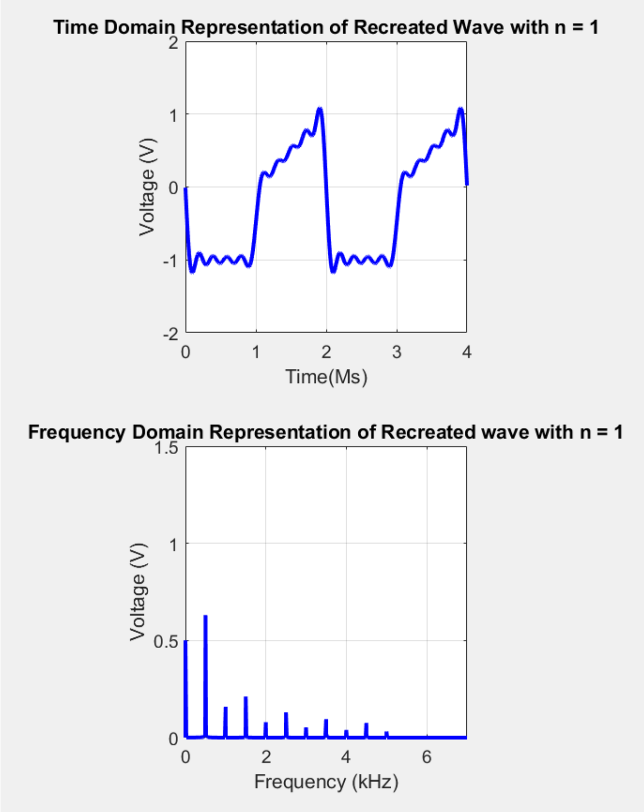


Fig. 6. Time and Frequency plots for wavelength of ten

```
fs = 1000;
f0= 0.5;
Ts= 1/fs;
dur = 1/f0 *1e3;
N= fs*dur;
t=0:Ts:(N-1)*Ts;
s1=0;
n=100;
for n = 1:1:n
    Aa=((1-(-1)^n)/((pi*n).^2));
    Ab=((((-1)^n)-2)/(pi*n));
    an= Aa.*cos(pi.*t*n);
    bn= Ab.*sin(pi.*t*n);
    s1=s1+an+bn;
end
a0 = -0.25;
s1=s1+a0;
xmin = 0;
xmax = 4;
ymin = -2;
ymax = 2;
figure
subplot(2,4,1);
plot(t,s1,'b-','linewidth',2)
axis([xmin xmax ymin ymax])
xlabel("Time(Ms)")
ylabel('Voltage (V)')
title("Time Domain Representation of Recreated Wave with n = 1")
grid on;
[freq, amp] = getSpectrum(s1,fs);
xmin = 0;
xmax = 7;
ymin = 0;
ymax = 1.5;
subplot(2,4,5);
plot(freq, amp,'b-','linewidth',2)
axis([xmin xmax ymin ymax])
xlabel("Frequency (kHz)")
ylabel("Voltage (V)")
title("Frequency Domain Representation of Recreated wave with n = 1")
grid on;
s1 = 0;
%subplot(2,4,2);
%plot(t,s1,'b-','linewidth',2);
```

Fig. 7. MATLAB Code for signal with wavelength of one hundred

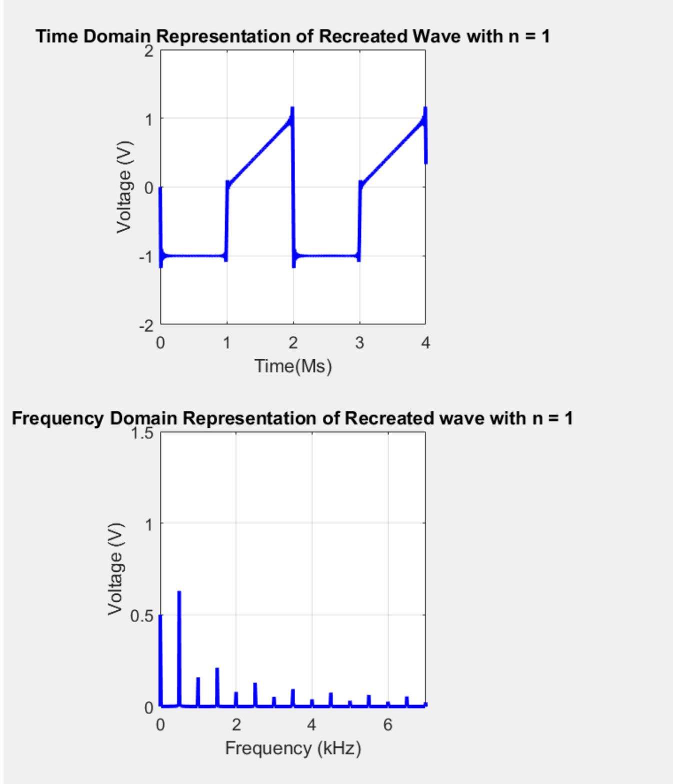
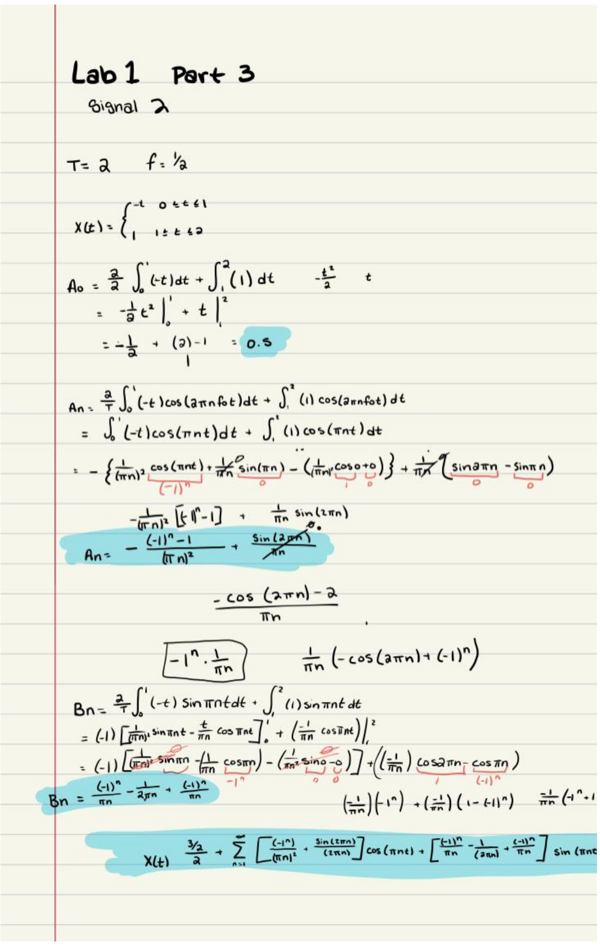


Fig. 8. Time and Frequency plots for wavelength of one hundred



Lab 1 Part 3

Signal 2

$T = 2 \quad f = 1/2$

$x(t) = \begin{cases} -t & 0 \le t \le 1 \\ 1 & 1 \le t \le 2 \end{cases}$

$A_0 = \frac{2}{2}\int_0^1 (-t)\,dt + \int_1^2 (1)\,dt \qquad -\frac{t^2}{2} \qquad t$

$= -\frac{1}{2}t^2 \Big|_0^1 + t \Big|_1^2$

$= -\frac{1}{2} + (2) - 1 = 0.5$

$A_n = \frac{2}{T}\int_0^1 (-t)\cos(2\pi n f_0 t)\,dt + \int_1^2 (1)\cos(2\pi n f_0 t)\,dt$

$= \int_0^1 (-t)\cos(\pi n t)\,dt + \int_1^2 (1)\cos(\pi n t)\,dt$

$= -\left\{\frac{1}{(\pi n)^2}\underbrace{\cos(\pi n t)}_{(-1)^n} + \cancel{\frac{1}{\pi n}}\underbrace{\sin(\pi n)}_{0} - \left(\frac{1}{(\pi n)^2}\underbrace{\cos 0}_{1} + \underbrace{0}_{0}\right)\right\} + \cancel{\frac{1}{\pi n}}\left(\underbrace{\sin 2\pi n}_{0} - \underbrace{\sin \pi n}_{0}\right)$

$-\frac{1}{(\pi n)^2}\left[(-1)^n - 1\right] + \frac{1}{\pi n}\sin(2\pi n)$

$A_n = -\frac{(-1)^n - 1}{(\pi n)^2} + \cancel{\frac{\sin(2\pi n)}{\pi n}}$

$\frac{-\cos(2\pi n) - 2}{\pi n}$

$\boxed{-1^n \cdot \frac{1}{\pi n}} \qquad \frac{1}{\pi n}\left(-\cos(2\pi n) + (-1)^n\right)$

$B_n = \frac{2}{T}\int_0^1 (-t)\sin \pi n t\,dt + \int_1^2 (1)\sin \pi n t\,dt$

$= (-1)\left[\frac{1}{(\pi n)^2}\sin \pi n t - \frac{t}{\pi n}\cos \pi n t\right]_0^1 + \left(\frac{-1}{\pi n}\cos \pi n t\right)\Big|_1^2$

$= (-1)\left[\cancel{\frac{1}{(\pi n)^2}\sin \pi n} - \frac{1}{\pi n}\underbrace{\cos \pi n}_{-1^n}\right) - \left(\cancel{\frac{1}{\pi n^2}\underbrace{\sin 0}_{0}} - \underbrace{0}_{0}\right)\Big] + \left(\left(\frac{-1}{\pi n}\right)\underbrace{\cos 2\pi n}_{1} - \underbrace{\cos \pi n}_{(-1)^n}\right)$

$B_n = \frac{(-1)^n}{\pi n} - \frac{1}{2\pi n} + \frac{(-1)^n}{\pi n}$

$\left(\frac{-1}{\pi n}\right)(-1^n) + \left(\frac{-1}{\pi n}\right)(1 - (-1)^n) \qquad \frac{-1}{\pi n}(-1^n + 1$

$x(t) \quad \frac{3/2}{2} + \sum_{n=1}^{\infty}\left[\frac{(-1^n)}{(\pi n)^2} + \frac{\sin(2\pi n)}{(2\pi n)}\right]\cos(\pi n t) + \left[\frac{(-1)^n}{\pi n} - \frac{1}{(2\pi n)} + \frac{(-1)^n}{\pi n}\right]\sin(\pi n t$

Fig. 9.

Fig. 10. Calculation of fourier series