Report for Fall 2020 EE 343L Lab Assignment 0

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Abstract:
In this lab, we perform various experiments with signals using MATLAB, including the implementation of a signal energy function, and the plotting of an amplitude modulated signal (AM) and a frequency modulated signal (FM). Our group was successful in performing these tasks and were able to familiarize ourselves with using MATLAB as a result of this lab.

1 Introduction

From this introductory lab session, we familiarized ourselves with using Matlab to create, plot, and analyze different types of signals. The tasks consisted of experiments involving the power and energy of signals as well as AM and FM signals.

In this report, Section 2 will discuss the Matlab parts of the lab tasks, how they were implemented, and the results. Section 3 will discuss the questions that were asked in the lab. Section 4 will contain our conclusions.

2 Matlab Tasks

Task 2A

The first Matlab task asked us to implement a function that calculates the energy of a signal using a vector (representing the signal) and sampling interval as arguments. The signal energy equation is shown in Figure 1, and our implementation of it using MATLAB is shown in Figure 2.

$$E_g = \int_{-\infty}^{\infty} |g(t)| dt$$

Figure 1. Signal energy equation

```
function e = energy(x, dt)
    e = sum(x .^ 2 * dt);
end
```

Figure 2. MATLAB implementation of a signal energy function

A small script was written to test this function, which seems to correctly calculate the energy of an example sinusoidal signal over 1 second. The code and output of the script is shown in Figure 3.

```
t = (0:0.001:1)'; % 0 to 1s
x = sin(2 * pi * 50 * t) + sin(2 * pi * 150 * t);  % sample sinusoid signal

fprintf('\nenergy => %f', energy(x, 0.001));

function e = energy(x, dt)
      e = sum(x .^ 2 * dt);
end
```

```
energy => 1.000000
```

Figure 3. Task 2A Script

Task 3A

Our second MATLAB task was to write and plot the following AM signal from 0 to 0.15 seconds with a sampling interval of 0.0001.

(a) Consider the message signal $m(t) = \sin(14\pi t)$. Plot the signal

$$x(t) = \Big[1 + .25m(t)\Big]\cos(2\pi f_c t) \qquad f_c = 250\text{Hz}.$$

Figure 4. Task 3A Prompt

We were able to successfully create this signal in MATLAB and plot the results with the following script in Figure 5.

```
t = (0:0.0001:0.15)';
m = sin(14 * pi * t);
x_1 = cos(2 * pi * 250 * t);
x = (1 + 0.25 * sin(14 * pi * t)) .* cos(2 * pi * 250 * t);

plot(t, x)
```

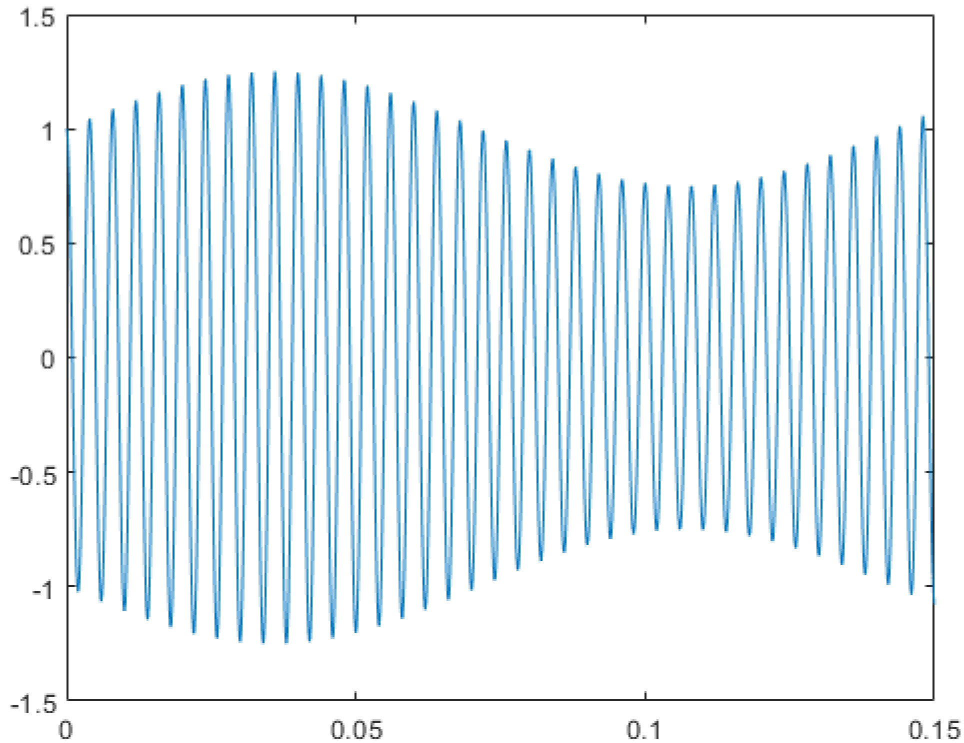

Figure 5. Task 3A MATLAB Script and Plot

For AM (or amplitude modulation) signals, the amplitude of the signal changes over time according to the message signal, which is shown correctly in this graph.

Task 3B

Our last MATLAB task was to write and plot the following FM signal from 0 to 0.15 seconds with a sampling interval of 0.0001. Implementing the message signal required the use of the built-in "piecewise" function from MATLAB.

(b) Consider the message signal

$$m(t) = \begin{cases} 1 & 0 \leq t \leq .05 \\ -2 & .05 \leq t \leq .1 \\ 0 & .1 \leq t \leq .15. \end{cases}$$

Consider the transmitted signal

$$x(t) = A\cos\left(2\pi f_c t + 2\pi k_f \int_{-\infty}^{t} m(\tau)d\tau\right)$$

where $A = 1$, $f_c = 180$ Hz, and deviation constant $k_f = 50$.

Figure 6. Task 3B Prompt

We were able to successfully write a script shown in Figure 7 that implements and plots this FM signal.

```
syms m(t_)

f = 0.0001;
t = (0:f:0.15)';
mt(t_) = piecewise(0 <= t_ <= 0.05, 1, 0.05 <= t_ <= 0.10, -2, 0.10 <= t_
<= 0.15, 0);
m = mt(t);
x = cos((2 * pi * 180 * t) + (2 * pi * 50 * cumsum(m) * f));

plot(t, x);
```

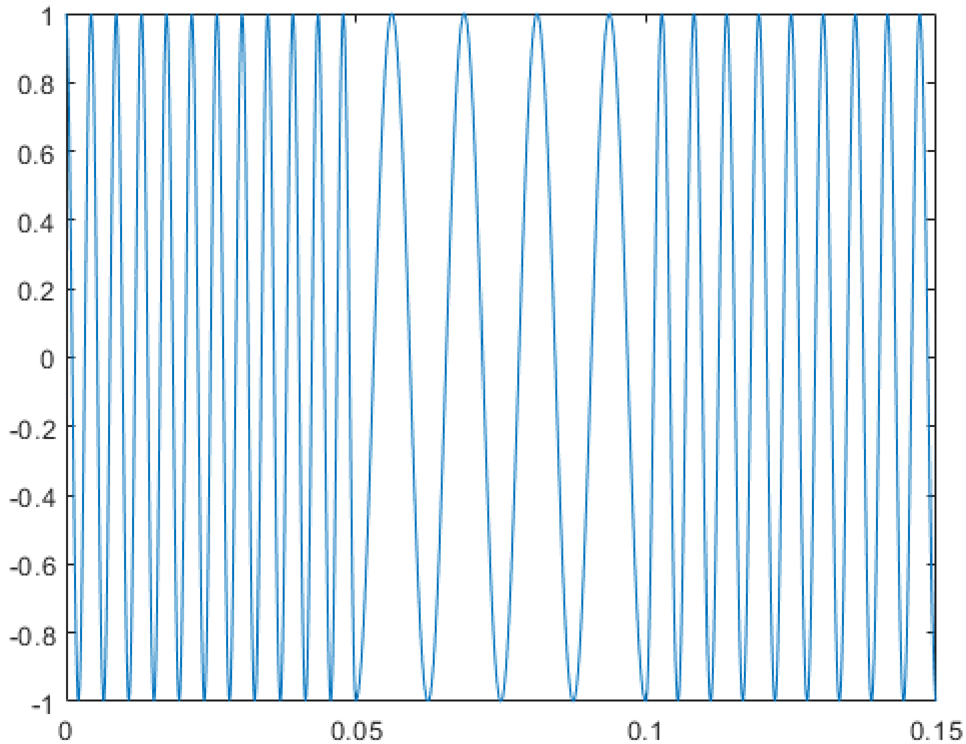

Figure 7. Task 3B MATLAB Script and Plot

In FM (or frequency modulation) signals, the frequency of the signal changes according to the message signal. This can be seen in this graph, by the variation of frequency in different parts of the sine wave.

3 Questions

Some tasks in this lab required a written response. This section will attempt to discuss each of these tasks.

Task 2B

In Task 2B we were asked to show that the given function correctly calculates the average power of an energy signal:

```
function p=spower(x)
p=(norm(x)^2)/length(x);
```

Figure 8. MATLAB Signal Power Function

In MATLAB, the norm function calculates the magnitude of a given vector. Squaring this gives us the summation of the squares of each component of the vector. Since we only deal with discrete values in MATLAB, this summation is equivalent to the integral needed in the signal power equation.

$$|\bar{x}|^2 = \left(\sqrt{x[1]^2 + x[2]^2 + \dots + x[n]^2}\right)^2$$

$$= x[1]^2 + x[2]^2 + \dots + x[n]^2$$

$$|\bar{x}|^2 = \sum_{k=1}^{n} x[k]^2$$

For energy signals, the energy is finite and since average power is calculated over an increasingly large interval that eventually approaches infinity, the computed average power will eventually approach 0.

4 Conclusion

Our lab group was successful in performing all the tasks in this introductory lab with minimal technical difficulty. From this lab, we were able to familiarize ourselves with MATLAB as well as learn to implement the signal energy equation, create and plot different types of signals such as AM and FM signals, and demonstrate an understanding of the theory used to complete these tasks.