MEMO Number CMPE323-Lab02
DATE: August 31, 2016
TO: CMPE323
FROM: EFC LaBerge
SUBJECT: Sinusoids, Time Delays, Time Scaling

1 INTRODUCTION

We have been talking about time functions, including common time functions like e^{-at}, $\cos(\omega t)$, $\sinh(\omega t)$ and specialized functions like $\delta(t)$, $u(t)$, $p(t;T) = u(t) - u(t-T)$, etc. MATLAB has virtually any common function you might encounter as a built-in function. We can, and should, and will use the anonymous function capability in MATLAB to build the specialized functions. Remember from previous labs, that sampling is important.

2 EQUIPMENT

For this lab, you need a laptop with MATLAB installed.

For the purpose of CMPE323, please use the following naming conventions for all output files:

CMPE323F17_Lab<Lab#>_<Your Campus ID>

For the purpose of CMPE323, please use the following naming conventions for MATLAB scripts or functions that you are required to submit.

<function name>_<Your Campus ID>

Examples will be given in the lab description. Follow the instructions exactly, or you may not get graded!

3 LAB TASKS

You might find it useful to use the MATLAB function `diary` to capture your inputs and outputs.

3.1 Time Delays with Sinusoids

3.1.1 Complicated Sinusoid

Use an anonymous function to create the Double Sideband Amplitude Modulated (DSB-AM) waveform used in the previous lab:

$$x(t) = 1 + 0.25\sin(180\pi t) + 0.15\sin(300\pi t) + 0.4\sin(2040\pi t) \tag{1}$$

Using this as your function, use MATLAB to show that a time delay corresponds to a *frequency-dependent* phase shift in each of the components. If this signal was the input to an LTI system, how could you demonstrate this on a piecemeal bases?

By *frequency dependent,* we mean that the phase shift for the 90 Hz, 150 Hz and 1020 Hz terms will be *different* for a fixed time delay. *Hint: Choose something like time delay of one-third of a cycle on the 1020 Hz term.*

3.1.2 Complex Exponential

Use MATLAB to demonstrate that a phase shift of a complex exponential $e^{j\omega t}$ to $e^{j(\omega t \mp \theta)}$ is equivalent to a time delay or advance. (You can assume an angular frequency $\omega = 10 \text{ rad/s}$.) That is, show that we get the same waveform by shifting the (constant) phase or by delaying the frequency-dependent part of the complex exponential. Make sure you use professional practices on your plots.

3.1.3 Time scaling

Use MATLAB and the real part of your complex exponential to demonstrate that time scale compression ($a > 1$) and time scale expansion ($a < 1$) are equivalent to a change in frequency, or, equivalently, changing the period. That is, we get the same function and plot by compressing or expanding the time scale or by changing the frequency. Derive an expression relating the new frequency, ω_N, and the old frequency, ω_0, in terms of the time scaling factor a. Provide your expression and demonstrate demonstrate that this relationship holds in your plots.

3.2 L? TI? Causal

Create the following MATLAB variables

b = [0.0201 0.0402 0.0201]
a = [1.0000 -1.5610 0.6414].

The MATLAB function `filter(b,a,x)` will use `b` and `a` to create a system that takes an input array `x`, representing $x(t)$ and returns an output array `y`, representing $y(t)$. We will use `filter(b,a,x)` often in the latter portions of the course.

Determine the impulse response of this system. Then, using your pulse anonymous function, create several experiments to determine if the system described by `b` and `a` has the properties of being linear, time invariant, and causal. *Hint: If you want to input a delta function, set x(t=0) to 1 and all other samples to zero.*

You will have multiple plots. Explain what the plots mean and why they demonstrate L, TI, or C properties. Please be explicit in your descriptions; convince me that you understand the concepts.

Note: A demonstration using MATLAB or equivalent is <u>not</u> a mathematical proof.

4 LAB SUBMISSIONS

Submit the following via the Blackboard assignment Lab 3.

Use this Word document to format your answers. You may copy the content of Sections 1 and 2, and use the outline of Section 3 to organize your plots and any discussion. You should make at least brief statements describing each plot and what you learned. You should answer the questions in the section in which they occur.

Your Word document should include the following:

a. The outputs generated in 3.1.1

b. The outputs generated in 3.1.2

c. The outputs generated in 3.1.3

d. The plots generated in 3.2 and any discussion.

e. Answers to all of the questions.

f. Relevant discussions as requested, or as you deem necessary for clarity.

Some extra credit points will be available in the Blackboard rubric for exceptional work, such as extra plots or discussions displaying extra insight.