CMPE 323: Signals and Systems

Dr. LaBerge

Lab 02 Report:

Sinusoids, Time Delays, Time Scaling

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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.

2. Equipment

A computer with MATLAB installed.

3. Time Delays with Sinusoids

3.1 Complicated Sinusoid

Create a Double Sideband Amplitude Modulated (DSB-AM) waveform given by the equation:

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

Nyquist Rate = $2 * \text{highest relevant frequency}, \frac{2040\pi}{2\pi} = 2040\ \text{Hz}$

Simulating with a sample rate of 100 times the Nyquist Rate:

$$100 \times 2040 = 204000\ Hz = 204\ kHz$$

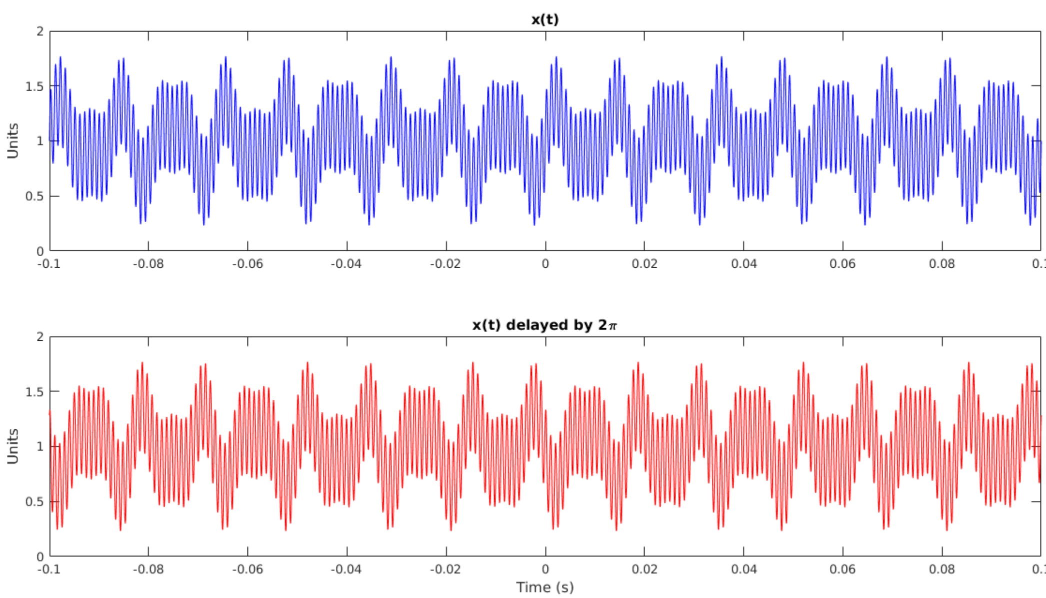

Figure 1: x(t) with a 2π Delay Demonstrating a Time Delay Corresponding to a Frequency Dependent Phase Shift

Create a Double Sideband Amplitude Modulated (DSB-AM) waveform is made up of 3 individual linear, time invariant functions.

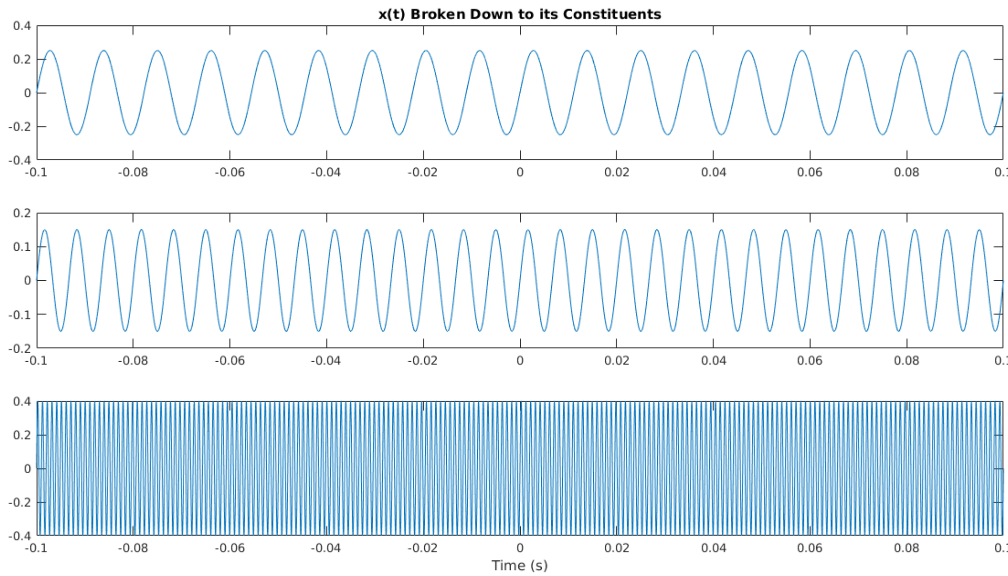

Figure 2: x(t) Broken Down to its Constituent Functions

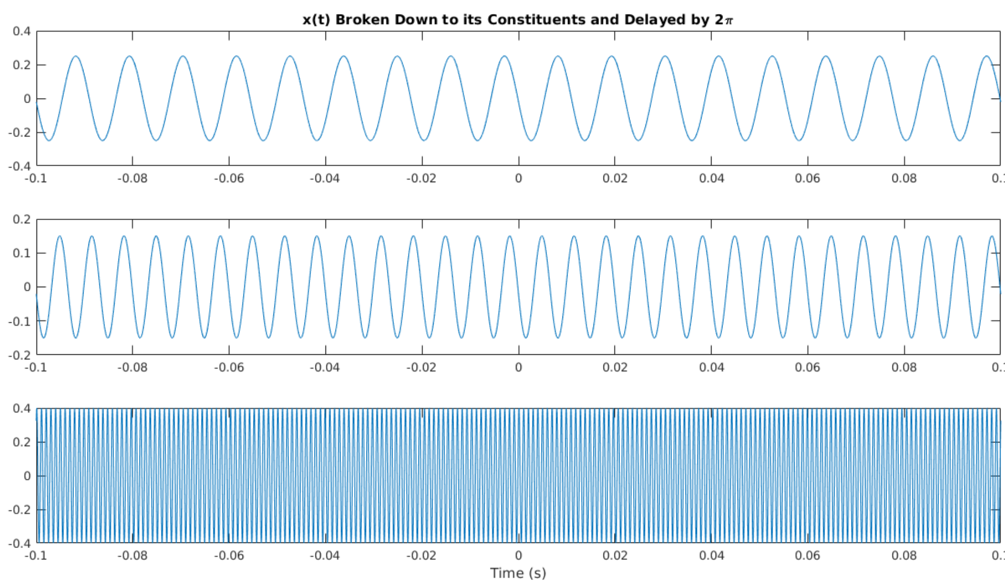

Figure 3: x(t) with a 2π Delay Broken Down to its Constituent Functions

3.2 Complex Exponential

Plotting a complex exponential with both its real and imaginary parts would create a circular function, which would not be useful for demonstrations of phase shifts and time delays. The following were plotted using the real values of the function against the time domain. ω is initialized at 100 Hz.

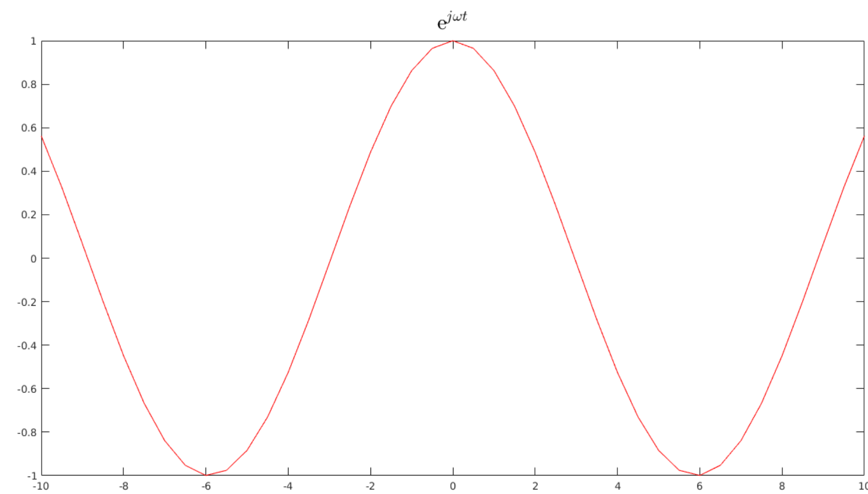

Figure 4: Complex Exponential with 100 Hz Frequency

To convert a periodic function from its cycles to frequency, we use the relationship $T = \frac{1}{f}$, where T and f represent period and frequency respectively.

$$e^{j\omega t + 2\pi} = e^{j\omega\left(t + \frac{2\pi}{j\omega}\right)}$$

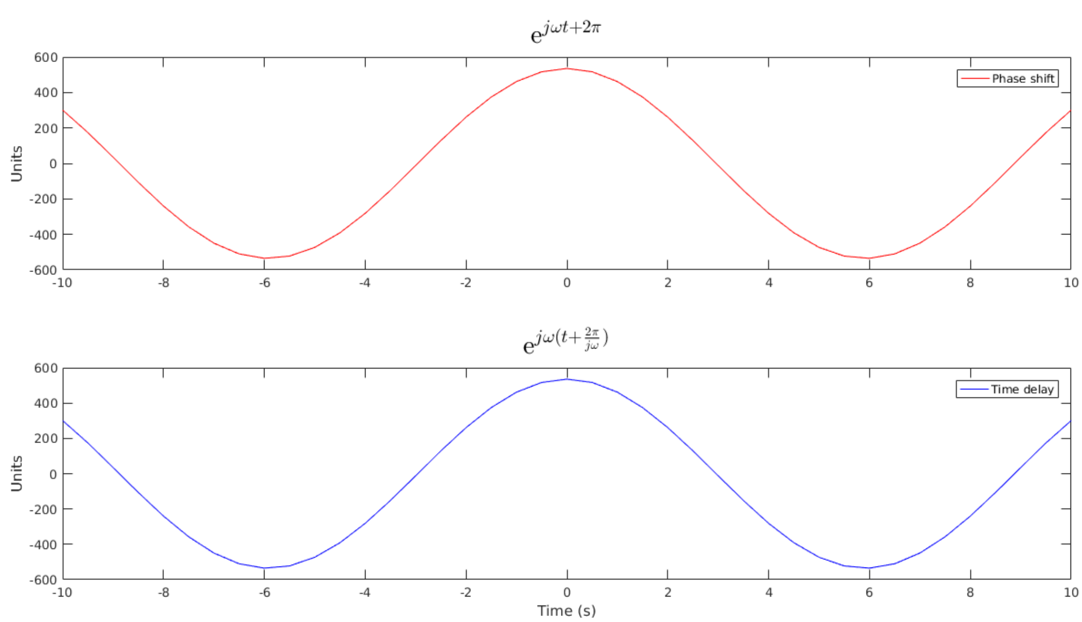

Figure 5: Complex Exponentials with a Phase Shift of 2π and Time Delay of $\frac{2\pi}{j\omega}$

3.3 Time Scaling

Using the same complex exponential, the equivalence of scaling the time domain and the frequency can also be demonstrated. ω is initialized at 100 Hz.

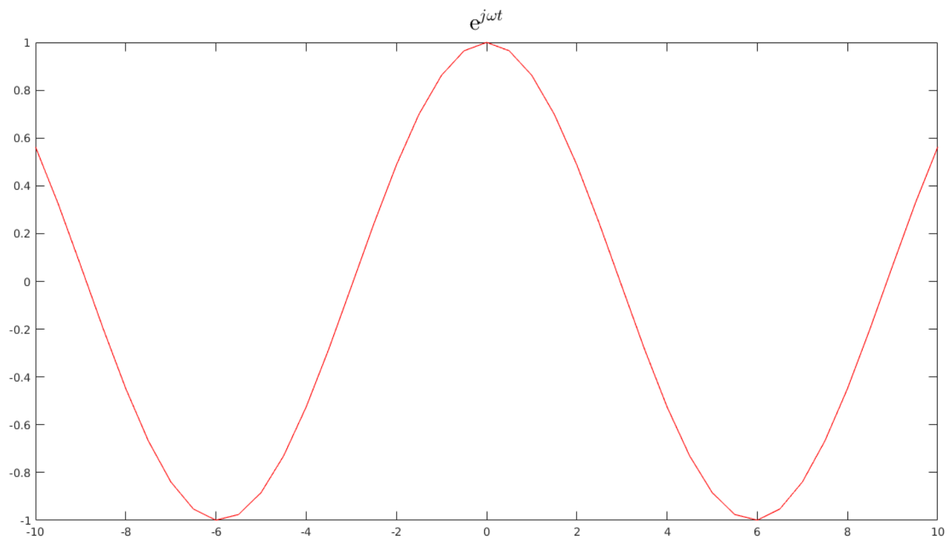

Figure 5: Complex Exponential with 100 Hz Frequency

The frequency is then adjusted to correspond with the scaling of the time domain. Initializing a, the scaling factor, at 0.1, the new frequency is obtained by $\omega_N = a \times \omega_o$

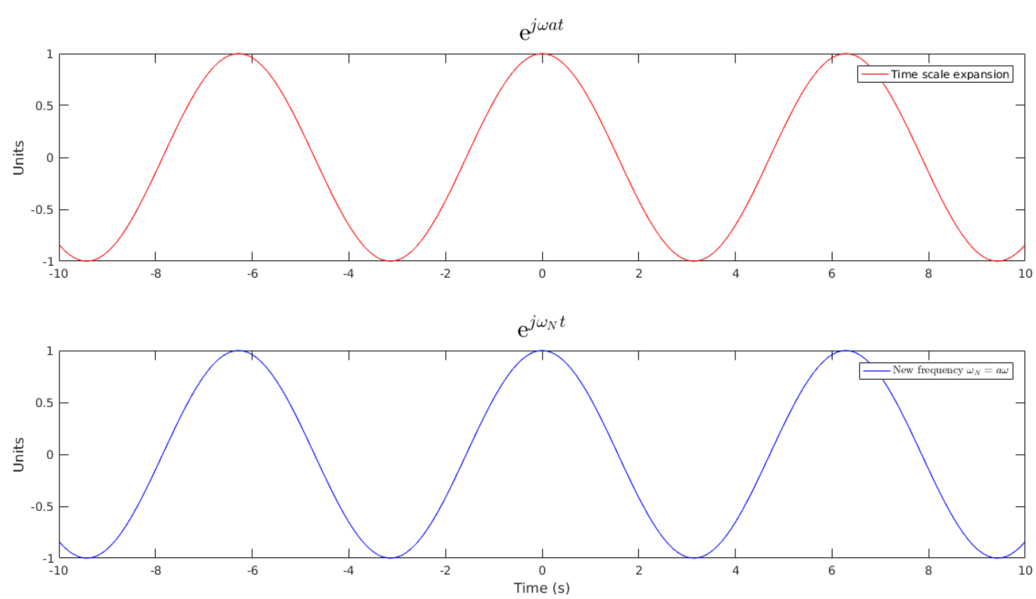

Figure 6: Complex Exponential with Time Scale Expansion and Changed Frequency