Lab 2

To: Ross Snider
From: Anthony Louis Rosenblum
Regarding: Lab 2
Date: January 18th, 2019

Summary

In the sections covered by this lab report I examined the summation of sinusoids as complex exponentials and also enjoyed a new experience learning how to design functions in MATLAB.

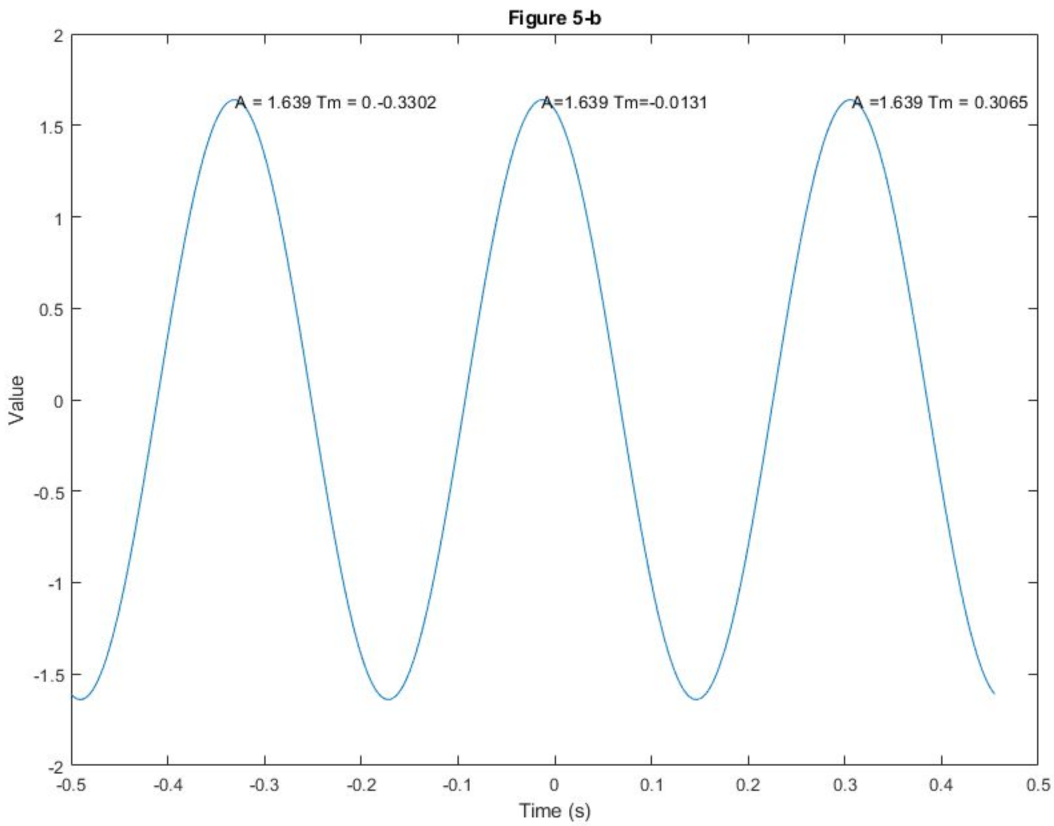
Main Body

Section 5)

Syn_sin function and function call:

```
function [xx,tt] = syn_sin(fk, Xk, fs, dur, tstart)
if nargin<5, tstart=0, end %--default value is zero
tt = tstart:1/fs:(tstart+dur);
j = sqrt(-1);
fk = fk*2*pi;
p = fk' * tt *j;
xx = real(Xk * exp(p))
subplot(2,1,1),plot(tt,real(xx))
subplot(2,1,2),plot(tt,angle(xx))
end
```

```
fk = [pi,pi,pi];
Xk = [2,2*exp(-1j * pi * 1.25),1-1j];
tstart = -0.5;
dur = (3 / pi);
[xx,tt] = syn_sin(fk, Xk, 10000, dur, tstart);
plot(tt,xx), xlabel('Time (s)'), ylabel('Value'),title('Figure 5-b'),
text(-0.3302,1.639,'A = 1.639 Tm = 0.-0.3302'), text(0.3065,1.639, 'A
=1.639 Tm = 0.3065')
```



Plot generated by the syn_sin function

5-b and 5-c:

After calculating the values of frequency, amplitude, and phase shift by hand after reading from the data cursor they were verified by the phasor addition theorem in MATLAB.

$$\text{Frq} = \frac{1}{\text{Per}} = \frac{1}{(0.3065 + 0.0131)} = 3.129 \text{ hz}$$

Amplitude = 1.639

$$\text{Phase: } \frac{(0 + 0.0131)}{(0.3065 + 0.0131)} = 0.0410 \rightarrow \cdot 2\pi \rightarrow +0.258 \text{ radians}$$

```
amp =

    1.6390

phase =

    0.2555
```

Phasor Addition in MATLAB:

```
%% 5-c
t = -0.5:1000:3/pi-0.5;
x1 = 2*exp(j*pi*t);
x2 = 2*exp(-1j * pi * 1.25) * exp(j*pi*t);
x3 = (1-1j)* exp(j*pi*t);

x4 = real(x1) + real(x2) +  real(x3)
x5 = imag(x1) + imag(x2) +  imag(x3)

amp = sqrt((x4)^2 + (x5)^2)
phase = atan(-x4/x5)
```

Section 6:

6-a:

Expression for direct signal delay:

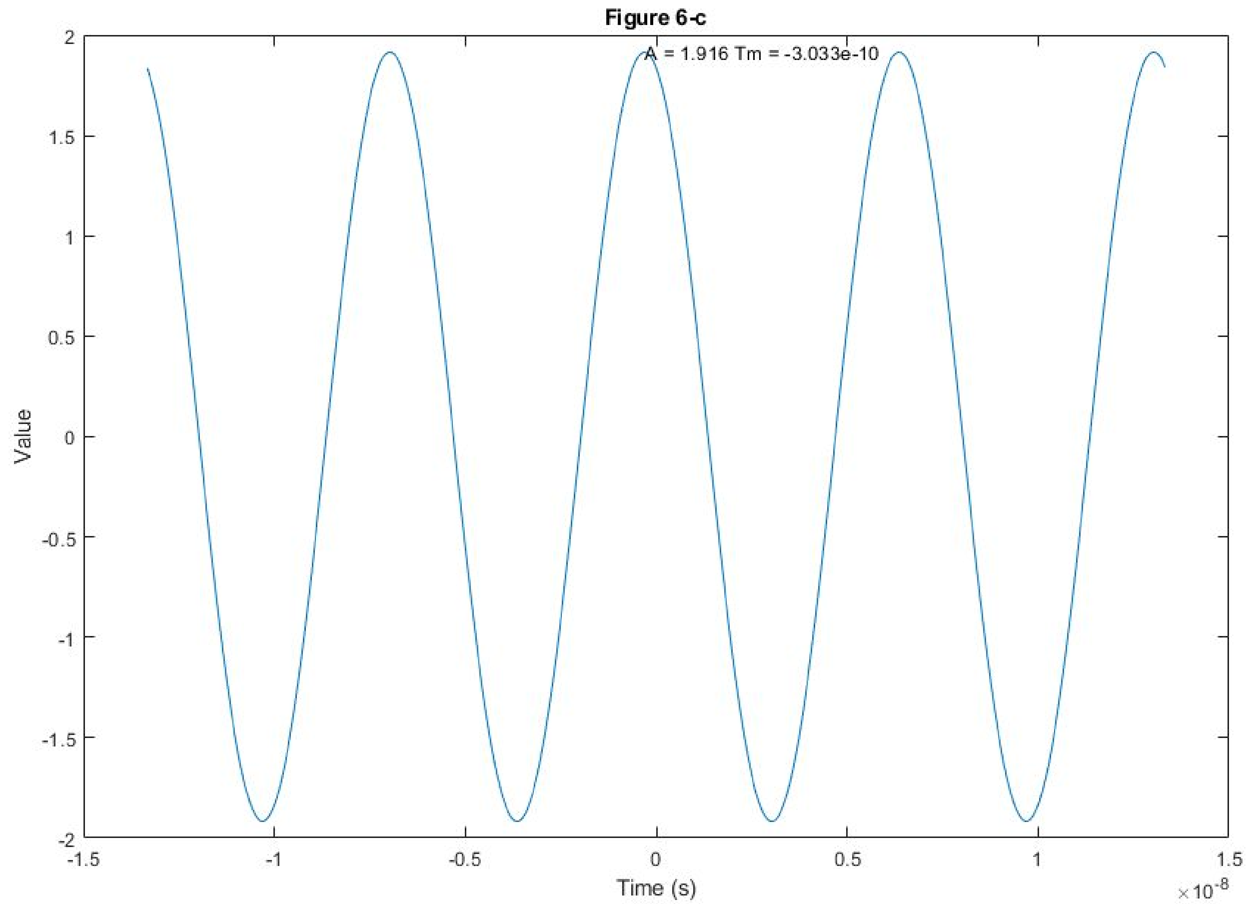
```
function[xx]= direct(yt,xv)
    xx = sqrt((yt)^2 + (xv)^2) / (3 * 10^8);

end
```

6-b:

Expression for reflected signal delay:

```
function[xx2] = bounce(dt,bx,by,xv)
    step = sqrt((dt-by)^2 + (bx)^2) + sqrt((bx-xv)^2 + (by)^2);
    xx2 = step / (3 * 10^8);
end
```

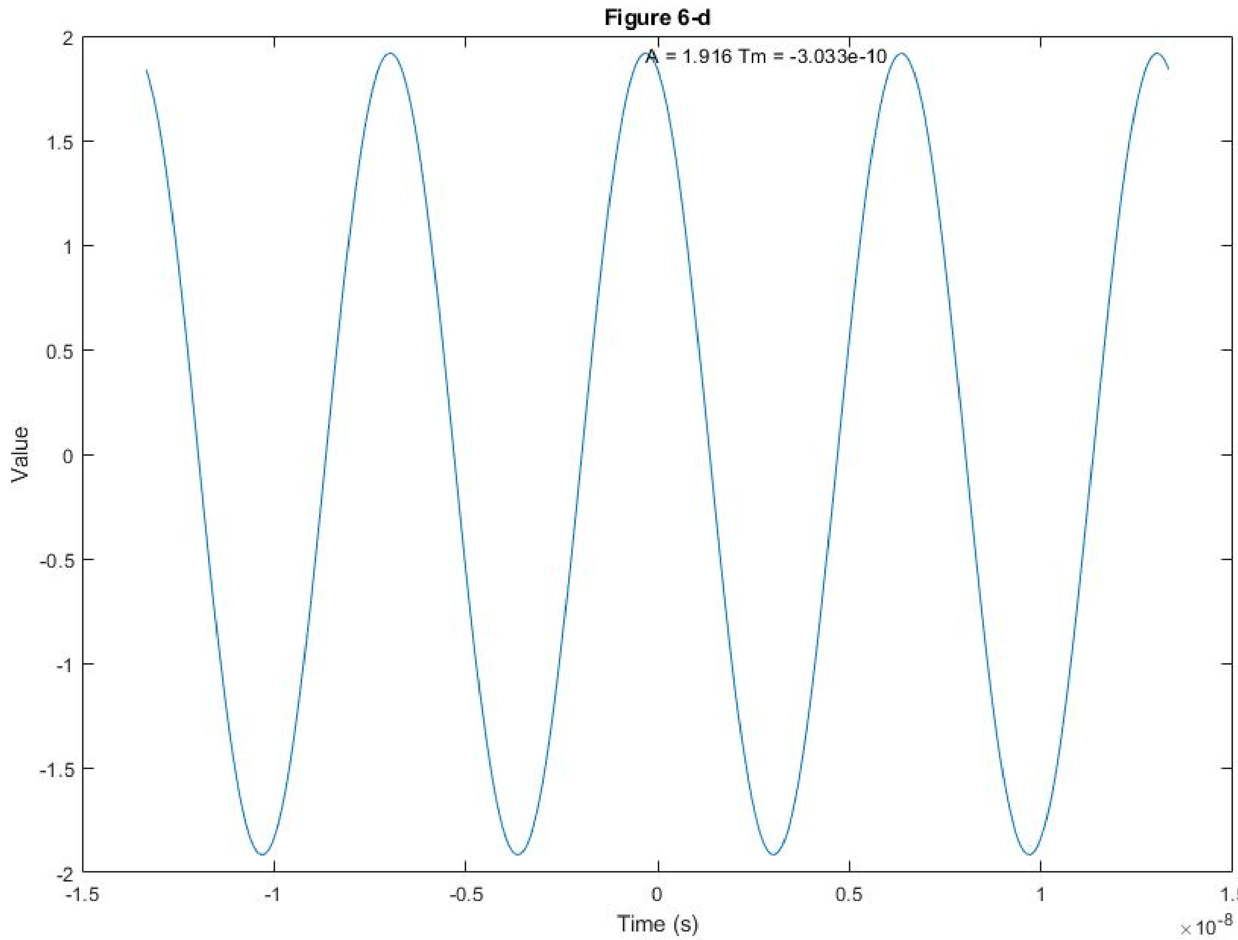


Signal received by stationary vehicle at 0 meters X

6-d)

Complex Exponential Representation

```
r = exp(-t1/per*2*pi*j)*exp(w*tt*j) +
exp(-t2/per*2*pi*j)*exp(w*tt*j);
```



Signal received by stationary vehicle at 0 meters X from complex exponential representation

6-e:

Function to calculate signal strength based on vehicle position

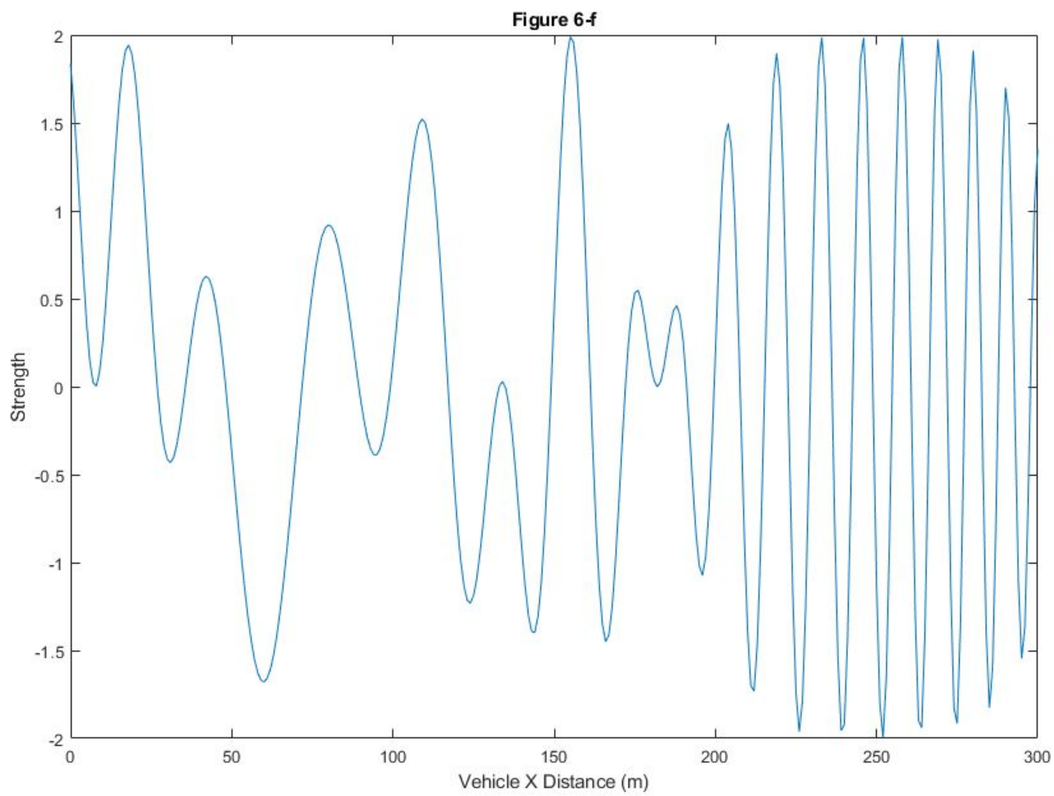
```
function[xx3,t1,t2] = go(xv)
    t1 = sqrt((1500)^2 + (xv).^2) / (3 * 10^8);
    step = sqrt((1500-900)^2 + (100)^2) + sqrt((100-xv).^2 +
(900)^2);
    t2 = step / (3 * 10^8);

    f = 150 * 1000000;
    per = 1/f;
    w = f * 2 * pi;
    tt = -10*per:1/100000000000:10*per;
```

```
    xx3 = exp(-t1/per*2*pi*j).*exp(w*xv*j) +
exp(-t2/per*2*pi*j).*exp(w*xv*j);
end
```

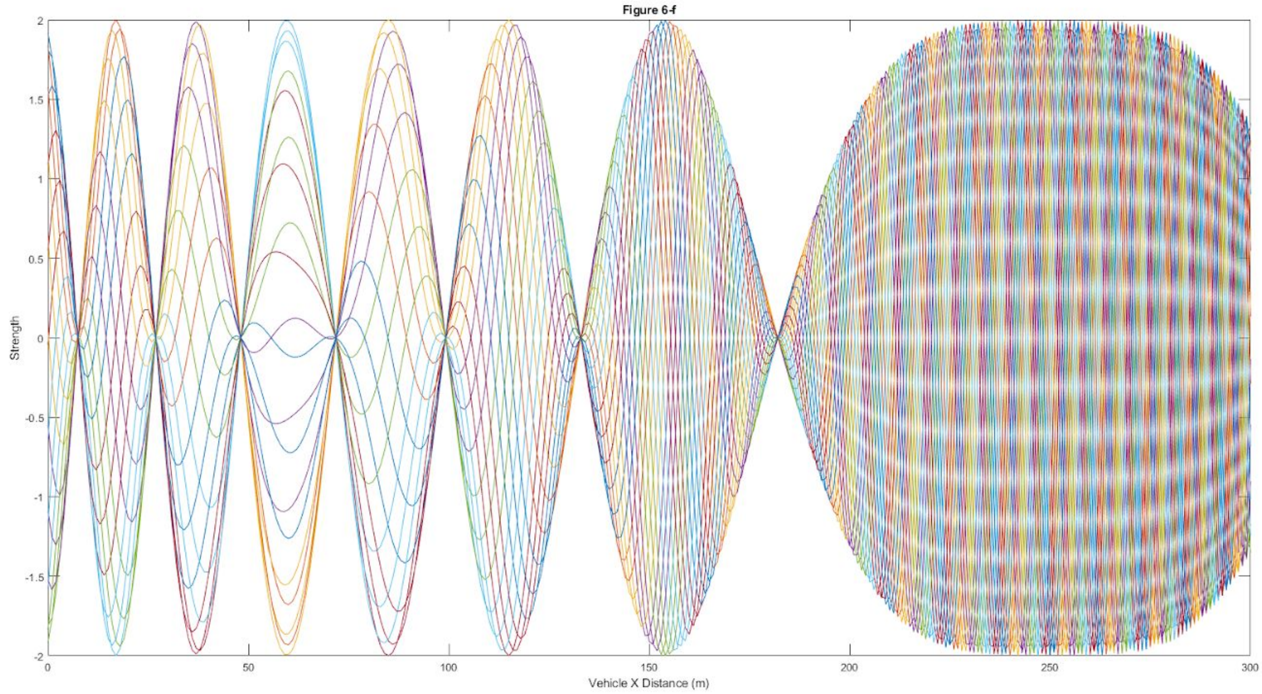
6-f:

Assuming the vehicle was going one meter per second, I chose to replace the time variable in the exponential calculation with the vehicle distance vector. This resulted in the following plot:



The peak signal strength I picked up was 1.989 at 155 meters by taking the real part of the complex exponential.

However the signals the vehicle receives is based on time measured via the time delay calculated through the opposing distances. So when replacing the vehicle distance with time as the dependent variable in the complex exponentials I received the following plot:



6-g:

The peak signal strength I picked up was 1.989 at 155 meters. At 8 meters the signal strength was zero. The signal was also almost zero at 182 meters. So yes, it seems it is possible to entirely cancel out the signal at certain points along the road.

Conclusion

It is more efficient to use vector calculations in MATLAB than to use for loops. Vector multiplications can be performed using prime matrices. The strength of radio signals can vary despite having the same frequency if they are received from two different paths and then summed. Radio signals can be effectively canceled at certain positions. The phenomenon shown in section 6 helped me understand how signals can be used for vessels to triangulate their position based on two reference points.