Lab 2

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Regarding: Lab 2
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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

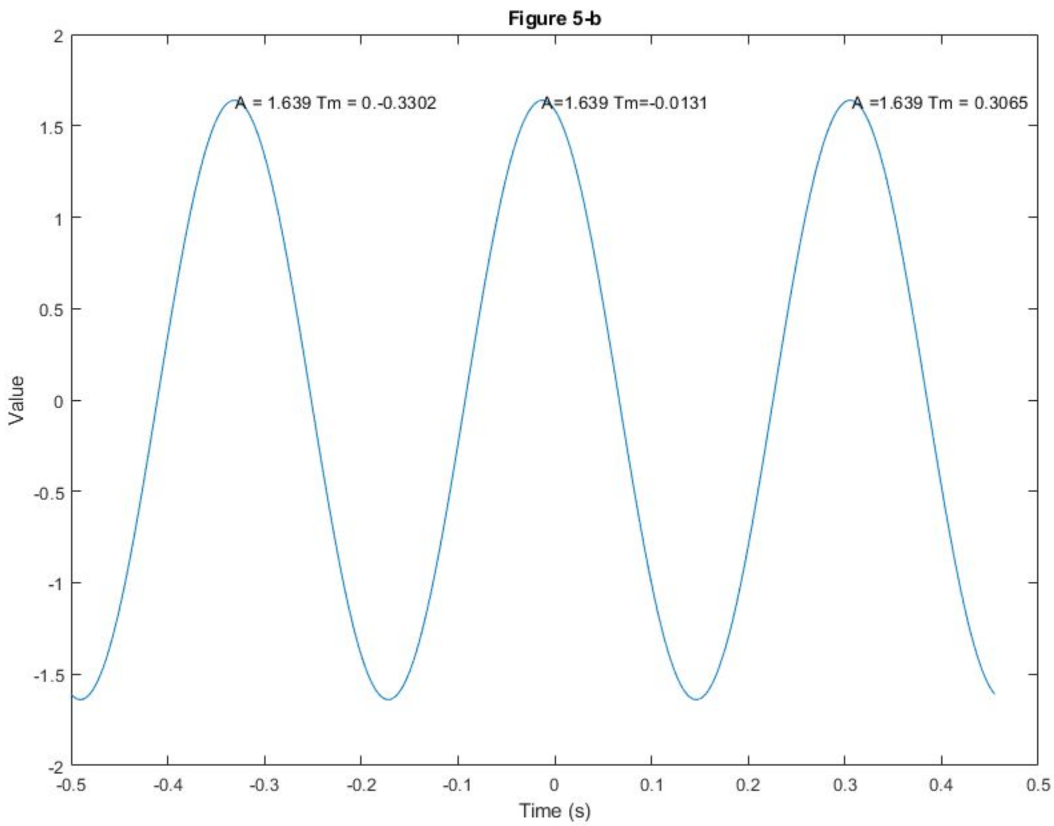
Section 5)

5-a)
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)

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
```

5-c)

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:

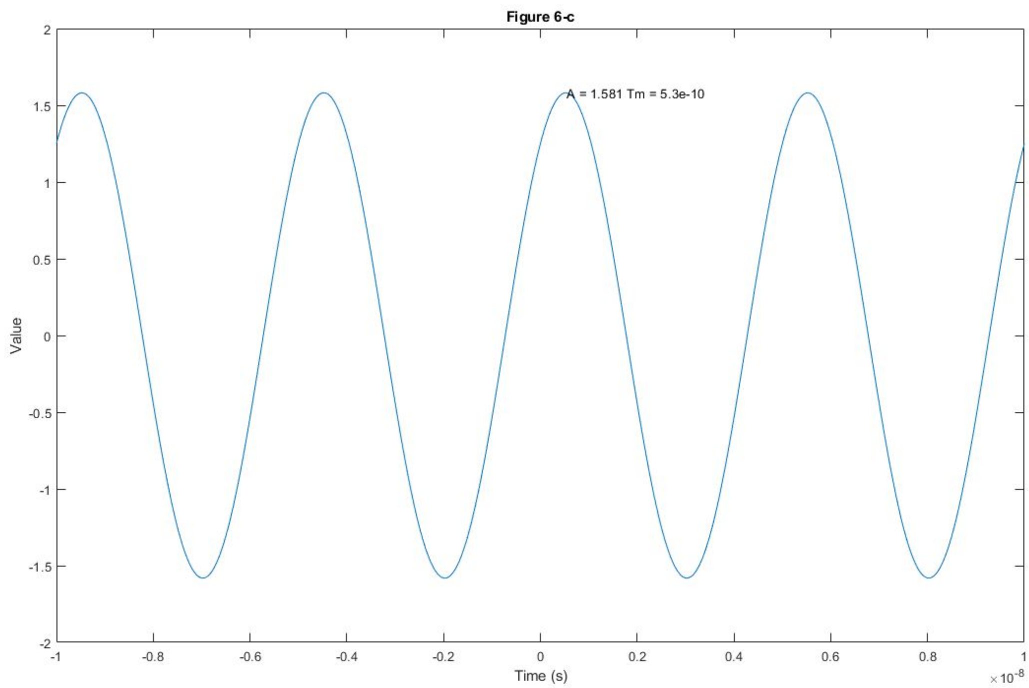
```
function[xx]= direct(yt,xv)
    xx = sqrt((yt)^2 + (xv)^2) / (3 * 10^8);

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
```

6-c:

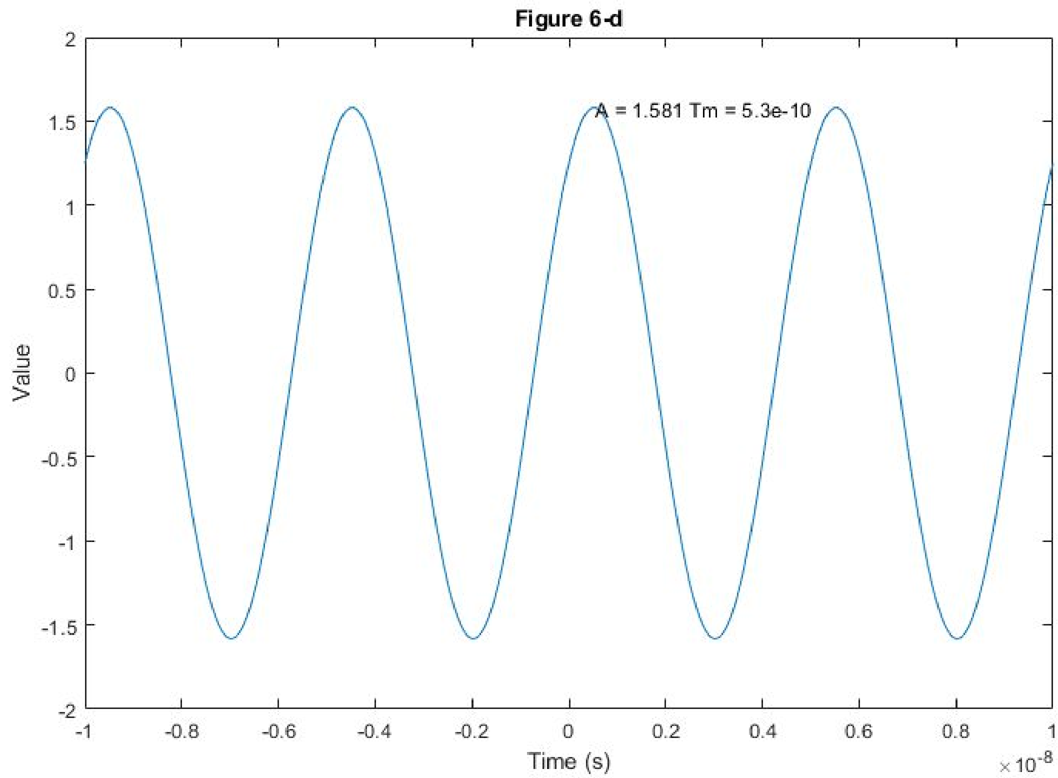


Signal received by stationary vehicle at 0 meters X

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:

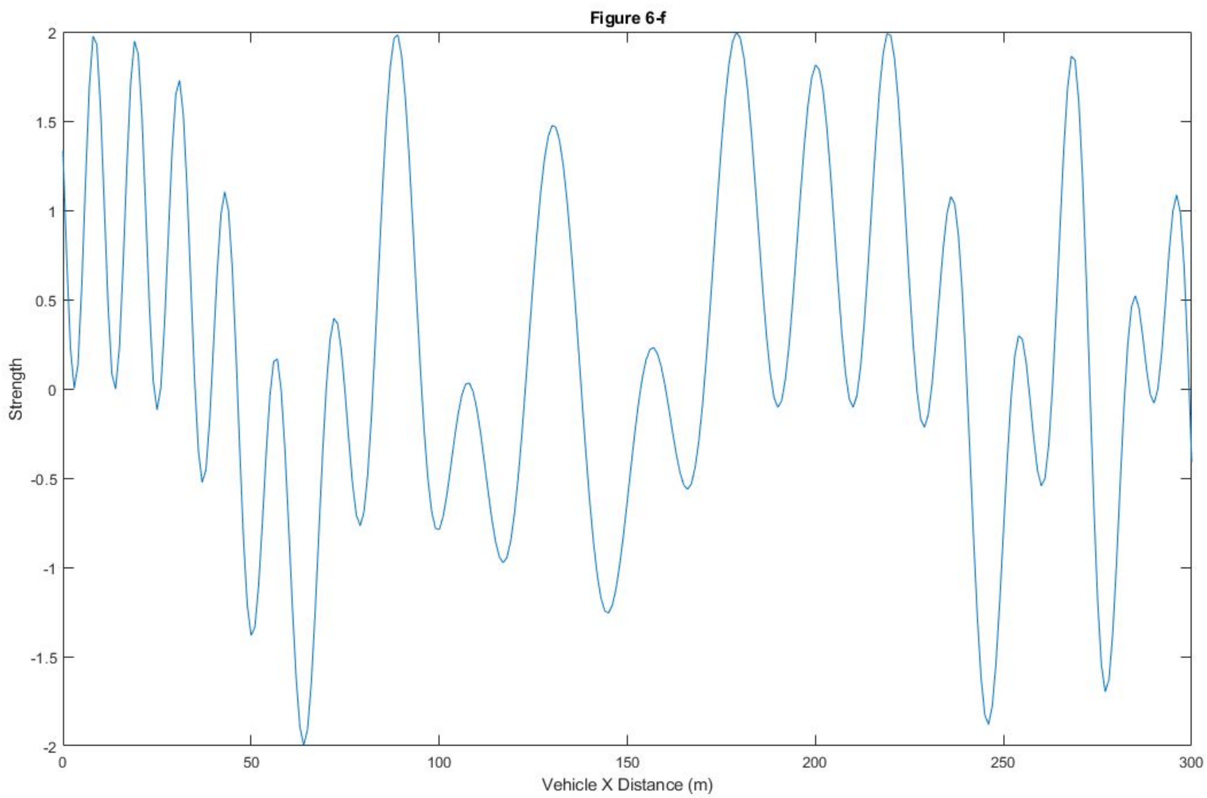
Function to calculate signal strength based on vehicle position

```
function[xx3,t1,t2] = go(xv)
    t1 = sqrt((2000)^2 + (xv).^2) / (3 * 10^8);
    step = sqrt((2000-1000)^2 + (200)^2) + sqrt((200-xv).^2 +
(1000)^2);
    t2 = step / (3 * 10^8);

    f = 200 * 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:



Combined signal as the car drives east

The peak signal strength I picked up was 1.997 at 179 meters by taking the real part of the complex exponential.

6-g:

The peak signal strength I picked up was 1.997 at 179 meters. At 3 and 14 meters the signal strength was effectively zero. 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.