Assignment

ASSIGNMENT # 2

Prepared by: **MUHAMMAD FAIZAN (飞赞)**

Roll Number: **M202161026**

School of Computer and Communication Engineering

University of Science and Technology Beijing

Submitted to: **Du Bing (杜冰)**

Subject: **Broadband Wireless Communication**

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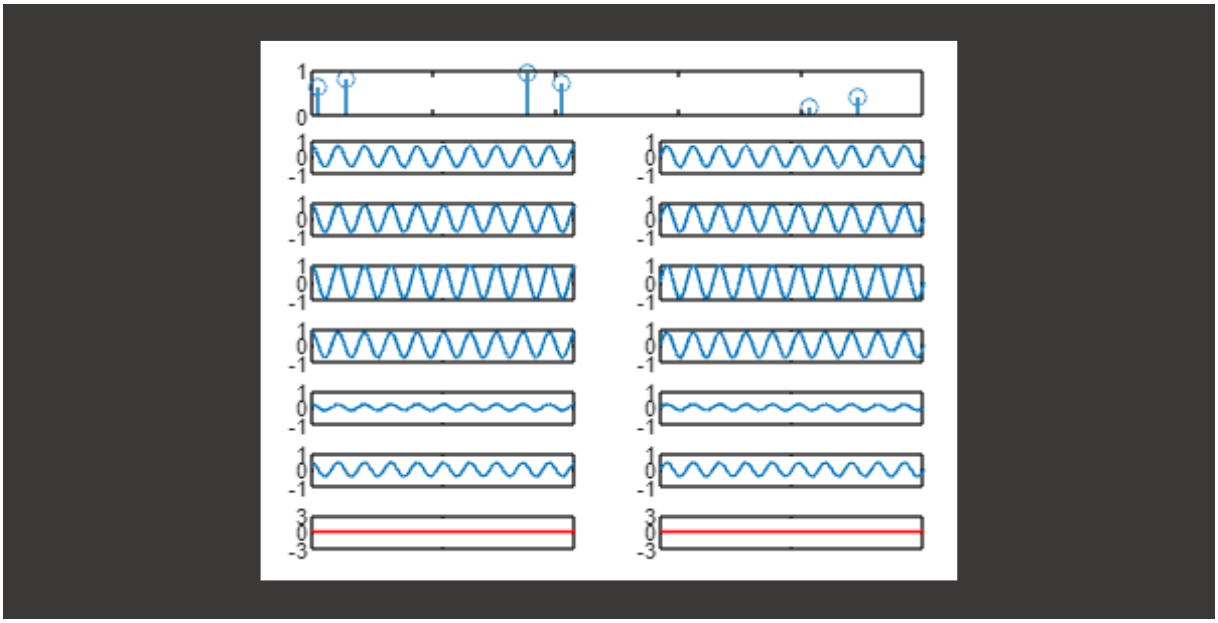
Code:

```
a=[0.6154 0.7919 0.9218 0.7382 0.1763 0.4057];

tau=[0.0099 0.0579 0.3529 0.4103 0.8132 0.8936];

t = 0:1/100:2;

w = 5;

N_path = length(tau);

exp_iwt_sum = zeros(1,length(t));

subplot(N_path + 2,2,[1 2]);


stem(tau,a);set(gca,'ytick',[0 1]);set(gca,'xticklabel',[]);

for d=1:1:N_path

exp_iwt = a(d) .* exp(j .* 2 .* pi .* w .* (t .- tau(d)) );

exp_iwt_sum += exp_iwt;

subplot(N_path + 2,2,2*d+1);

plot(t,real(exp_iwt));      xlim([0      2]);ylim([-1      1]);
set(gca,'xticklabel',[]);

set(gca,'ytick',[-1 0 1]);

subplot(N_path + 2,2,2*d+2);

plot(t,imag(exp_iwt));      xlim([0      2]);ylim([-1      1]);
set(gca,'xticklabel',[]);

set(gca,'ytick',[-1 0 1]);

end


d = N_path + 1;

subplot(N_path + 2,2,2*d+1);

plot(t,real(exp_iwt_sum),'r-');   xlim([0   2]);ylim([-3   3]);
set(gca,'xticklabel',[]);

set(gca,'ytick',[-3 0 3]);

subplot(N_path + 2,2,2*d+2);

plot(t,imag(exp_iwt_sum),'r-');   xlim([0   2]);ylim([-3   3]);
set(gca,'xticklabel',[]);

set(gca,'ytick',[-3 0 3]);
```

Output:

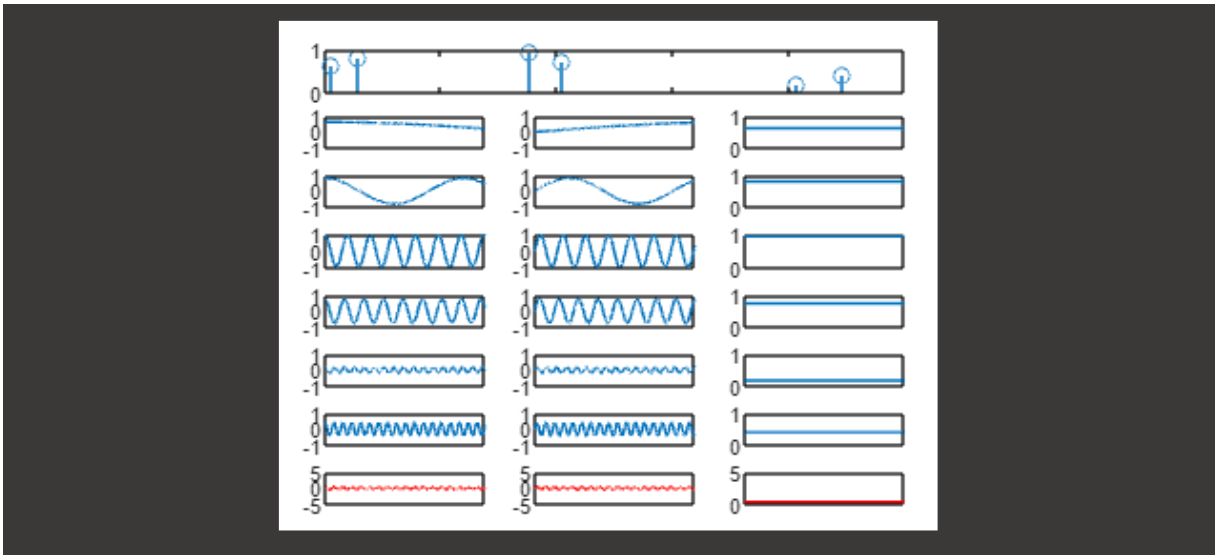


Code:

```
a=[0.6154 0.7919 0.9218 0.7382 0.1763 0.4057];

tau=[0.0099 0.0579 0.3529 0.4103 0.8132 0.8936];

w = 0:pi/100:40*pi;

wmax = max(w);

N_path = length(tau);

Hw_sum = zeros(1,length(w));

subplot(N_path + 2,3,[1 3]);

stem(tau,a);set(gca,'ytick',[0 1]);set(gca,'xticklabel',[]);

for d=1:1:N_path

Hw = a(d) .* exp(j * w * tau(d) );

Hw_sum += Hw;

subplot(N_path + 2,3,3*d+1);

plot(w,real(Hw));       xlim([0       wmax]);ylim([-1       1]);
set(gca,'xticklabel',[]);

set(gca,'ytick',[-1 0 1]);

subplot(N_path + 2,3,3*d+2);

plot(w,imag(Hw)); xlim([0 wmax]);ylim([-1 1]);
```

```
set(gca,'xticklabel',[]);

set(gca,'ytick',[-1 0 1]);

subplot(N_path + 2,3,3*d+3);

plot(w,abs(Hw));        xlim([0        wmax]);ylim([0        1]);
set(gca,'xticklabel',[]);

set(gca,'ytick',[0 1]);

end

d = N_path + 1;

subplot(N_path + 2,3,3*d+1);

plot(w,real(Hw_sum),'r-');    xlim([0    wmax]);ylim([-5    5]);
set(gca,'xticklabel',[]);

set(gca,'ytick',[-5 0 5]);

subplot(N_path + 2,3,3*d+2);

plot(w,imag(Hw_sum),'r-');    xlim([0    wmax]);ylim([-5    5]);
set(gca,'xticklabel',[]);

set(gca,'ytick',[-5 0 5]);

subplot(N_path + 2,3,3*d+3);

plot(w,abs(Hw_sum),'r-');     xlim([0     wmax]);ylim([0     5]);
set(gca,'xticklabel',[]);

set(gca,'ytick',[0 5]);
```

Output:



MATLAB code that calculates not only frequency shift but also the angle(theta) to figure out the location of the train more easily.

Doppler shift at specific time:

$$f_s(t) = f_d \cos\theta(t)$$

$$\cos(\theta(t_0)) = \frac{Ds/2}{\sqrt{D\min^2 + (Ds/2)^2}}$$

Code:

```
fd = 750;
 Dmin = 2; % in meter
 Ds = 300; % in meter
 v = 300 * 1000/3600; % in m/s
 tmin = 0;
 tmax = 20;
 tstep = 0.1;
 fs = [];
 th = [];
 for t = tmin:tstep:tmax
 costh = CosTh(t,Dmin,Ds,v);
 y = fd .* CosTh(t,Dmin,Ds,v);
 fs = [fs y];
 th = [th acos(costh)];
 end
 subplot(2,1,1);
 plot(tmin:tstep:tmax,fs,'r-');
 xlim([tmin tmax]); ylim([-1000 1000]);
 ylabel('fs(t)');
 grid();
 subplot(2,1,2);
 plot(tmin:tstep:tmax,th,'b-');
```

```
 xlim([tmin tmax]);
 ylim([0 pi()]);
 set(gca,'ytick',[0 pi/4 pi/2 3*pi/4 pi]);
 set(gca,'yticklabel',{'0', 'pi/4', 'pi/2', '3*pi/4', 'pi'});
 ylabel('\theta (t)');
 grid();
end


function y = CosTh(t, Dmin, Ds, v)
 if (t >= 0) && ( t <= Ds / v)
 y = (Ds ./ 2 - v .* t)/sqrt(Dmin .^ 2 + (Ds ./ 2 - v .* t)^2);
 elseif (t > Ds / v) && ( t <= (2 .* Ds ./ v))
 y = (-1.5 .* Ds + v .* t)/sqrt(Dmin .^ 2 + (-1.5 .* Ds + v .*
t)^2);
 elseif (t > 2 .* Ds ./ v)
 y = CosTh(mod(t, 2 .* Ds ./ v),Dmin, Ds, v);
 end
end
```

Output: