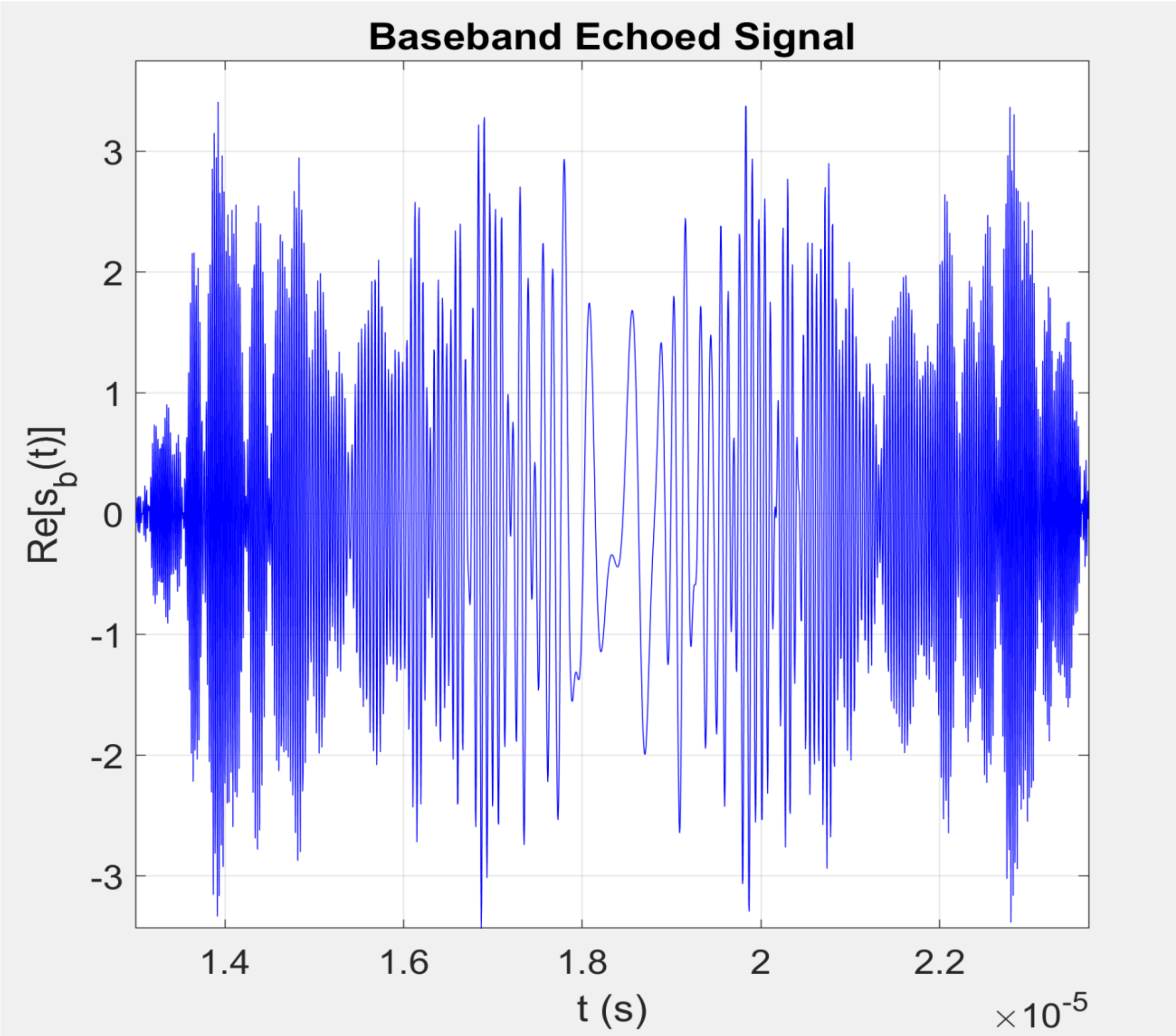
EE562 PROJECT #1

Based on the given problem, Matlab program was generated and the results are as follows:

P1.1

Result

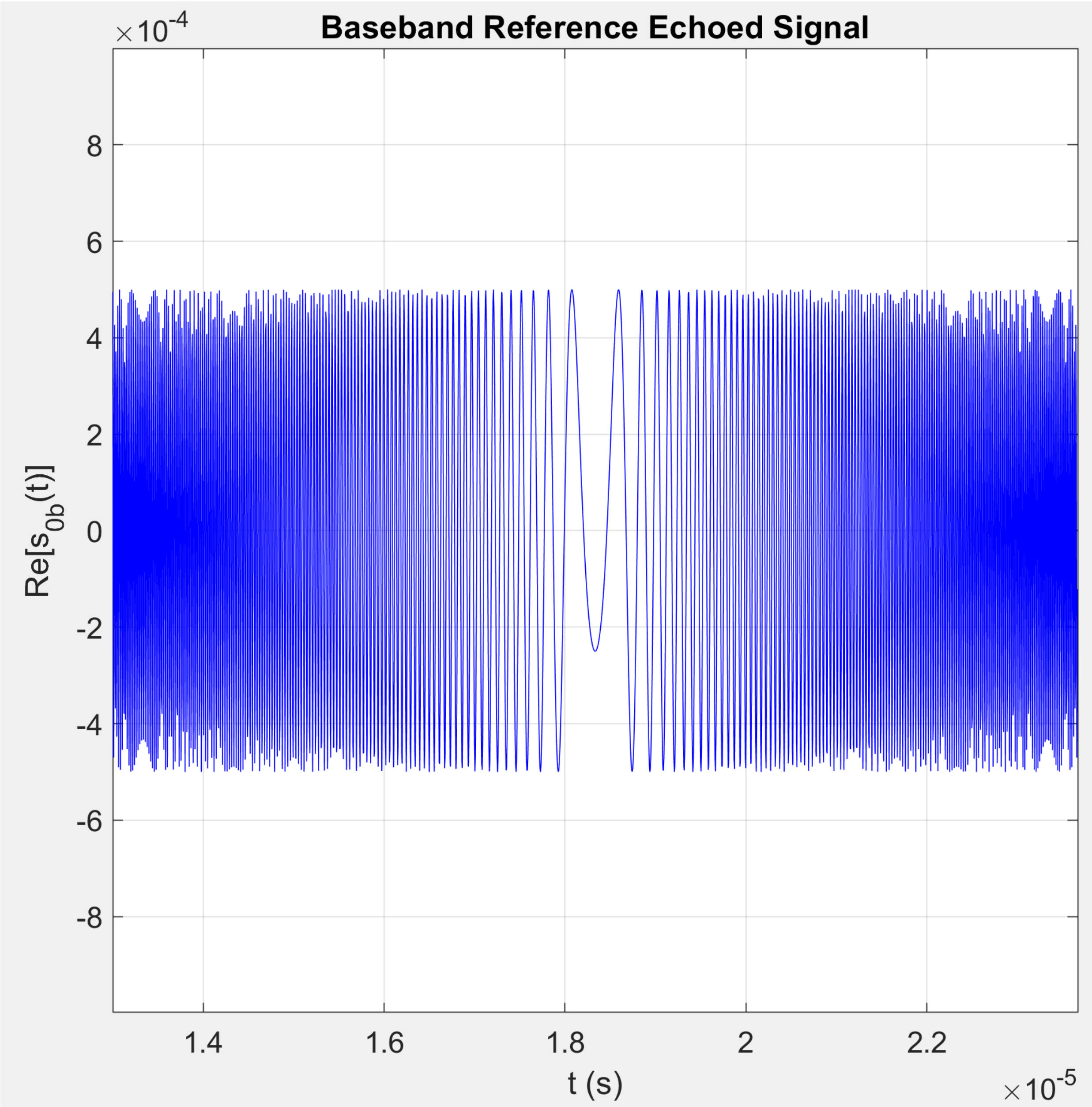


Analysis

The chirp signal that is sent from the RADAR hits the target and the signal is echoed back. This echoed signal from the target scene is captured and the baseband conversion is done. This is the Baseband echoed signal. For the baseband conversion, the echoed signal is multiplied with exponential of (-j*wc*t). The real part of the resultant values are plotted in the time domain. In the graph, there is a delay in time slots where the signal hits the target. Thus indicating the presence of a target.

P1.2

Result

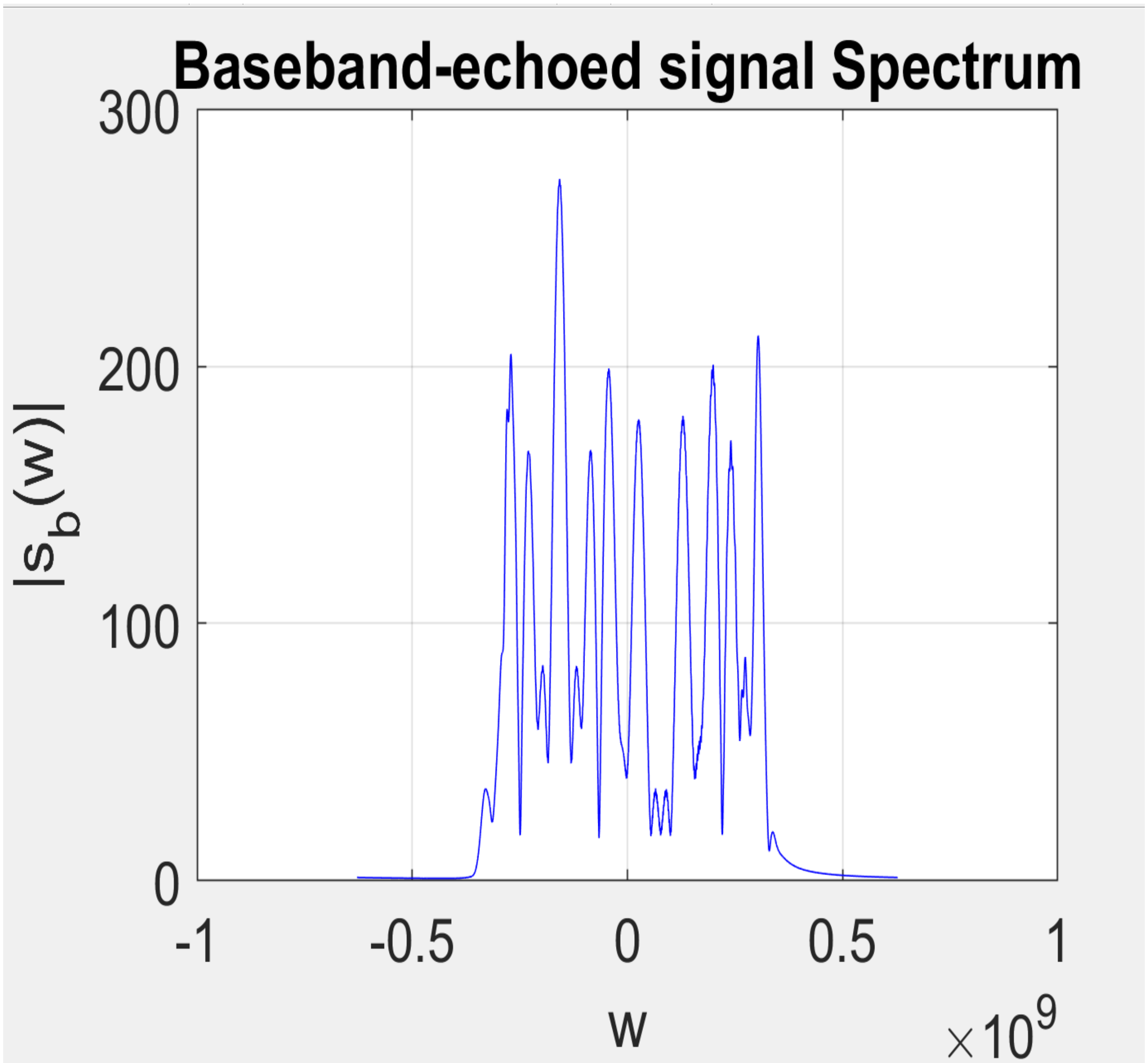


Analysis

The chirp signal delayed by (2*Xc/c) is called as the reference signal. So the echoed signal from the target when delayed by (2*Xc/c) is considered as the reference echoed signal. This signal is then multiplied with exponential of (-j*wc*t) for baseband conversion. The resulting signal is said to be baseband reference echoed signal. This signal is plotted in time domain with respect to the up sampled time array. No much delay is observed in the graph. In the code, the real part of $s_{0b}(t)$ is multiplied with dt/Tp to reduce the magnitude of the signal, so that it is observable.

P1.3

Result

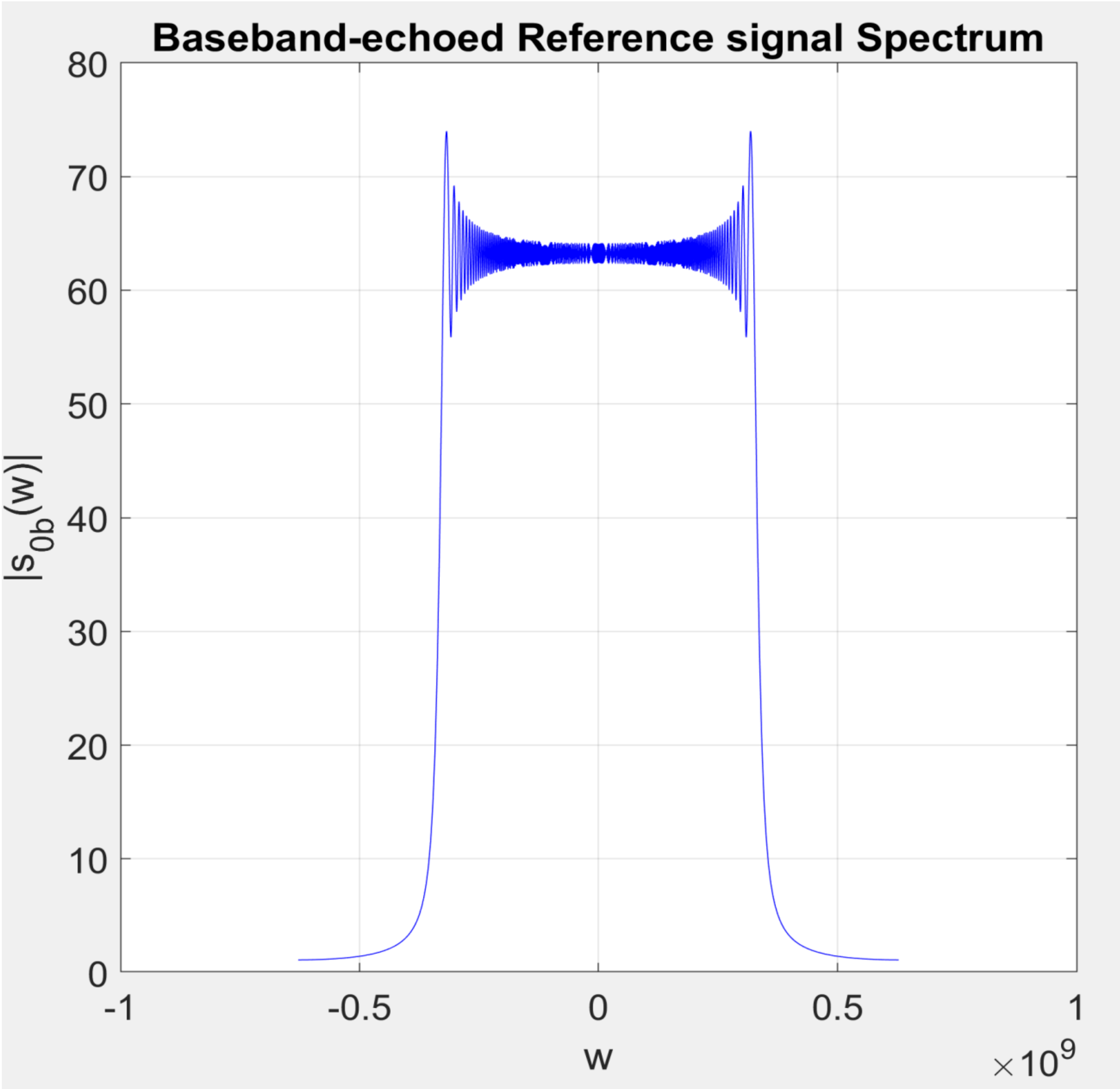


Analysis

Earlier, the signal echoed from the target scene (after baseband conversion) was plotted in time domain. The alias free version of $s_b(t)$ was recovered from the alias free version of $s_{cb}(t)$. Now the same signal is plotted in frequency domain i.e. with respect to w. In this the baseband echoed signal is converted in frequency domain by taking Fourier transform. In the code it is done by using 'fty'. The support band of $s_b(w)$ is $[w_c-w_0, w_c+w_0]$. The magnitude of the $s_b(w)$ plotted against w shows 5 high peaks indicating the presence of targets in those regions. Also the plotted is centered at 0, indicating the unit reflector at X_c.

P1.4

Result

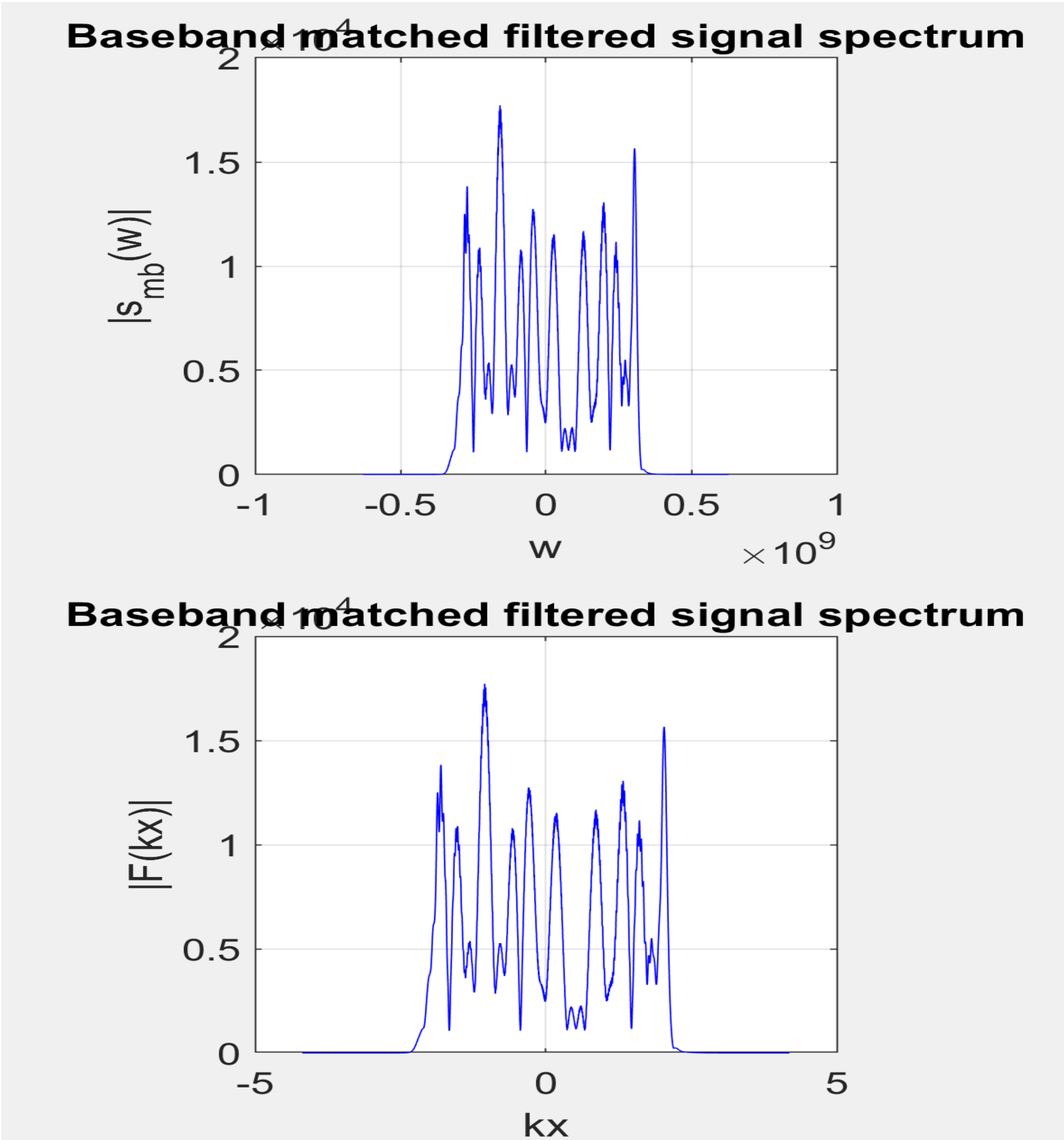


Analysis

The reference signal is from a unit reflector at the center of the target region. When Fourier transform is applied to the baseband echoed reference signal, it is referred to as baseband echoed reference spectrum. In matlab, this is performed by using 'fty' to the baseband echoed reference signal. This signal when plotted in frequency domain gives a result as shown above. In this there is no high peaks indicating it to be the reference signal not hit on any target. This reference signal is later used to perform matched filtering for range reconstruction.

P1.5

Result



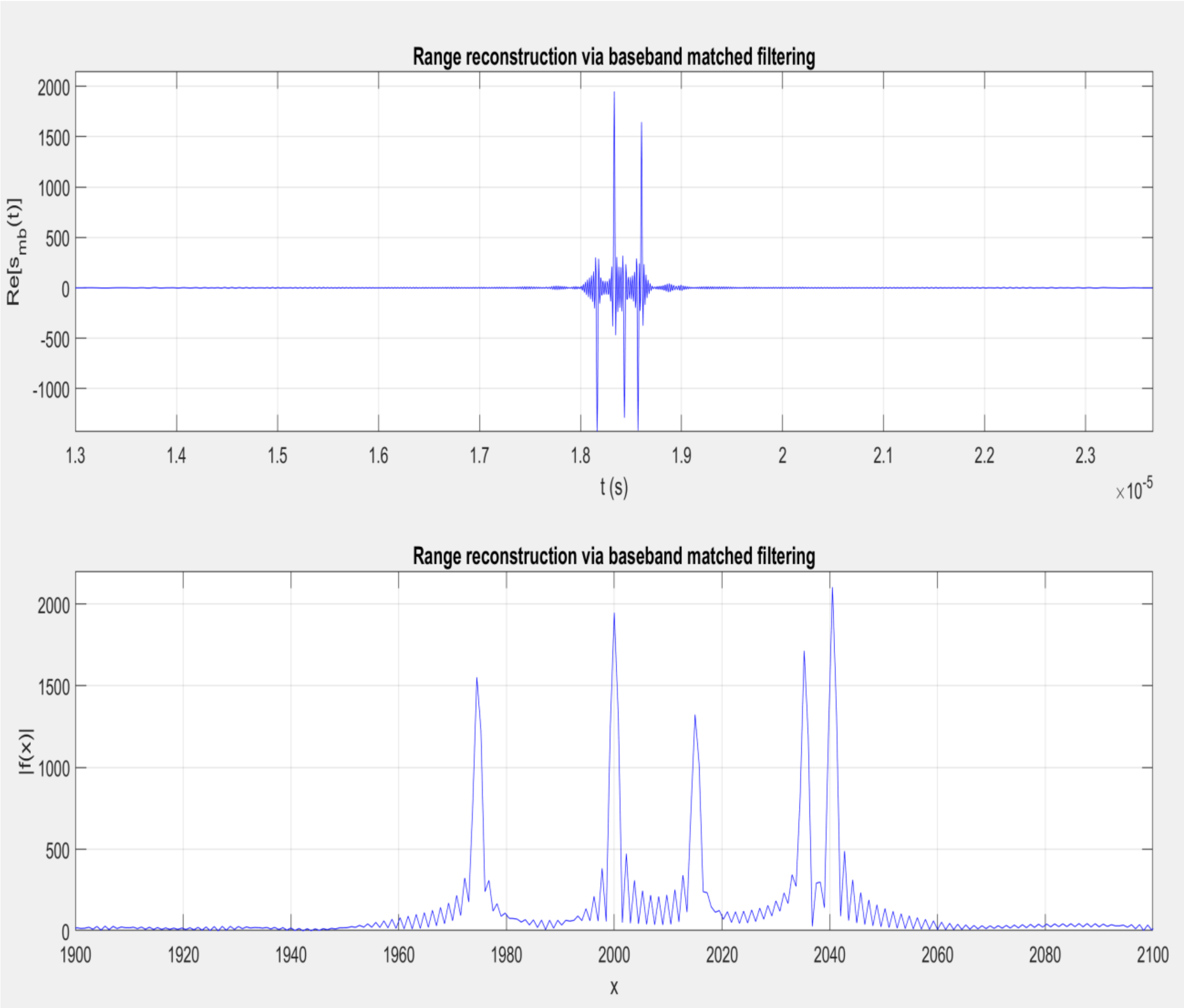
Analysis

In this first figure, the signal after performing matched filtering is taken and Fourier transform is done. This is called the baseband matched filtered signal spectrum. It is plotted against the frequency array w to show that the signal is reconstructed after hitting the 5 targets.

In the second figure, |F(kx)| denotes the absolute value of $S_{mb}(w)$. It is plotted against the spatial frequency array kx. Here kx is calculated by using the formula, kx=(2*w)/c. Since the unit reflector is at X_c , the formula can be rewritten as kx=(2*(w-w_c)/c). In both the figures we can observe 5 high peaks indicating the 5 targets and also the graphs are centered at 0 indicating the unit reflector at Xc.

P1.6

Result

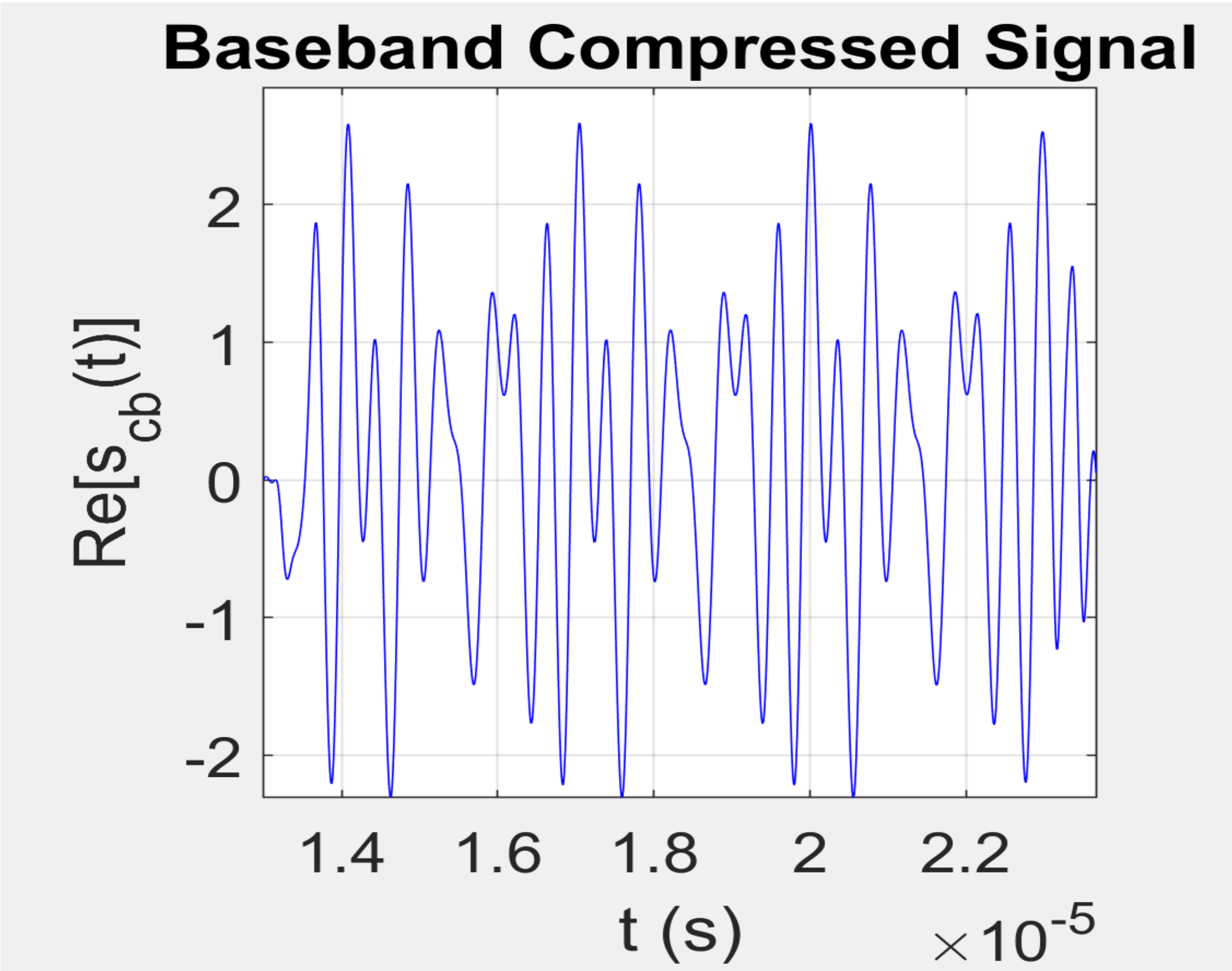


Analysis

The chirp signal from the RADAR after hitting the target is echoed back. This echoed signal has to be reconstructed so that the location of the targets can be easily identified. This reconstruction can be done by baseband matched filtering. For the matched filtering, the reference signal is first defined. This reference signal undergoes baseband conversion. This is convoluted with the baseband echoed signal. In order to reduce the complexity due to convolution, both the signals are converted in frequency domain. $F(s_{mb})$= conjugate($F(s_{0b})$) *$F(s_b)$ is used to obtain the matched filtered signal spectrum. Then inverse Fourier transform is done using 'ifty'. This gives the baseband matched filtered signal which is plotted above. In the first figure, it is plotted in time domain which indicates the targets through the delay in the signal. The second figure highlights 5 sharp peaks showing the 5 targets. In this |f(x)| is the $|s_{mb}(t)|$ as it is the reconstructed version of the chirp signal sent by the RADAR.

P1.7

Result

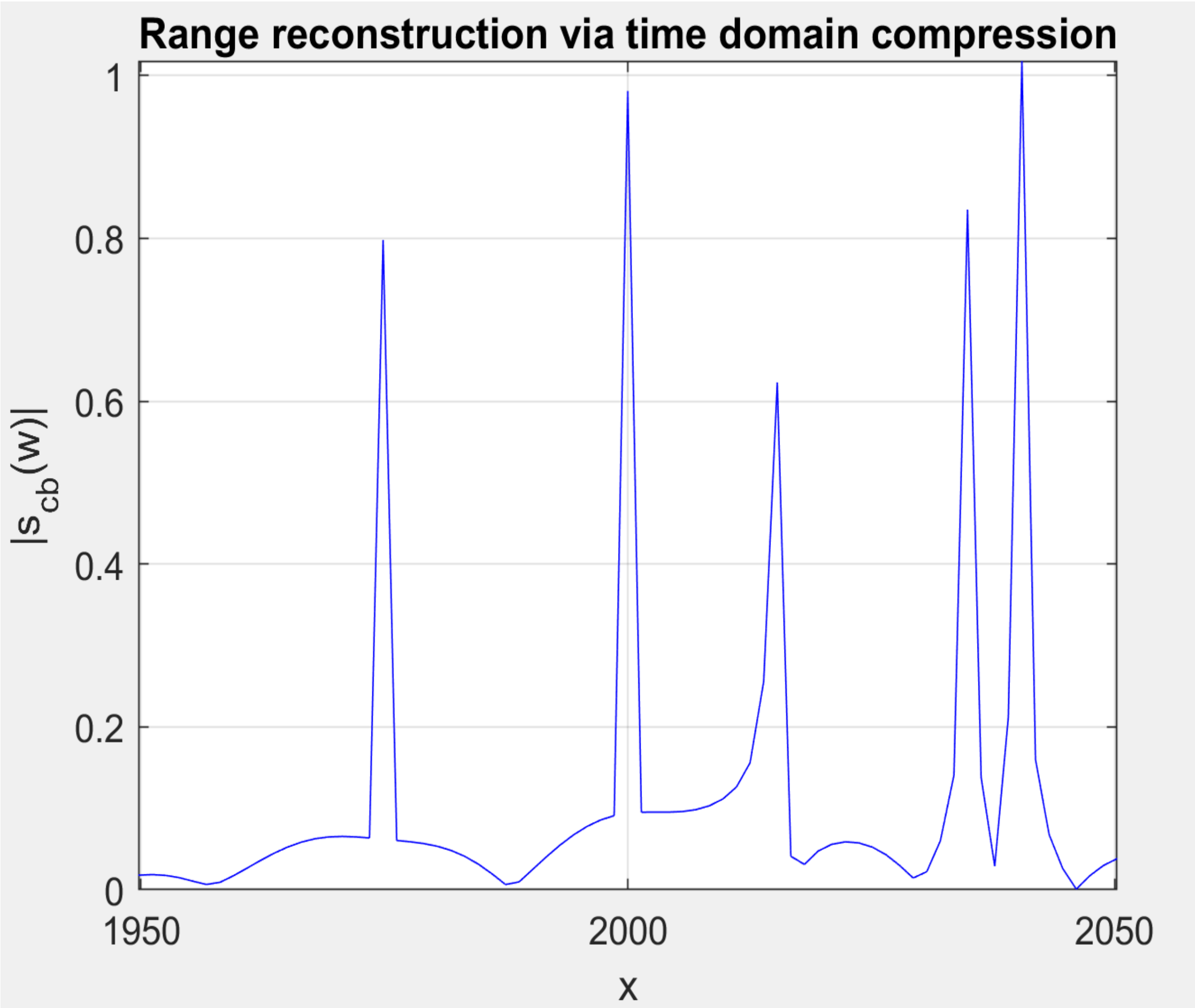


Analysis

The compressed signal is obtained by mixing complex conjugate of s(t) with the phase of the transmitted chirp signal, i.e. $s_c(t)$= conjugate(s(t)) *exponential(j*beta*t+j*alpha*t^2). Then baseband conversion gives the baseband compressed signal which is plotted against the time array. The signals are compressed before sampling because the sampling space of the baseband compressed signal is less restrictive as it puts less burden on the A/D converters. After sampling, the discrete samples of $s_{cb}(t)$ is obtained. These samples are not aliased. Such alias free samples of $s_{cb}(t)$ can be obtained from the alias free $s_b(t)$.

P1.8

Result



Analysis

The signal reconstructed via pulse compression of the chirp signal in the time domain is referred here. The signal is first compressed and then baseband conversion is performed. Then Fourier transform of this signal is plotted with respect to the range bins x. This 5 sharp peaks in the figure indicate that there are 5 targets in the target region. The value of x at the sharp peaks give the exact location of these targets.

MATLAB CODE:

```
clear all
close all
cj=sqrt(-1);
pi2=2*pi;
c=3e8;
B0 = 50e6;
w0=pi2*B0;
fc=1e9;
wc=pi2*fc;
Xc=2.e3;
Tp = 10e-6;

alpha=w0/Tp;
beta=wc-alpha*Tp;

dx=c/(4*B0);
dt=pi/(2*alpha*Tp);

Tx=0.67e-6;
X0 =(c*Tx)/4;
dtc=pi/(2*alpha*Tx);

Ts=(2*(Xc-X0))/c;
Tf=(2*(Xc+X0))/c+Tp;

flag=0;

if Tx < Tp,
   flag=1;
   dt_temp=dt;
   dt=dtc;
end;


n=2*ceil((.5*(Tf-Ts))/dt);
t=Ts+(0:n-1)*dt;
dw=pi2/(n*dt);
w=wc+dw*(-n/2:n/2-1);
x=Xc+.5*c*dt*(-n/2:n/2-1);
kx=(2*w)/c;
```

```
x= (((w-wc)*c)/(4*alpha))+Xc;



ntarget=5;

xn(1)=0;            fn(1)=1;
xn(2)=.7*X0;        fn(2)=.8;
xn(3)=.8*X0;        fn(3)=1;
xn(4)=-.5*X0;       fn(4)=.8;
xn(5)=.3*X0;        fn(5)=.7;

s=zeros(1,n);

for i=1:ntarget;
    td=t-2*(Xc+xn(i))/c;
    pha=beta*td+alpha*(td.^2);
    s=s+fn(i)*exp(cj*pha).*(td >= 0 & td <= Tp);
end

if    flag == 1
      td0=t-2*(Xc+0)/c;
      pha0=beta*td0+alpha*(td0.^2);
      scb = conj(s).*exp(cj*pha0).*exp(cj*2*beta*Xc/c-cj*4*alpha*Xc^2/(c^2));
      fscb = fty(scb);

figure(8)
subplot(1,1,1)
plot(x,(dt/Tp)*abs(fscb),'b-'); grid on;
axis([Xc-X0 Xc+X0 0 max((dt/Tp)*abs(fscb))])
xlabel('x')
ylabel('|s_c_b(w)|')
title('Range reconstruction via time domain compression');
set(gca,'fontsize',12);

      scb=[scb,scb(n:-1:1)];
      fscb=fty(scb);

      dt=dt_temp;
      n_up=2*ceil((.5*(Tf-Ts))/dt);
      nz=n_up-n;
      fscb=(n_up/n)*[zeros(1,nz),fscb,zeros(1,nz)];

      scb=ifty(fscb);
      scb=scb(1:n_up);
```

```
    n=n_up;
    t=Ts+(0:n-1)*dt;
    dw=pi2/(n*dt);
    w=wc+dw*(-n/2:n/2-1);
    x=Xc+.5*c*dt*(-n/2:n/2-1);
    kx=(2*w)/c;
    s=conj(scb).*exp(cj*beta*t+cj*alpha*t.^2-cj*4*alpha*Xc*t/c);
end

sb=s.*exp(-cj*wc*t);
fsb = fty(sb);

td0=t-2*(Xc+0)/c;
pha0=beta*td0+alpha*(td0.^2);
s0= exp(cj*pha0);
s0b= s0.*exp(-cj*wc*t);
fs0b= fty(s0b);
fsmb= conj(fs0b).*fsb;
smb= ifty(fsmb);


figure(1)
subplot(1,1,1)
plot(t,real(sb),'b-'); grid on;
xlabel('t (s)')
ylabel('Re[s_b(t)]')
title('Baseband Echoed Signal');
axis('square')
axis([Ts Tf min(real(sb)) 1.1*max(real(sb))])
set(gca,'fontsize',18);

figure(2)
subplot(1,1,1)
plot(t,(dt/Tp)*real(s0b),'b-'); grid on;
xlabel('t (s)')
ylabel('Re[s_0_b(t)]')
title('Baseband Reference Echoed Signal');
axis('square')
axis([Ts Tf 2*min((dt/Tp)*real(s0b)) 2*max((dt/Tp)*real(s0b))])
set(gca,'fontsize',14);

figure(3)
subplot(1,1,1)
plot(w-wc,abs(fsb),'b-'); grid on;
xlabel('w')
ylabel('|s_b(w)|')
```

```
title('Baseband-echoed signal Spectrum');
set(gca,'fontsize',18);


figure(4)
subplot(1,1,1)
plot(w-wc,abs(fs0b),'b-'); grid on;
xlabel('w')
ylabel('|s_0_b(w)|')
title('Baseband-echoed Reference signal Spectrum');
axis('square')
set(gca,'fontsize',18);

figure(5)
subplot(2,1,1)
plot(w-wc,abs(fsmb),'b-'); grid on;
xlabel('w')
ylabel('|s_m_b(w)|')
title('Baseband matched filtered signal spectrum');
axis('square')
set(gca,'fontsize',14);

kx=(2*(w-wc))/c;
subplot(2,1,2)
plot(kx,abs(fsmb),'b-'); grid on;
xlabel('kx')
ylabel('|F(kx)|')
title('Baseband matched filtered signal spectrum');
axis('square')
set(gca,'fontsize',14);

figure(6)
subplot(2,1,1)
plot(t,real(smb),'b-'); grid on;
xlabel('t (s)')
ylabel('Re[s_m_b(t)]')
title('Range reconstruction via baseband matched filtering');
axis([Ts Tf min(real(smb)) 1.1*max(real(smb))])
set(gca,'fontsize',12);

subplot(2,1,2)
plot(x,abs(smb),'b-'); grid on;
xlim([1900 2100])
ylim([0 2200])
xlabel('x')
ylabel('|f(x)|')
```

```
title('Range reconstruction via baseband matched filtering');
set(gca,'fontsize',12);


figure(7)
subplot(1,1,1)
plot(t,real(scb),'b-'); grid on;
xlabel('t (s)')
ylabel('Re[s_c_b(t)]')
title('Baseband Compressed Signal');
axis('square')
axis([Ts Tf min(real(scb)) 1.1*max(real(scb))])
set(gca,'fontsize',18);
```