Transmission signal synthesis:

Transmission signal proposed is composed of “M” coherence lengths, where each coherence length is made up of “N” phase jumps. We synthesize a transmission signal with following time domain specifications:

M=coherence lengths=300

N=phase jumps in each coherence lengths=15

Fc=Center Frequency=6GHz

Fs=sampling frequency=(N+1)*Fc=96GS/s

No.of cycles per phase jump(1st window)=2

No.of cycles added to each phase jump after each successive coherence length=1

Total phase jumps=2*pi/((N+1)*(M+1))

“Synthesize_Tx_signal.m” :

```
clc;
clear all;
close all;
format short
%% time specifications
M=300;   % M+1 coherence lengths
N=15;  % N+1 phase jumps in each coherence window <=8
Fc=6e9; % carrier frequency
Fs=16*Fc; % sampling Frequency
c=3e8; % speed of light
init_cycles=2; % no. of cycles in 1st coherence window, per phase length
incr_cycles=1; % no. of  cycles to be  added to each coherence length,
per phase length
phi=(-pi+(2*pi/((N+1)*(M+1))):(2*pi/((N+1)*(M+1))):pi); % uniform
phase jumps
Tx=[];
corr_lengths=[];
%% Transmission Signal Synthesis
for i=1:1:M+1
    for j=1:1:N+1
        t=0:1/Fs:(init_cycles/Fc+(i-1)*incr_cycles/Fc)-(1/Fs);
        Tx=horzcat(Tx,cos(2*pi*Fc*t+phi(j+(i-1)*(N+1))));
    end
    corr_lengths(i)=(N+1)*(length(t)); % coherence lengths
end
```

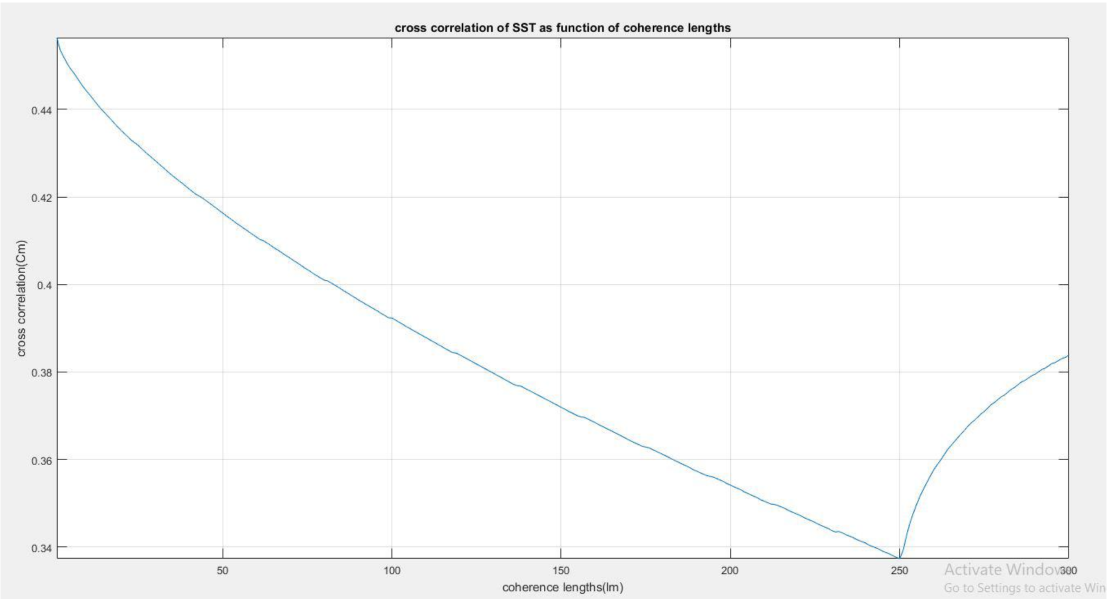
SST(Single Stationary Target):

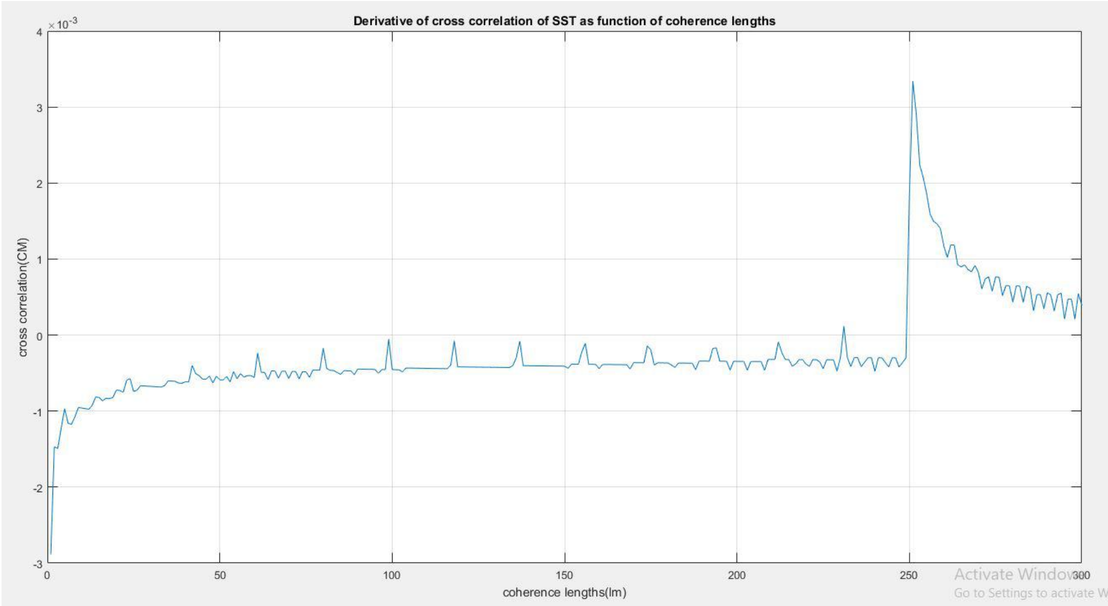
A single target object with delay equal to 250th coherence length was assumed, correspondingly we get break point at 250, when cross correlation is displayed as function of coherence length(lm).

"SST.m":

```
%% Targets and receiver
D=corr_lengths(250); % corresponds to 250th coherence lengths
Rx=[Tx(end-D:end) Tx(1:(end-(D+1)))];
Cm=zeros(1,M+1);
for i=1:1:M+1
    if i==1
        Cm(i)=mean(Tx(1:corr_lengths(i)).*Rx(1:corr_lengths(i)));
    else

Cm(i)=mean(Tx(corr_lengths(i-1)+1:corr_lengths(i)).*Rx(corr_lengths(i
-1)+1:corr_lengths(i)));
    end
end
figure
plot(1:1:length(Cm),Cm)
grid on
title('cross correlation of SST as function of coherence lengths')
xlabel('coherence lengths(lm)')
ylabel('cross correlation(Cm)')
axis([1 M -inf inf])
CM=diff(Cm); % differentiating cross correlation
[pk,loc]=max(CM)
figure
plot(1:1:length(CM),CM)
grid on
title('Derivative of cross correlation of SST as function of coherence
lengths')
xlabel('coherence lengths(lm)')
ylabel('cross correlation(CM)')
```

Snaps:





MST(Multiple Stationary Target):

Two stationary targets with delays 10000 samples and 30000 samples corresponding to 41st and 120th coherence length respectively were assumed. We get two breakpoints at 41 and 120 coherence points.

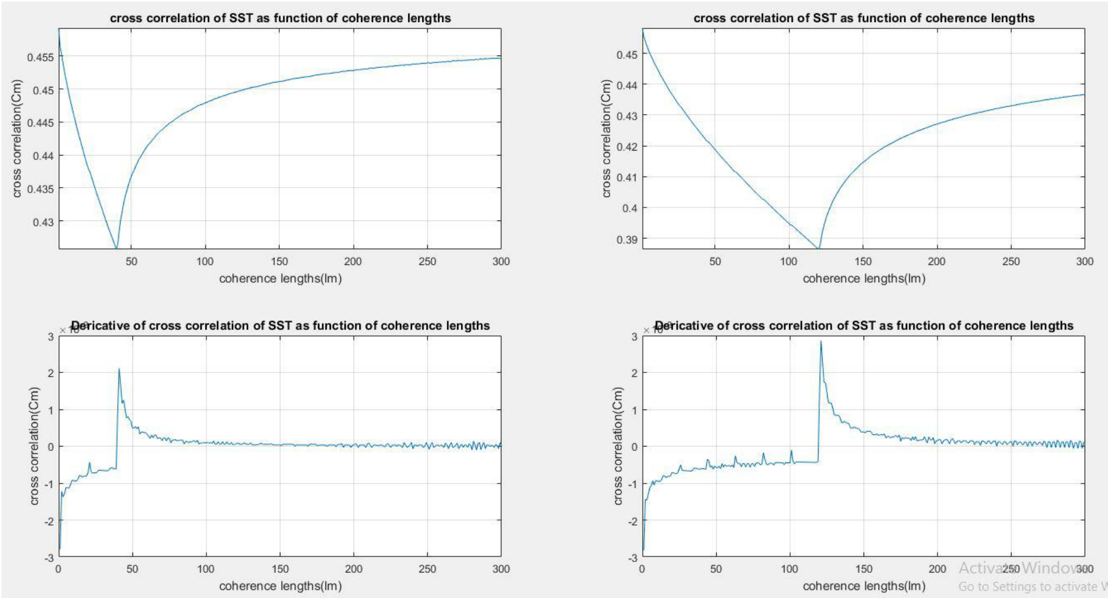
"MST.m":

```
%% Targets
D0=10496;
Targ0=(D0/(16*Fc)*(c/2)); % in terms of coherence lengths
D1=30976;
Targ1=(D1/(16*Fc)*(c/2)); % in terms of coherence lengths
Rx1=[Tx(end-D0:end) Tx(1:(end-(D0+1)))]; % reflection of first target
seperately
Rx2=[Tx(end-D1:end) Tx(1:(end-(D1+1)))]; % reflection of second target
seperately
RX=Rx1+Rx2; % combined reflections of 1st and 2nd target
% Correlation at coherence lengths
Cm1=zeros(1,M+1);
Cm2=zeros(1,M+1);
cm=zeros(1,M+1);
for i=1:1:M+1
    if i==1
        Cm1(i)=mean(Tx(1:corr_lengths(i)).*Rx1(1:corr_lengths(i)));
        Cm2(i)=mean(Tx(1:corr_lengths(i)).*Rx2(1:corr_lengths(i)));
        cm(i)=mean(Tx(1:corr_lengths(i)).*RX(1:corr_lengths(i)));
    else

Cm1(i)=mean(Tx(corr_lengths(i-1)+1:corr_lengths(i)).*Rx1(corr_lengths
(i-1)+1:corr_lengths(i)));

Cm2(i)=mean(Tx(corr_lengths(i-1)+1:corr_lengths(i)).*Rx2(corr_lengths
(i-1)+1:corr_lengths(i)));

cm(i)=mean(Tx(corr_lengths(i-1)+1:corr_lengths(i)).*RX(corr_lengths(i
-1)+1:corr_lengths(i)));
    end

end
```

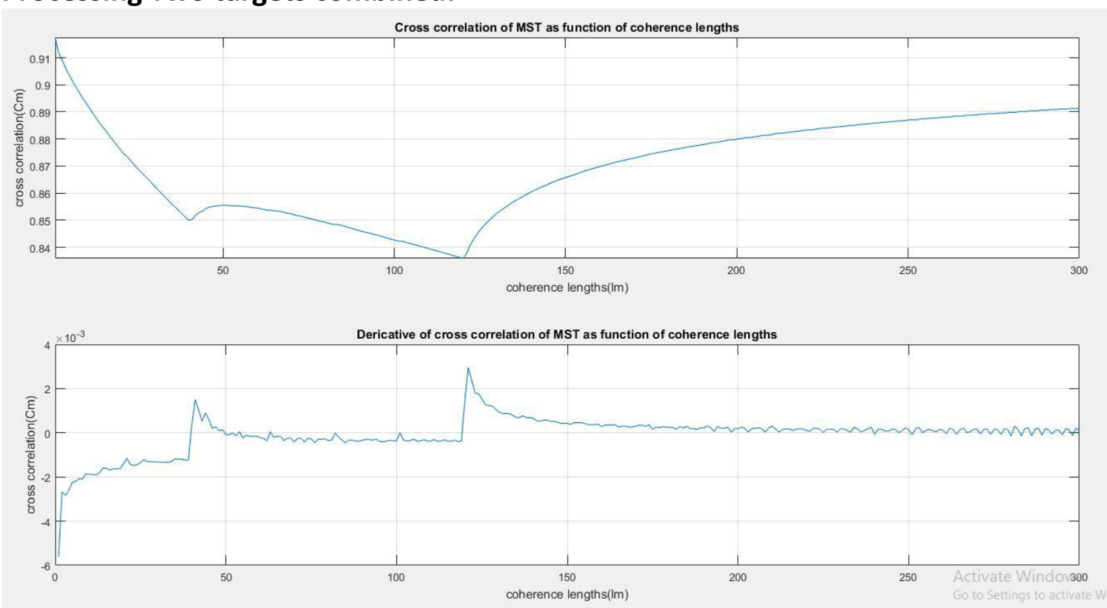
```
% display each target seperately
figure
subplot(221)
plot(1:1:length(Cm1),Cm1)
axis([1 M -inf inf])
grid on
title('cross correlation of SST as function of coherence lengths')
xlabel('coherence lengths(lm)')
ylabel('cross correlation(Cm)')
subplot(222)
plot(1:1:length(Cm2),Cm2)
axis([1 M -inf inf])
grid on
title('cross correlation of SST as function of coherence lengths')
xlabel('coherence lengths(lm)')
ylabel('cross correlation(Cm)')

CM1=diff(Cm1);
CM2=diff(Cm2);
subplot(223)
plot(1:1:length(CM1),CM1)
grid on
title('Dericative of cross correlation of SST as function of coherence
lengths')
xlabel('coherence lengths(lm)')
ylabel('cross correlation(Cm)')
[pk1,loc1]=max(CM1)
subplot(224)
plot(1:1:length(CM2),CM2)
grid on
title('Dericative of cross correlation of SST as function of coherence
lengths')
xlabel('coherence lengths(lm)')
ylabel('cross correlation(Cm)')

% Display both targets at once,
figure
subplot(211)
plot(1:1:length(cm),cm)
axis([1 M -inf inf])
grid on
title('Cross correlation of MST as function of coherence lengths')
xlabel('coherence lengths(lm)')
ylabel('cross correlation(Cm)')

subplot(212)
c_m=diff(cm);
plot(1:1:length(c_m),c_m)
grid on
title('Dericative of cross correlation of MST as function of coherence
lengths')
xlabel('coherence lengths(lm)')
ylabel('cross correlation(Cm)')
```

Snaps:

Processing Two targets individually:



Processing Two targets combined:

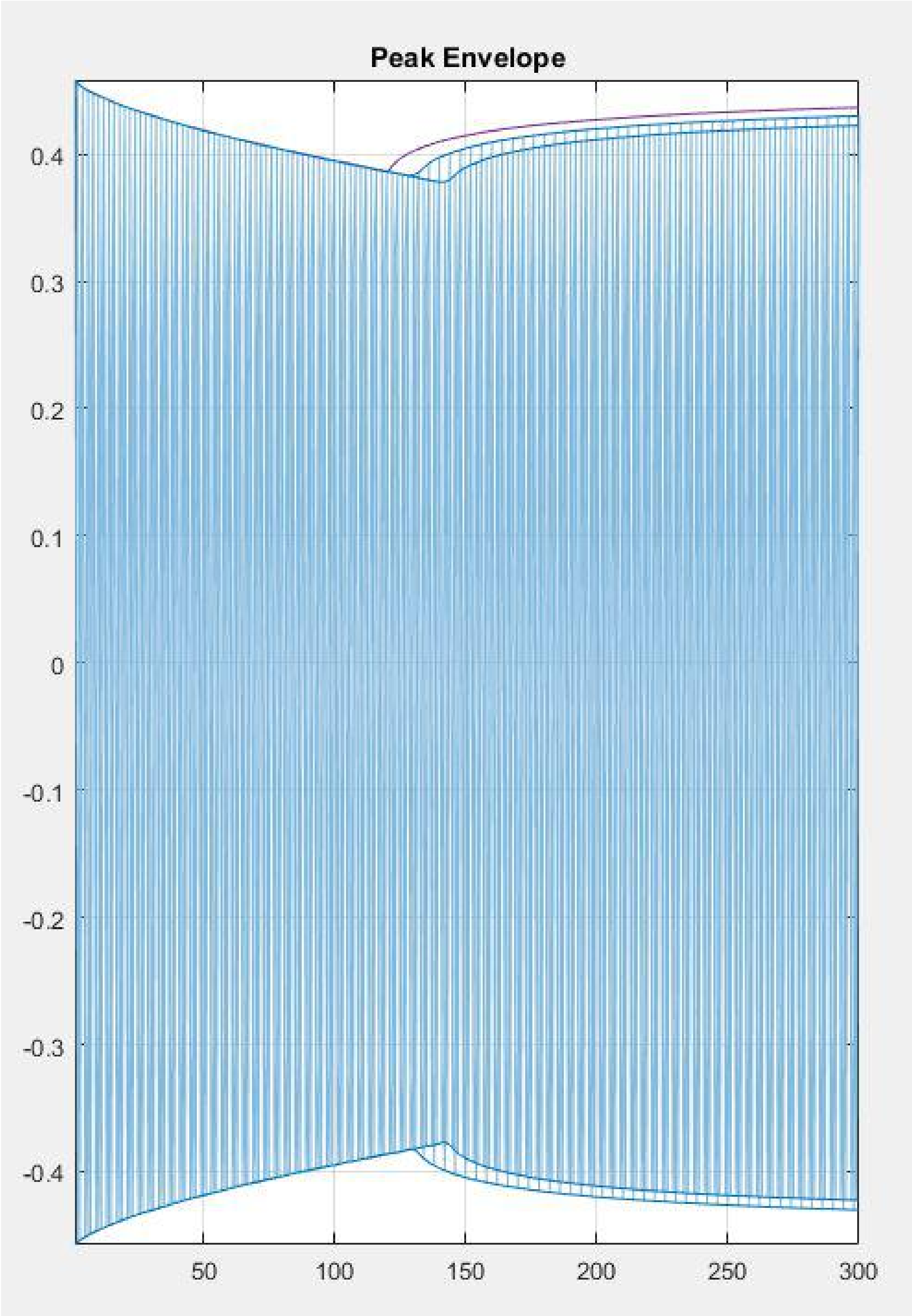


SMT(Single Moving Target):

A single Accelerated target is assumed at two different accelerations, double of each. Correspondingly the slope of cross correlation is less than stationary case as displayed.

"SMT.m":

```
%% targets and reflections
targ_speed=4; % = 2,4,6
targ_pos=30976; % initial target position in number of samples (round trip delay in samp)
C_m=zeros(1,M+1);
C_M=zeros(1,M+1);
for i=1:1:M+1
    D0=targ_pos;
    if i==1
        ph_shift=0;
    else
        ph_shift=targ_speed*i*10; % phase shift for each sweep-per-point
    end
    DD=D0+ph_shift;
    rx=[Tx(end-D0:end) Tx(1:(end-(D0+1)))];
    RRx=[Tx(end-DD:end) Tx(1:(end-(DD+1)))];
    if i==1
        C_m(i)=mean(Tx(1:corr_lengths(i)).*rx(1:corr_lengths(i)));
        C_M(i)=mean(Tx(1:corr_lengths(i)).*RRx(1:corr_lengths(i)));
    else

C_m(i)=mean(Tx(corr_lengths(i-1)+1:corr_lengths(i)).*rx(corr_lengths(
i-1)+1:corr_lengths(i)));

C_M(i)=mean(Tx(corr_lengths(i-1)+1:corr_lengths(i)).*RRx(corr_lengths
(i-1)+1:corr_lengths(i)));
    end
end
plot(1:1:length(C_m),C_m)
grid on
axis([1 M -inf inf])
hold on
plot(1:1:length(C_M),C_M)
hold on
envelope(C_M,2,'peak')
hold on
```


Peak Envelope
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
50
100
150
200
250
300