```
close all; clear all; clc;
% https://www.youtube.com/playlist?list=PLJAlx-5DOdeMNjpg4sRO6cty3gL_PZeCE
```

Radar Specifications

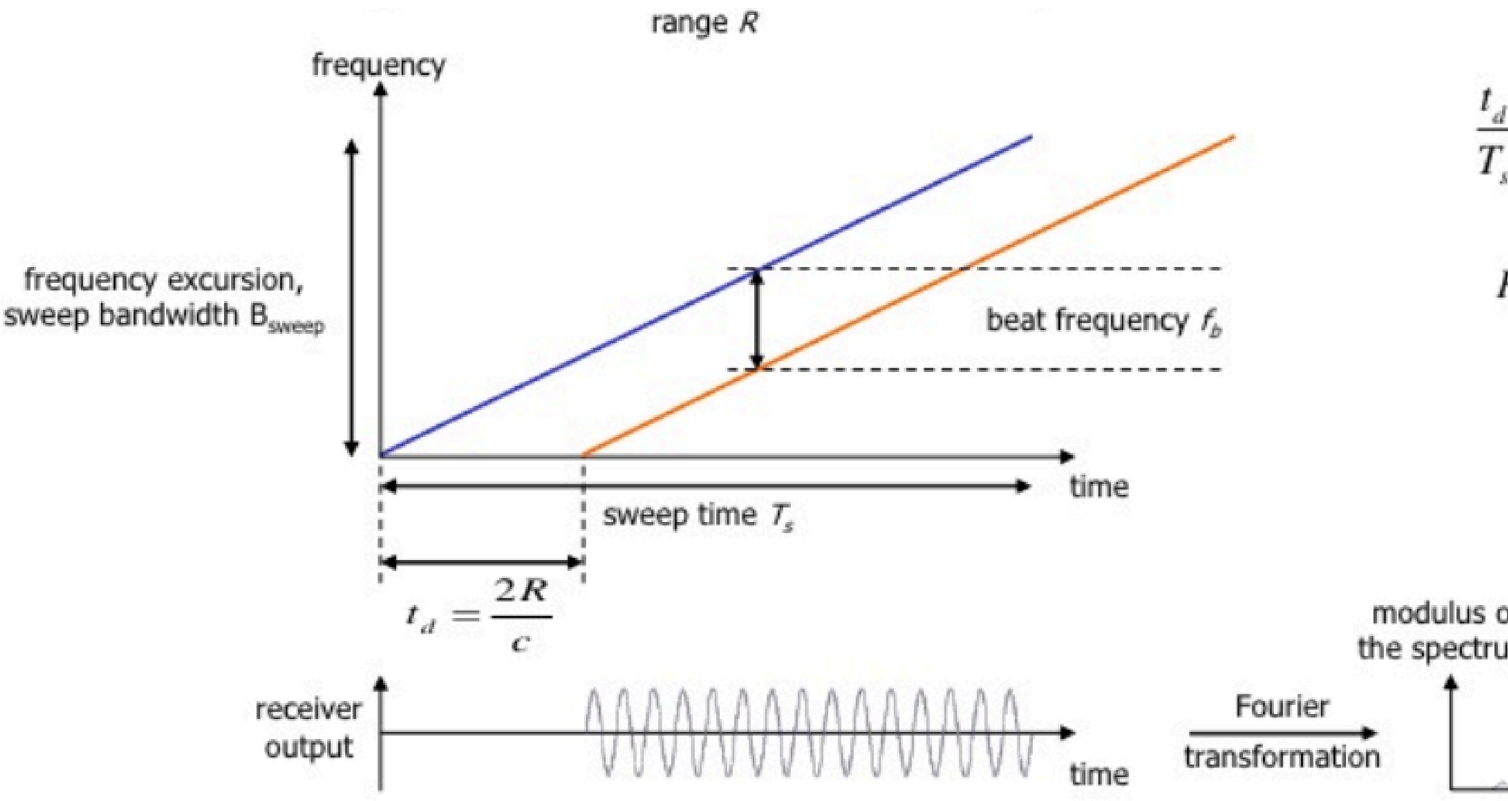
```
%-------------------------------------------%
% Frequency of operation = 77GHz
% Max Range = 200m
% Range Resolution = 1 m
% Max Velocity = 100 m/s
% speed of light = 3*10^8 m/s
%-------------------------------------------%
```

User Defined Range and Velocity of target

```
% *%TODO* :
% define the target's initial position and velocity. Note : Velocity remains contant

Range_of_target        = 160;
Velocity_of_target     = -20;
Max_Range_of_Radar     = 200;
Max_Velocity_of_Radar  = 100;
```

FMCW Waveform Generation

```
% *%TODO* :
% Design the FMCW waveform by giving the specs of each of its parameters.
% Calculate the Bandwidth (B), Chirp Time (Tchirp) and Slope (slope) of the FMCW
% chirp using the requirements above.


%Operating carrier frequency of Radar
fc                  = 77 * 10^9;            % carrier freq
sweep_time_factor   = 5.5;                  % Should be more than 2 to avoid the inter
speed_of_light      = 3*10^8;
Range_Resolution    = 1;
```




```
B_sweep  = speed_of_light / (2 * Range_Resolution);                       % Bandwidth o
T_s      = (sweep_time_factor * 2 * Max_Range_of_Radar) / speed_of_light; % Chirp Time
slope    = B_sweep / T_s;                                                 % Slope of th
ga
%The number of chirps in one sequence. Its ideal to have 2^ value for the ease of runni
%for Doppler Estimation.
Nd = 128;                                         % #of doppler cells OR #of sent periods

%The number of samples on each chirp.
Nr = 1024;                                        %for length of time OR # of range cells

% Timestamp for running the displacement scenario for every sample on each chirp
t = linspace(0,Nd*T_s,Nr*Nd);                     %total time for samples

%Creating the vectors for Tx, Rx and Mix based on the total samples input.
Tx  = zeros(1,length(t));               %transmitted signal
Rx  = zeros(1,length(t));               %received signal
Mix = zeros(1,length(t));               %beat signal

%Similar vectors for range_covered and time delay.
range_t = zeros(1,length(t));
time_delay  = zeros(1,length(t));
```

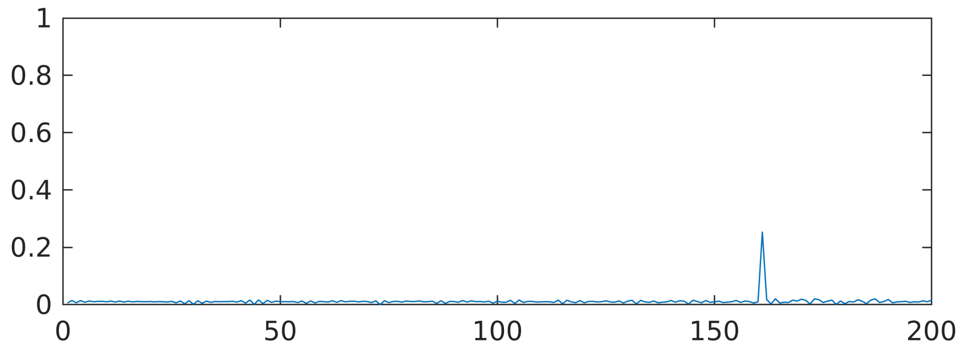
Signal generation and Moving Target simulation

```
% Running the radar scenario over the time.

for i=1:length(t)
    % *%TODO* :
    %For each time stamp update the Range of the Target for constant velocity.
    range_t(i)    = Range_of_target + (Velocity_of_target*t(i));
    time_delay(i) = (2*range_t(i)) / speed_of_light; % time delay

    % *%TODO* :
    %For each time sample we need update the transmitted and
    %received signal.
    Tx(i) = cos( 2*pi*( fc*(t(i)                ) + ( 0.5 * slope * t(i)^2)
    Rx(i) = cos( 2*pi*( fc*(t(i) - time_delay(i)) + ( 0.5 * slope * (t(i) - time_delay(

    % *%TODO* :
    %Now by mixing the Transmit and Receive generate the beat signal
    %This is done by element wise matrix multiplication of Transmit and
    %Receiver Signal
    Mix(i) = Tx(i).*Rx(i);
end
```

RANGE MEASUREMENT

```
% *%TODO* :
%reshape the vector into Nr*Nd array. Nr and Nd here would also define the size of
%Range and Doppler FFT respectively.
Mix = reshape(Mix,[Nr,Nd]);

% *%TODO* :
%run the FFT on the beat signal along the range bins dimension (Nr) and
sig_fft1 = fft(Mix,Nr);

%normalize.
sig_fft1 = sig_fft1./Nr;

% *%TODO* :
% Take the absolute value of FFT output
sig_fft1 = abs(sig_fft1);

% *%TODO* :
% Output of FFT is double sided signal, but we are interested in only one side of the s
% Hence we throw out half of the samples.
single_side_sig_fft1 = sig_fft1(1:Nr/2);

%plotting the range
figure ('Name','Range from First FFT')
subplot(2,1,1)

% *%TODO* :
% plot FFT output
```

```
plot(single_side_sig_fft1);
axis ([0 200 0 1]);
```

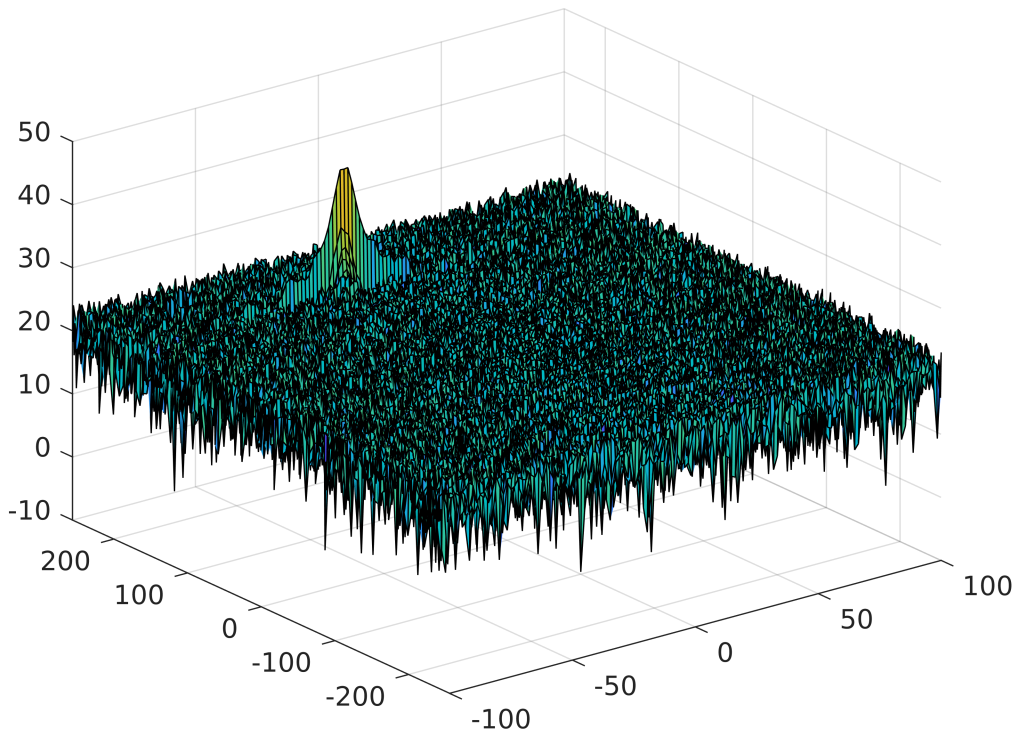



```

```

RANGE DOPPLER RESPONSE

```
% The 2D FFT implementation is already provided here. This will run a 2DFFT
% on the mixed signal (beat signal) output and generate a range doppler
% map.You will implement CFAR on the generated RDM

% Range Doppler Map Generation.

% The output of the 2D FFT is an image that has reponse in the range and
% doppler FFT bins. So, it is important to convert the axis from bin sizes
% to range and doppler based on their Max values.

Mix=reshape(Mix,[Nr,Nd]);

% 2D FFT using the FFT size for both dimensions.
sig_fft2 = fft2(Mix,Nr,Nd);

% Taking just one side of signal from Range dimension.
sig_fft2 = sig_fft2(1:Nr/2,1:Nd);
sig_fft2 = fftshift (sig_fft2);
RDM = abs(sig_fft2);
RDM = 10*log10(RDM) ;
```

```
%use the surf function to plot the output of 2DFFT and to show axis in both
%dimensions
doppler_axis = linspace(-100,100,Nd);
range_axis = linspace(-200,200,Nr/2)*((Nr/2)/400);
figure,surf(doppler_axis,range_axis,RDM);
```



CFAR implementation

```
%Slide Window through the complete Range Doppler Map

% *%TODO* :
%Slide Window through the complete Range Doppler Map

% *%TODO* :
%Select the number of Training Cells in both the dimensions.
Tr = 10;
Td = 10;

% *%TODO* :
%Select the number of Guard Cells in both dimensions around the Cell under
%test (CUT) for accurate estimation
Gr = 4;
Gd = 4;
```

```
% *%TODO* :
% offset the threshold by SNR value in dB
offset = 1.4;

% *%TODO* :
%Create a vector to store noise_level for each iteration on training cells
%noise_level = zeros(1,1);


% *%TODO* :
%design a loop such that it slides the CUT across range doppler map by
%giving margins at the edges for Training and Guard Cells.
%For every iteration sum the signal level within all the training
%cells. To sum convert the value from logarithmic to linear using db2pow
%function. Average the summed values for all of the training
%cells used. After averaging convert it back to logarithimic using pow2db.
%Further add the offset to it to determine the threshold. Next, compare the
%signal under CUT with this threshold. If the CUT level > threshold assign
%it a value of 1, else equate it to 0.

RDM = RDM/max(max(RDM));

for i = Tr+Gr+1:(Nr/2)-(Gr+Tr)
    for j = Td+Gd+1:Nd-(Gd+Td)

       %Create a vector to store noise_level for each iteration on training cells
        noise_level = zeros(1,1);

        % Calculate noise SUM in the area around CUT
        for p = i-(Tr+Gr) : i+(Tr+Gr)
            for q = j-(Td+Gd) : j+(Td+Gd)
                if (abs(i-p) > Gr || abs(j-q) > Gd)
                    noise_level = noise_level + db2pow(RDM(p,q));
                end
            end
        end

        % Calculate threshould from noise average then add the offset
        threshold = pow2db(noise_level/(2*(Td+Gd+1)*2*(Tr+Gr+1)-(Gr*Gd)-1));
        threshold = threshold + offset;
        CUT = RDM(i,j);

        if (CUT < threshold)
            RDM(i,j) = 0;
        else
            RDM(i,j) = 1;
        end

    end
end

% *%TODO* :
% The process above will generate a thresholded block, which is smaller
%than the Range Doppler Map as the CUT cannot be located at the edges of
```

```
%matrix. Hence,few cells will not be thresholded. To keep the map size same
% set those values to 0.

RDM(union(1:(Tr+Gr),end-(Tr+Gr-1):end),:) = 0;  % Rows
RDM(:,union(1:(Td+Gd),end-(Td+Gd-1):end)) = 0;  % Columns


% *%TODO* :
%display the CFAR output using the Surf function like we did for Range
%Doppler Response output.
figure('Name','CA-CFAR Filtered RDM')
surf(doppler_axis,range_axis,RDM);
colorbar;
```