Code:

final.m

/MATLAB Drive/PCS_Quiz-3/final.m

```matlab
% Aarya Gupta R.NO. -> 2022006
%---------------------------------------------------------%

% Parameters
KEY = 6;
K = KEY * 1e15; % Chirp rate (Hz/s)
% speed of increasing signal frequency -> Key
B = 3e9; % Bandwidth of the transmitted signal (Hz)
PRI = 520e-6; % Pulse repetition interval (s)
% radar pulses ke beech ka time gap
R1 = KEY * 10; % Target 1 range (m)
% distance of target 1 from radar
R2 = KEY * 20; % Target 2 range (m)
c = 3e8; % Speed of light (m/s)

% Chirp duration T = B/K (chirp signal ki time duration for which it is active)
T = B / K; % 5e-8 seconds (50 ns)

% Sampling frequency (10x bandwidth)
% (just for clarity, taking it 10 times of bandwith)
fs = 10 * B; % 3e10 Hz
dt = 1 / fs; % 3.333e-11 seconds

% Time vectors
t_tx = -T/2 : dt : T/2 - dt; % Transmitted signal time
t_rx = 0 : dt : 1e-6; % Received signal time (up to 1 µs)

% Transmitted signal
s_tx = cos(pi * K * t_tx.^2);
s_tx(abs(t_tx) > T/2) = 0; % Apply rectangular window

% Received signal (two delayed chirps)
% target se reflected chirps...
tau1 = 2 * R1 / c; % Delay for target 1 (4e-7 s) {time b/w radar and target 1}
tau2 = 2 * R2 / c; % Delay for target 2 (8e-7 s)

% Generate received signal
t1 = t_rx - tau1; % Adjusting time vector for 1st target
s_rx1 = cos(pi * K * t1.^2); % Generated 1st target ke reflected signal
s_rx1(abs(t1) > T/2) = 0; % Rectangular window lagake signal bound kiya

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t2 = t_rx - tau2;
s_rx2 = cos(pi * K * t2.^2);
s_rx2(abs(t2) > T/2) = 0;

s_rx = s_rx1 + s_rx2; % Combining the received signals

% Plot transmitted and received signals
figure;
subplot(2,1,1);
plot(t_tx, s_tx, 'Color', 'b');
title('Transmitted Signal');
xlabel('Time (s)');
ylabel('Amplitude');

subplot(2,1,2);
plot(t_rx, s_rx, 'Color', 'g');
title('Received Signal');
xlabel('Time (s)');
ylabel('Amplitude');

% Matched filter output (cross-correlation)
[corr_output, lags] = xcorr(s_rx, s_tx);
time_lags = lags / fs; % Convert lags to seconds
range = (c * time_lags) / 2; % Convert to range (m)

% Find peaks
[pks, locs] = findpeaks(abs(corr_output), 'MinPeakHeight', 0.5*max(abs(corr_output)));

% Plot matched filter output
figure;
plot(range, abs(corr_output), 'Color', 'r');
xlabel('Range (m)');
ylabel('Amplitude');
title('Matched Filter Output');
grid on;
hold on;
plot(range(locs), pks, 'ro');
hold off;

% Display detected ranges
detected_ranges = round(range(locs), 2);
```


```

% Display detected ranges
detected_ranges = round(range(locs), 2);
```


```
disp('Detected ranges (m):');
disp(detected_ranges);
```

Outputs:

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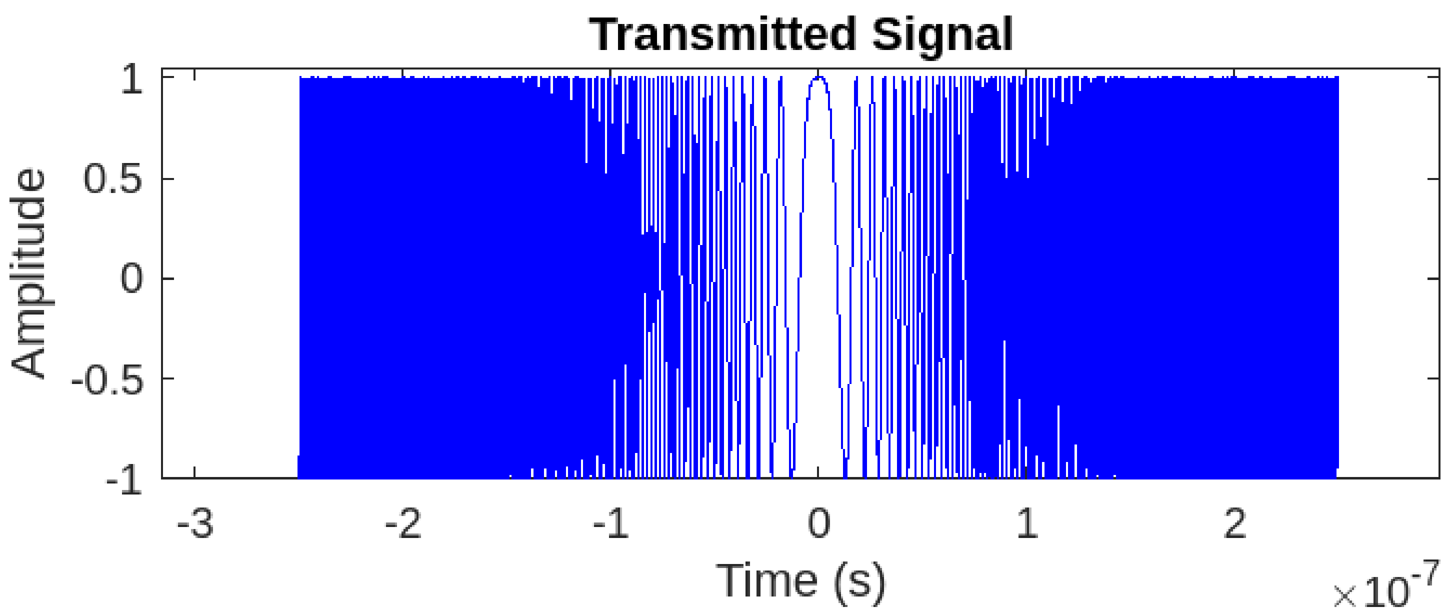
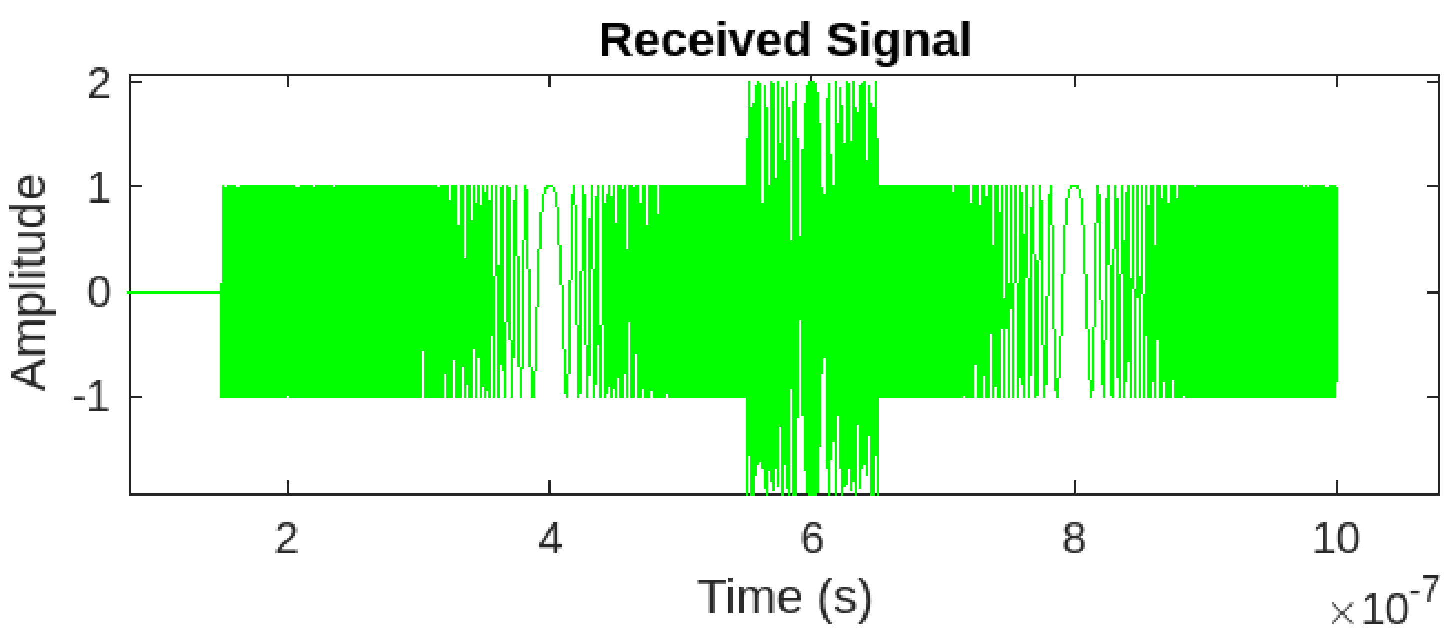
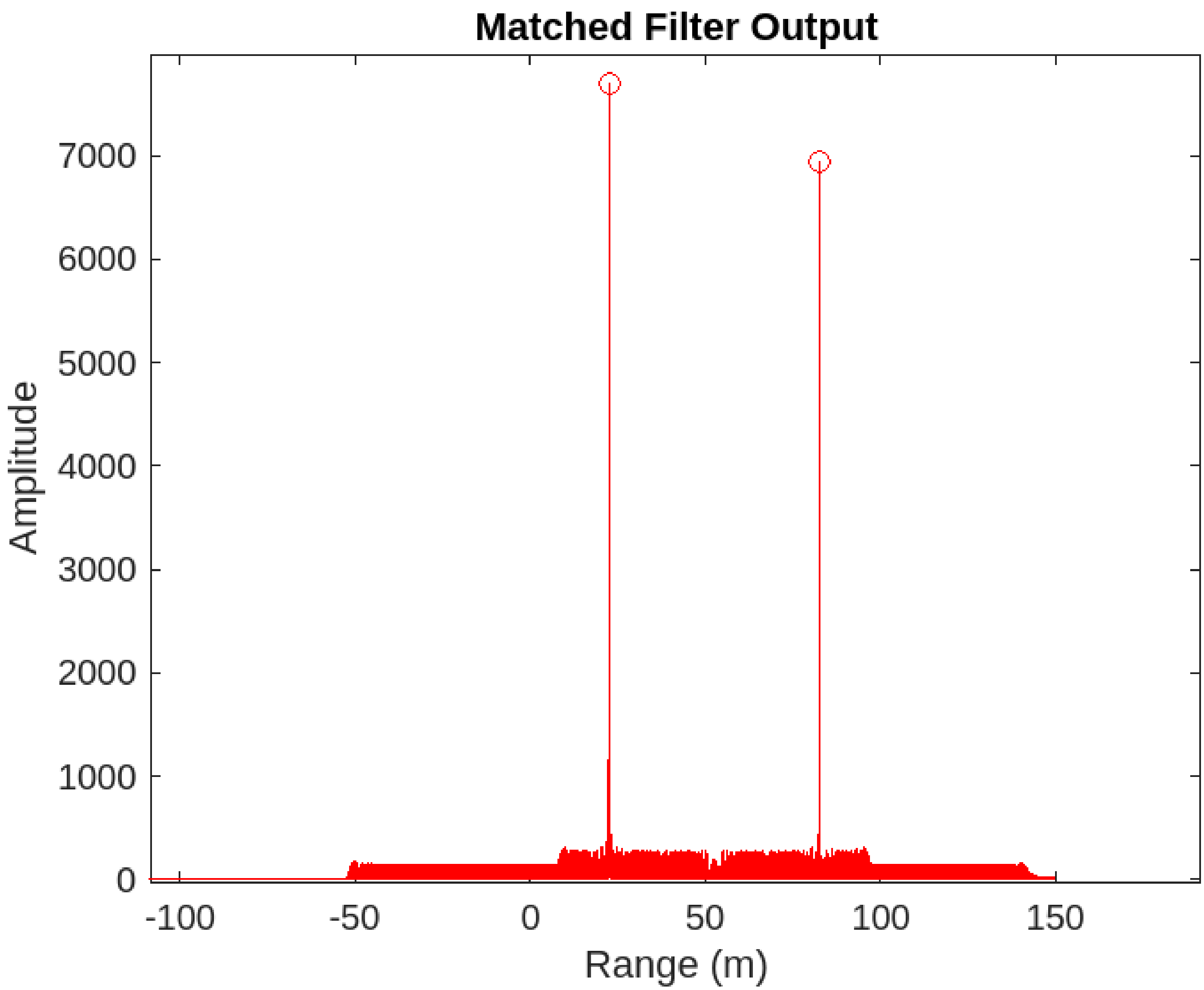
Detected ranges (m):
   22.5000   82.5000
```

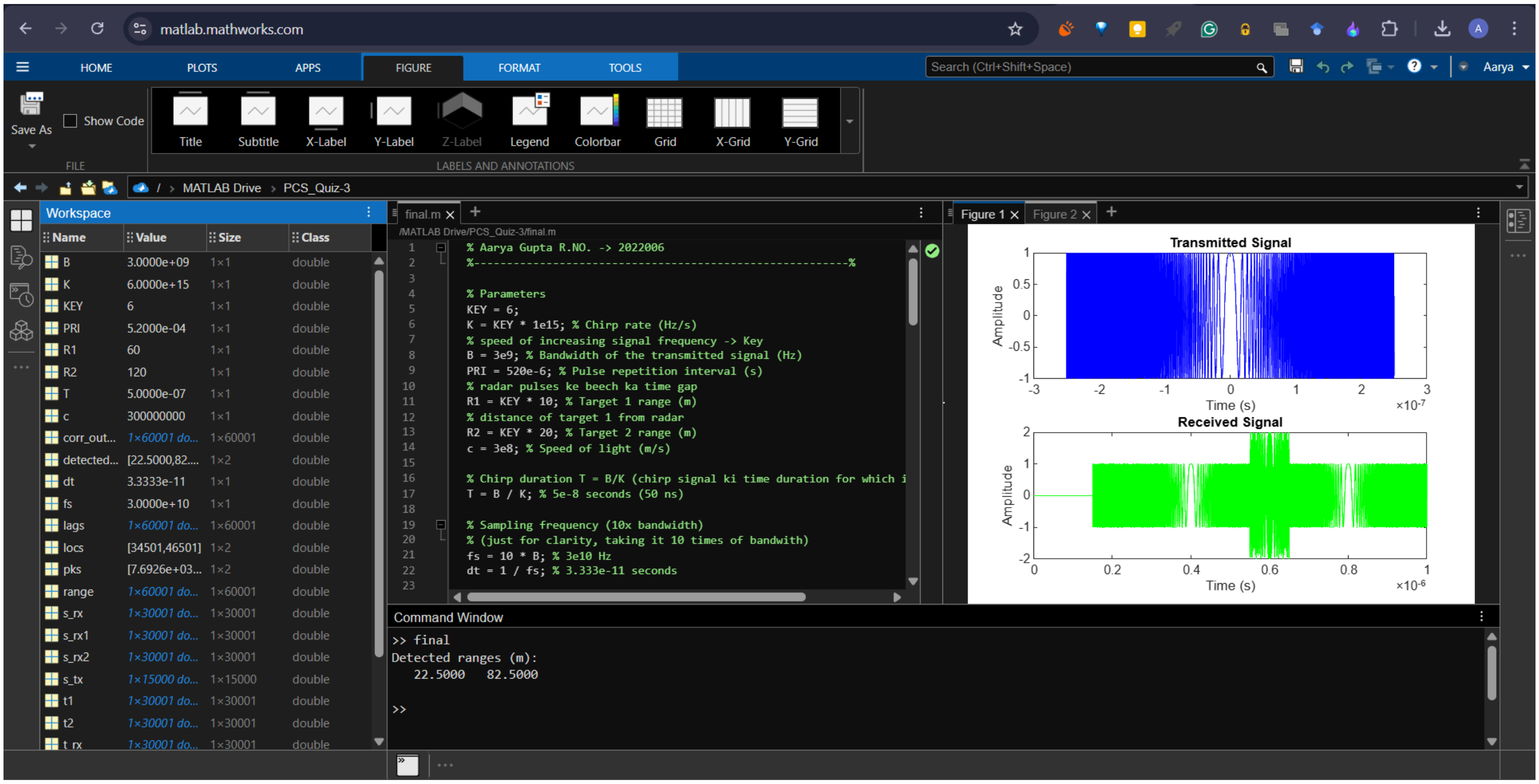
Plots:






Matched Filter Output
Amplitude
7000
6000
5000
4000
3000
2000
1000
0
-100
-50
0
50
100
150
Range (m)

Screenshot showing that the code was compiled:



THEORY QUESTIONS:

#QUIZ-3 (THEORY)

Aarya Gupta
2022006

Given: KEY = 6 (∵ R.No. → 2022006)

$K = 6 \times 10^{15}$ Hz/s

PRI = 20 μs

B = 3 GHz.

Tx: $s(t) = \cos(\pi k t^2) \cdot \Pi(t/T)$

Target 1: key × 10 = 60m

Target 2: key × 20 = 120m

Separation = 120 − 60 = 60 m

a) We know:-

$$h(t) = \begin{cases} s(T-t) & \forall\ 0 \le t \le T \\ 0 & \text{otherwise} \end{cases}$$

$\Pi(t/T) \Rightarrow rect(t/T)$

$$\Rightarrow h(t) = \cos[\pi \cdot k \cdot (T-t)^2] \cdot \Pi\left(\frac{T-t}{T}\right)$$ (Time Domain)

$\Updownarrow$

$$H(f) = S^*(f) \cdot e^{-j(2\pi f T)}$$ (Fourier Domain)

b) $\phi(t) = \pi k t^2$

$$\Rightarrow f_i(t) = \frac{1}{2\pi}\frac{d\phi(t)}{dt} = \frac{1}{2\pi}(2\pi k t) = kt$$ (Instant. Freq.)

c) Range resolution for a radar: $\Delta R = \frac{c}{2B}$

$$\Rightarrow \Delta R = \frac{3 \cdot 10^8}{2 \cdot 3 \cdot 10^9} = 0.05\ m$$

d) Target Resolution

∵ distance/separation b/w the two targets (60m) is far larger than the resolution range (0.05m), hence the two targets will be resolved in the range domain.

30/03/2025 05:04

QUIZ-3 (THEORY)

2022006
AARYA GUPTA

Given: Tx: $S_{tx}(t) = \cos(\pi k t^2) \cdot \Pi\left(\frac{t}{T}\right)$

$K = 6 \times 10^{15}$ Hz/s

PRI = 20 μs

B = 3 GHz

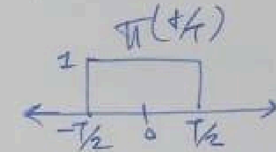
Targets distance ⇒ 60 m & 120 m

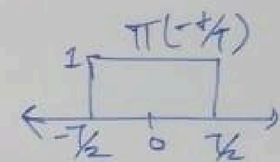
Solⁿ a) Impulse response of matched filter:

$h(t) = S^*_{tx}(-t)$

$= \left(\cos(\pi k t^2) \cdot \Pi\left(\frac{-t}{T}\right)\right)^*$

$\Rightarrow \boxed{h(t) = \cos(\pi k t^2) \cdot \Pi\left(\frac{t}{T}\right)}$





Now; $h(t) \rightleftharpoons H(f)$

$S^*_{tx}(t) \rightleftharpoons S^*_{tx}(f)$

$\Rightarrow h(t) = S^*_{tx}(-t)$

$\Updownarrow$

$H(f) = S^*_{tx}(f)$

b) Phase: $\phi(t) = \pi k t^2$

$f = -\frac{1}{2\pi}\frac{d\phi}{dt} = \frac{-1}{2\pi}\frac{d}{dt}(\pi k t^2) = -\frac{1}{2\pi} \cdot 2\pi k t = -kt.$

$\boxed{\therefore f = -kt}$

c) $\Delta r = \frac{c}{2B} = \frac{3 \cdot 10^8}{2 \cdot 3 \cdot 10^9} = 50$ mm. (range resolution)

d) Distance b/w 2 targets $= 20\text{Key} - \text{Key} \cdot 10 = 10\text{Key} = 60$

Targets can be resolved if $60 > 0.05$ (TRUE)

∴ The two targets will be resolved for these values of Key.