Part 1 – Doppler and Chirped Radar: Q1 (a)

Calculate the Doppler shift given: v = 300 m/s, f■ = 1 GHz

Using f_d = (2v/c) * f■ = (2 * 300 / 3e8) * 1e9 = 2000 Hz

Q1 (b)

What is the minimum recording time needed to resolve the Doppler shift?

T_min = 1 / f_d = 1 / 2000 = 0.0005 sec (0.5 ms)

Q1 (c)

If we sample at 2 GHz, how many samples are required?

N = 0.0005 * 2e9 = 1,000,000 samples

Q2 (a)

*Derive the equation: R = (c * ∆f) / (2k)*

Start with $\Delta f = k * \tau \rightarrow \tau = \Delta f / k \rightarrow R = (c * \tau) / 2 \rightarrow R = (c * \Delta f) / (2k)$

Q2 (b)

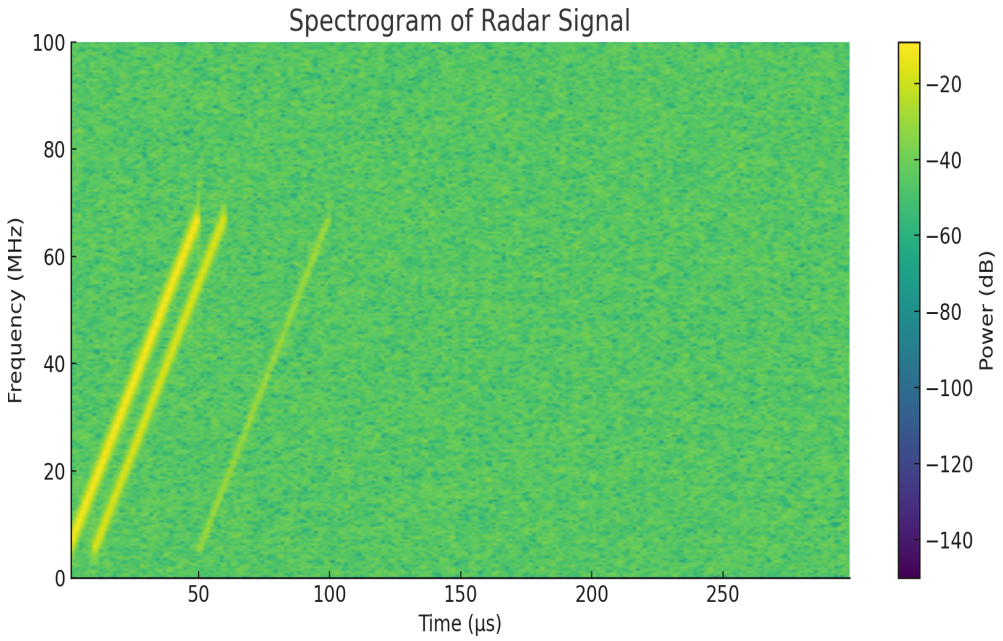
Use ∆f = 25 MHz, k = 1 MHz/μs, c = 3e8 m/s to find range.

R = (3e8 * 25e6) / (2 * 1e12) = 3.75 km

Q3

Use Octave to compute the spectrogram of doppler_shift.dat.

We estimated fs ≈ 2 GHz, used a Hanning window with nperseg = 512, overlap = 256. Spectrogram shows two distinct chirps, suggesting multiple aircraft.



Spectrogram of Radar Signal from doppler_shift.dat

Q4 (a–c)

From the spectrogram, identify the two strongest chirp peaks and their ranges.

Peaks at 6.25 MHz → 0.94 km Peaks at 7.81 MHz → 1.17 km Thus, we detect at least 2 aircraft.

Part 2 – Image Processing: Q1–Q3 + Bonus

Apply a 3x3 kernel to enhance the image and identify visible cockpit number.

The filtered image reveals the cockpit number: '054'. The aircraft model is likely Sukhoi Su-57 Felon based on nose, camo, and silhouette.

Filtered Aircraft Image Showing Cockpit Area